

# Citation Patterns and Documentation for the History of Science: Some Methodological Considerations

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## Research Needs

IN DEALING WITH the enormous problems posed by modern scientific documentation, in contrast to librarianship's concern with the published record, the archival profession has developed no visibly active research component. Yet the problems posed by the continuous production of unpublished correspondence, reports, notebooks, notes, computer records, and the like, by the scientific and technological communities, are just as compelling as those that have driven the library profession to research. For archivists as, of course, for librarians, the problems are not unique to science and technology; and an investigation of the nature of the documentary problems in the history of science, and the lessons learned thereby, should affect archival practice in general.

In terms of principles and practices, archivists still are in the early stages of standardization, a process sometimes resisted, often, perhaps, in spite of the archivist's better judgment. In serving the scholarly community,<sup>1</sup> an archivist's joys are in building institutional resources to meet the unpredictable demands of the artist-histo-

rian. Archival canons of selectivity are based largely on that sixth sense developed through familiarity with many collections, through conversations with researchers, through knowledge of historians' needs gained from long years of moving back and forth between the reading room and the stacks, through reading the literature of history grown from the historian's plowing in the fields of the archivist.

The economics