The Value of Mathematical Archives

Steve Batterson
with Charles Curtis, Albert Lewis, and Karen Parshall

Archives are indispensable resources to scholars in many disciplines. It is at such repositories that the papers of Thomas Jefferson and William Faulkner are stored. Unpublished materials, including correspondence and manuscript drafts, may reveal important insights that are not apparent in published works. Thus it is understandable that colleagues in the social sciences and humanities rely on archival study to advance their research. The case for mathematical archives may seem less compelling, especially since few mathematicians have ever ventured into an archive. Yet the papers of John von Neumann, G. D. Birkhoff, and other leading mathematicians are readily available.

The purpose of this article is to promote the donation and use of archival material by mathematicians.[1] Below are three accounts, by Karen Parshall, Charles Curtis, and myself, of how unpublished records have contributed to studies in the history of mathematics.

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[1] *This article grew out of the meeting of the AMS Archives Committee in Baltimore in January 2003. The members of that Committee are Steve Batterson, Robert Daverman (ex officio), Albert Lewis (chair), and Karen Parshall.*

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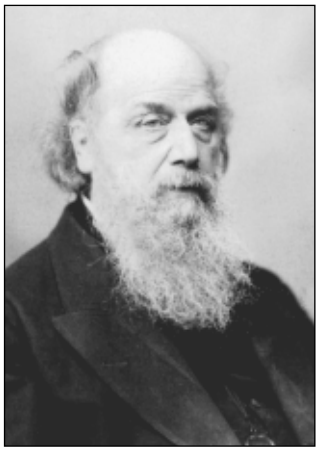
Karen Parshall on James Joseph Sylvester

In 1870 one of the two most renowned mathematicians in England, the fifty-five-year-old James Joseph Sylvester, found himself out of a job; the regulations governing the Royal Military Academy, Woolwich, where he had held the professorship of mathematics since 1855 had just been changed to prohibit any civilian over the age of fifty-five from holding a teaching position at the school. Sylvester spent the next five years unemployed and living off of his pension in London, but he was restless and eager for another position in mathematics. In the winter of 1875 the London newspapers carried news both of the death of the professor of mathematics at the University of Melbourne and of the search for his replacement. Writing to his friend, Arthur Cayley, England's other most renowned mathematician, Sylvester confessed to being "more than half inclined to go out to the Antipodes rather than remain unemployed ... in England" [4, page 144]. It would have been a very bold move for the sixty-year-old Englishman, but he had a clear sense of life not yet fulfilled.

By the summer of 1875 news of more job openings, this time in America at the newly forming Johns Hopkins University in Baltimore, reached England. Sylvester's friends both at home and in the United States wrote to the University's president-designate, Daniel Coit Gilman, with their unanimous recommendation for the professorship of mathematics. Joseph Henry, the first Secretary of the Smithsonian Institution and a friend since Sylvester's first sojourn in the United States in the 1840s, described Sylvester to Gilman as "one of the



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James Joseph Sylvester

very first living mathematicians", one whose "appointment would give a celebrity to the institution which would at once direct to it the attention of the whole scientific world" [5, page 72]. Like Henry, Benjamin Peirce, the Perkins Professor of Astronomy and Mathematics at Harvard and another longtime friend of Sylvester's, knew that Gilman was in search of proven researchers who would train future researchers and in so doing make a name internationally for the new university. Peirce minced no words in telling Gilman that Sylvester was the mathematician for the job, at the same time that he was *not* the teacher for the undergraduate classroom. "[A]s the barn yard fowl cannot understand the flight of the eagle," he explained to Gilman, "so it is the eaglet only who will be nourished by his instruction.... Among your pupils, sooner or later, there must be one, who has a genius for geometry. He will be Sylvester's special pupil—the one pupil who will derive from the master, knowledge and enthusiasm—and that one pupil will give more reputation to your institution than the ten thousand, who will complain of the obscurity of Sylvester, and for whom you will provide another class of teachers" [5, pages 73–74].

After personal interviews in London, Gilman had settled on Sylvester as his choice for the professorship of mathematics by the late fall of 1875, but the mathematician played hardball. Writing on 17 December 1875 in response to an official letter from the Hopkins Board of Trustees, Sylvester accepted the University's offer only "if the $5,000 salary therein named be understood to mean gold and if a house and the club fees be attached to [his] appointment" [4, page 150]. Sylvester had been burned financially by the Royal Military Academy, and he was not about to take a financial risk in addition to the risk he would already be taking in making a transatlantic move. After numerous telegrams and letters back and forth across the Atlantic in January and February and after at least one withdrawal of his acceptance of the post, Sylvester and the Hopkins authorities agreed on Sylvester's terms, and the Englishman made a move not to the Antipodes but to Baltimore in the spring of 1876. He was once again gainfully employed, and this time he had the chance, for the first time in his career, to train students at the graduate level.

Sylvester's seven-and-a-half years at Hopkins were a marked success. Nine of the "eaglets" Peirce envisioned completed their doctorates under Sylvester's influence; the *American Journal of Mathematics* began in 1878 under Sylvester's leadership; Sylvester put Hopkins on the international mathematical map. These successes did not come without their prices, however.

Sylvester could be difficult. In February of 1881, he blew up at his teaching associate and the associate editor of the *American Journal*, William Story, and in taking the matter to Gilman, blew up in the president's office, too. That fit brought a stern, written rebuke from Gilman. "I have always intended to treat you with the respect due to an honored colleague," Gilman stated, "but I must refuse to be again exposed to such a scene as occurred in my office on Thursday for no business can be transacted wisely when either party is excited" [4, page 199]. Eighteen months later Sylvester was once again displeased, but this time with Gilman's handling of an invitation to Lord Kelvin. In a letter dated 10 August 1882, Sylvester carped about the invitation before dropping a bombshell on the unsuspecting president. "I am wearied and dispirited and feel no longer equal to the discharge of what I consider to be the duties of my office in a manner satisfactory to myself or conducive to the best interests of the University," Sylvester stated. "I write therefore (after much anxious deliberation) to request that you will take the first opportunity to lay my resignation before the Board of Trustees to take effect as soon after the 1st of October next as may be found not too inconvenient" [4, pages 209–210]. Sylvester, debilitated by the heat and humidity and depressed by the fact that he had remained in the United States for the first summer since he had taken the job at Hopkins, had clearly overreacted. Several carefully penned letters from Gilman, who had become Sylvester's personal friend in the years of their professional association, calmed and heartened the mathematician. The crisis was averted.

Not even this brief sketch of Sylvester's association with Hopkins would have been possible without archives. Sylvester, never very organized, made no provisions for his papers at the time of his death. The relatively large collection of his letters that exists at his alma mater, St. John's College, Cambridge, is there only because Cayley was organized, because Susan Cayley, his wife, preserved them after Cayley's death in 1895, and because after her death they fell to the mathematician W. W. Rouse Ball, who saw to their deposition. Without these letters, we would have no hint of the lengths Sylvester considered going to—literally the other side of the globe—in securing another job in academe. If the letters Cayley saved were all that remained, moreover, we would know little of Sylvester's stay in Baltimore beyond the mathematics he worked on while there. Gilman's presidential papers, held at the Johns Hopkins University, contain everything from letters of recommendation like those from Henry and Peirce

to correspondence to and from individual faculty members like Sylvester to letters of application from potential students and annual reports from graduate students on their progress in their programs. The Sylvester letters there represent a major cache that allow us to flesh out not only Sylvester the professor of mathematics but also to glimpse, in ways not possible through published mathematical papers, Sylvester the man. The picture that emerges is one of a living, breathing individual with strong motivations and feelings, not merely a name attached to four volumes of published mathematical papers and to which amusing anecdotes have been associated. We could not hope to know Sylvester without archives, and, in not knowing him, we would be deprived of one of the most fascinating characters in the history of mathematics.

Charles Curtis on Representation Theory

My interest in the history of mathematics was awakened during my collaboration with Irving Reiner when writing our book [2]. While the book was intended to give an introduction to the work of Richard Brauer on modular representation theory of finite groups, we soon discovered that Brauer presupposed familiarity with the work done around the turn of the twentieth century by Ferdinand Georg Frobenius, William Burnside, and Issai Schur. Collected works of these authors were not yet available, and we were forced to explore the archives of libraries to find the volumes of the *Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin* containing Frobenius's great papers of 1896 and 1897 in which he created the theory of characters and representation of finite groups, and subsequent papers by Frobenius and by Schur, along with Burnside's publications in the journals of the London Mathematical Society, which were the starting points of Brauer's work.

In 1990 I was invited to give a joint AMS-MAA lecture at the annual meeting in Louisville, and chose as a topic "Representation Theory of Finite Groups: from Frobenius to Brauer". Following the lecture I was encouraged to write a book on the subject, and the result was [3].

My aim in writing the book was to give an account of the early work on representation theory with enough of the mathematics to enable an interested graduate student or professional mathematician to follow the development and read the proofs of some of the main results in detail. An account of the early history of representation theory had already been published in the *Archive for History of Exact Sciences* by Thomas Hawkins. I realized that I needed to give impressions of Frobenius, Burnside, Schur, and Brauer as persons and how their mathematics fitted into their lives. For this I needed to consult archives containing their personal records, correspondence, etc.

The first item of correspondence available to me that hinted at what might be found in the archives was a letter about Burnside from W. L. Edge at Cambridge to Louis Solomon, which Solomon received in 1979 and kindly made available to me. In it Edge stated that while Burnside is generally thought of as belonging to Pembroke College, he was admitted to Cambridge University with an entrance scholarship to St. John's College and migrated to Pembroke College after a year for reasons connected with his interest in rowing. Edge also mentioned and included notes on some correspondence between Burnside and H. F. Baker that was acquired by the library at St. John's College after Baker's death in 1956.

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William Burnside

In the fall of 1992 I visited the Institute for Experimental Mathematics at the University of Essen, and I began my historical research with a visit to archives in Berlin where I hoped to find information about Schur and Frobenius, who had both been professors at the University of Berlin (now Humboldt University) and members of the Academy of Science. Christine Bessenrodt, a member of the Institute, helped arrange a meeting with Hannalore Bernhardt, a historian at Humboldt University, Berlin. She in turn set up appointments for me at the archives of Humboldt University and the archives of the Berlin-Brandenburg Academy of Science (all done at a rather hectic pace, as it turned out that she was leaving the next day to run in the New York Marathon).

At the university archives the personnel records of Frobenius and Schur were available along with a few letters on the non-Aryan Schur reporting to the *Reichminister für Wissenschaft, Erziehung und Volksbildung* [minister of science and education] in the Nazi government. For example, one letter stated that Schur had been diagnosed with arterial sclerosis in 1936, while in another, Ludwig Bieberbach, who was then the dean of faculty, reported on Schur's visit to Zürich in February 1936 to give a course on group representations. At the archives of the Academy of Science, I was able to copy handwritten letters of recommendation for Frobenius's admission to the Academy by Weierstrass and Fuchs, and by Fuchs and Helmholtz. These were

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translated by Jens Jantzen, and appear in Chapter II of my book.

A short time later, with the help of Jan Saxl at Cambridge University, I visited the archives at Pembroke College and St. John's College, Cambridge, where I had access to correspondence and other documents associated with William Burnside. The correspondence between Burnside and Henry Frederick Baker (1866–1956), who was at the time the correspondence began around 1903 a Fellow at St. John's College, was particularly interesting as it showed the breadth of Burnside's mathematical interests. Burnside was professor of mathematics at the Royal Naval College, Greenwich, from 1885 until his retirement. The letters to Baker showed that he was a regular participant in Baker's geometry seminar, or "tea party", held at his home every Saturday during term. According to W. V. D. Hodge it "was the prototype of the numerous seminars that are held nowadays, but was for a long time the only one of its kind" in England. Burnside continued until his death in 1927 to correspond with Baker, and the letters, along with occasional telegrams, covered a wide range of topics, from algebraic geometry related to Baker's seminar to Galois theory and the theory of invariants of finite groups, to which Burnside devoted a chapter of the second edition of his book.

The archives at Pembroke College contained other letters from the Burnside–Baker correspondence, an inventory of Burnside's collection of mathematics books, some reprints of his papers, and items related to rowing events in which Burnside participated. These showed that Burnside was known for more than his mathematical teaching and research. For example there was a clipping of an obituary of Burnside, from the "Sports Gossip" page of "The Evening News" (London), August 31, 1927, which began, "Rowing men will regret to hear of the death of W. Burnside, one of the best known athletes of his day." The obituary mentions Burnside's teaching career at the Royal Naval College, but omits any reference to his mathematical research.

One of the main topics in my book was the historical development of Richard Brauer's research, beginning with his research on central simple algebras and his collaboration with Emmy Noether and Helmut Hasse. While I was working on this part, I learned from Bhama Srinivasan that a collection of letters and postcards from Emmy Noether to Richard Brauer had been placed in the archives of the Bryn Mawr College Library. I obtained copies of them, and found that although I knew they contained important information about the mathematics I was writing about, I was unable to read the handwriting. Walter Ledermann translated some of the crucial letters containing information about how the collaboration of Brauer, Hasse, and Noether began, and the letters appear in Chapter VI of my book. The letters from Noether to Brauer, and another set of letters from Brauer to Hasse and from Noether to Hasse from the Hasse papers in the *Handschriftenabteilung* of the *Staats- und Universitätsbibliotek Göttingen*, are in the process of being transcribed and put on the internet with commentaries by Peter Roquette and Franz Lemmermeyer.

Steve Batterson on Stephen Smale

Early in 1956 a University of Michigan graduate student was completing his thesis research and looking for jobs. He approached one of his professors, Raymond Wilder, for a letter of recommendation. Wilder was a good choice. As the current president of the American Mathematical Society, his judgement carried considerable weight. Wilder knew the student well, recognizing him as an underachiever who had recently seemed to catch fire. Wilder composed the following letter for the future Fields Medalist:

> Stephen Smale, one of our graduate students, asked me to drop you a note regarding his mathematical promise.
>
> I believe he shows lots of promise. I did not think so, however, until this year. Maybe his getting married was the turning point; for he has been developing very rapidly this year. He has been participating in my seminar, and shows himself very quick to pick up suggestions for investigation, as well as quick to bring in results. Possibly you heard his paper at the recent meeting in New York; this was a result of the seminar, and embodied a homotopy analogue of the Vietoris mapping theorem. He formulated the conditions himself (as well as the proof, of course).
>
> I haven't the slightest idea of Bott's opinion of him; as you probably know, he is writing his dissertation under Bott and Bott is at the Institute this year. I assume you will get his independent opinion of Smale. Perhaps Bott does not know Smale's wife; she is a very charming and capable lady—a professional librarian. She is working in Dearborn—commutes every day—to help out with family expenses. [1, pages 37–38].

Smale immediately exceeded these modest expectations. By the end of the year he obtained his famous result on everting the sphere. In 1960 Smale established the higher dimensional Poincaré Conjecture and the following summer the

h-Cobordism Theorem. These remarkable papers are available in the *Transactions of the American Mathematical Society*, the *Annals of Mathematics*, and the *American Journal of Mathematics*, respectively. Wilder also published his mathematical results in such traditional outlets. However, it is because Wilder archived his papers that we gain insight into the suddenness of Smale's rise to mathematical prominence. Much of Wilder's correspondence and work are stored among his papers in the Archives of American Mathematics at The Center for American History in Austin.

Wilder's incongruous remarks about Clara Smale are a reminder that his letter must be viewed in the cultural context of a different time. This raises a question as to whether Wilder's assessment has been devalued by years of inflation. Further calibration of Wilder's norms comes from comparing a letter that he wrote at the same time for one of his own students. Wilder enthusiastically predicts a brilliant future and makes a comparison to Norman Steenrod. Even with allowances for possible favoritism toward his progeny, it is clear that Wilder had no clue as to Smale's true talent. Wilder was not the only one who underestimated Smale. Recollections of other department members are more or less consistent with the appraisal in the letter above. However, contemporaneous writings, when available, provide a stark authenticity.

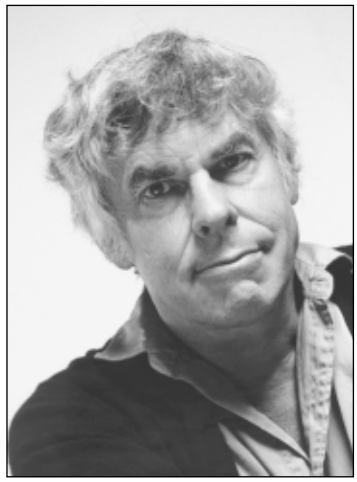
Other perspectives of Smale's college days are found in the University of Michigan archives located in the Bentley Historical Library on the Ann Arbor campus. Smale was among a handful of students who were prominent in left-wing political groups. During these McCarthy-era years, University administrators closely scrutinized gatherings of such bodies, fearful that their beliefs might become popular with impressionable students. When Smale attended a dinner with an unauthorized, controversial speaker, he and the other participants were charged with disciplinary violations. The Michigan archives contain transcripts of Smale's interrogation at the ensuing hearings. His uncooperative testimony reveals a young man who could not be intimidated to betray his principles.

In another document the dean of women offers the president her analysis of six leading campus radicals. Dean Bacon reviews personal and intellectual characteristics of the students and then speculates on the threat each poses to subverting peers. There was no concern about Smale. In this case it was Smale's leadership potential that was being sold short. One decade later he would collaborate with Jerry Rubin to launch a historic campaign of civil disobedience against the Vietnam War.

These testimonies demonstrate the role of archives in lending perspective on the development of mathematics and of mathematicians. The success of this process depends on three factors. Individuals and institutions must make a long-term investment by supplying the materials they control, repositories require support to maintain these records, and scholars must avail themselves of the opportunities that are afforded.

It is impossible to foresee what current materials will have importance one hundred years from now. Regrettably, it will then be too late to resurrect items that are being discarded today. Please consider whether you or your department have papers that should be available in perpetuity. Pointers on how to proceed can be found at `http://www.ams.org/mathweb/History/donors.html`. Moreover, the nature of materials and storage is changing as electronic means become prevalent. The sidebar by Albert Lewis on the next page offers an update on these issues.

A list of archival collections, ordered by mathematician, is maintained by the AMS-MAA Joint Archives Committee and is available on the Web at `http://www.ams.org/mathweb/History/collections.html`. The committee encourages use of these resources. Since mathematicians are unlikely to be familiar with the workings of the library subculture associated with archives, the guide on page 1415 is designed to enhance the experience.



Stephen Smale

Raymond Wilder

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[2] Charles Curtis and Irving Reiner, *Representation Theory of Finite Groups and Associative Algebras*, Interscience Publishers, 1962.

[3] Charles Curtis, *Pioneers of Representation Theory: Frobenius, Burnside, Schur, and Brauer*, History of Mathematics, Volume 15, American Mathematical Society and London Mathematical Society, 1999.

[4] Karen Hunger Parshall, *James Joseph Sylvester: Life and Work in Letters*, Clarendon Press, 1998.

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Preserving the Electronic Record

The archives committee has sometimes been asked, How do you propose to encourage the preservation of the historical record in the face of the rapidly increasing use of electronic communication? A similar question probably arose for archivists and historians when use of the telephone became widespread, at least for business use, in the 1920s. In some ways the telephone presented more of a challenge, since at the time there was no widely available means of recording those conversations that the participants may have wished to preserve. Today it is possible, at least in principle, to automatically record all electronic, digitized communications. However, just as with an electro-magnetic recording that might have been made in the 1920s, this does not ensure the long-term preservation of the record. For one thing, the physical medium deteriorates; the lifespan of present-day optical media, such as CDs, can range from 15 to 200 years, for example. This can be overcome by a program of transferring to new media. An even more significant factor working against preservation is the obsolescence of the encoding protocol and of the software and hardware used to create and make use of the original documents, images, databases, and so forth. The computer landscape of the past forty years is heavily littered with machines, programming languages, software, and their output that have been rendered unusable in the wake of advancement. Solutions to this problem are being investigated, including the feasibility of preserving, in effect, the software and hardware itself through emulation.

As the reliance on centralized electronic resources increases, new problems arise that go beyond the traditional preservation issues. The very advantages of accessibility and modifiability that the electronic age has brought to the realm of documents also opens up the possibility of changing what we normally think of as the historical past. The recent case of the publisher Elsevier removing, without notice, entire journal articles from their electronic database of published journals is an example. The protest over this particular incident led to changes in Elsevier's policy ("Elsevier Announces New Procedures for Retracting Online Articles", *The Chronicle of Higher Education*: Information Technology, February 28, 2003, Volume 49, Issue 25, Page A35), but, as libraries move away from paper and subscribe only to such electronic repositories for their journals, this raises the larger question of what constitutes the historical record which publication in multiple paper copies traditionally provided. Again, we understand that means are being investigated of ensuring the long-term integrity of these types of community records.

Closer to home, the AMS has had a records management policy in place for some years that provides guidelines for its administrative offices with respect to record retention and archival transfer. It is mainly directed at paper records and may need to be updated with respect to new media, but it has proven to be an effective program. Much if not most of the Society's official records (agendas and minutes of committees, for example) still appears to be in paper form, even if often in parallel with electronic propagation. The AMS as a whole, however, continues to computerize more of its operations, especially within its publications division and particularly in the production of journals—from article submissions and refereeing, to publication. Special policies are in place for the archiving of AMS electronic products, and there are procedures for maintaining their historical integrity. Evidently a movement is beginning that could eventually see the digitizing of the whole of the mathematical literature, past and future. (John Ewing, "Twenty Centuries of Mathematics: Digitizing and Disseminating the Past Mathematical Literature", *Notices* **49** (2002), 771–777.)

In the face of such changes and unsolved problems, the best advice the committee feels it can give to individuals and institutions at this point is threefold:

1) Retain electronic copies of at least those documents (including emails) that would be retained were the documents in paper form only, including significant drafts. The fact that electronic copies take up less room may invite saving more documents than otherwise might be saved, and this certainly does not hurt.

2) Develop a personal or institutional records management plan, however modest. For example, try to have more than one archival copy stored separately from on-going work, and move it to new media as new storage devices are acquired.

3) For the most important documents, consider keeping a paper copy as well—still the most reliable form of document preservation.

This leaves much to be done by repositories which may eventually receive this material. Even without the special task of maintaining electronic records, it is no small undertaking for a research library to acquire, process, and store traditional paper archives and to make them available to users. The whole of the mathematical community will benefit as new ways are found to meet the new needs.

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A User's Guide for a First Visit to an Archive

Collections are normally organized into acid-free folders that are placed in numbered boxes. The most important terminology is *finding aid*, the index to a collection. The detail in finding aids varies substantially. In seeking a particular item, say a letter to a known correspondent, consulting the finding aid should narrow the search to a specified box, or boxes. It is always desirable to view the finding aid prior to the actual visit. Some finding aids are easily obtained on the Web. For example, the finding aid URL for John von Neumann's papers at the Library of Congress is `http://lcweb2.loc.gov/cgi-bin/query/r?faid/faid:@field(DOCID+ms996003)`. If the finding aid is available only at the site or a more detailed version is in existence there, the reference staff may be willing to mail a copy upon request.

Much can be gained with an advance phone call. For example, some materials may be stored at a different site. Making a request for retrieval prior to the visit can avoid a frustrating delay. Even if an online finding aid states that papers are available onsite, it is a good idea to confirm that the information is current. Some collections may restrict access or require advance permission.

Upon arrival at the archive, the first step is to register and to receive indoctrination on the local rules. There are likely to be restrictions on what possessions are permitted in the study area. Writing implements other than pencils are normally forbidden. When these preliminaries are completed, requested materials become available for viewing. Expect surprises, both interesting and mundane.

Duplication procedures and costs should be explored early in the visit. If self-copying is permitted, it may be necessary to obtain a card elsewhere. Check out the machines and assess their availability. Sometimes the facilities are inadequate and competition leads to lines. Under such circumstances it is a good idea to formulate a strategy on when to copy. Many archives require that the duplication be performed by members of their staff. These policies are motivated by security concerns. Costs for these services vary, but are often on the order of 25 cents per page. If the number of copies is small and the job is requested well before closing time, it may be completed on the same day. Typically it is mailed a week or so later. Each archive has its own procedures for researchers to indicate which records are to be duplicated.

Publishing a quotation from an archival record is likely to require additional permission. This issue should be discussed with the reference staff, and the appropriate citation should be ascertained. It is advisable to identify a knowledgeable staff member with whom to maintain communication. Archives tend to attract long-term personnel who are dedicated to connecting scholars with the material they are seeking. Sometimes researchers assume items do not exist when actually they are stored under an unfamiliar heading or in a different collection. An experienced staff member can be a valuable resource in suggesting additional stones to overturn. Finally, it is possible to return from a visit and realize that one or two additional records are needed. Obtaining help electronically or over the phone goes more smoothly if a relationship has already been established.

—Steve Batterson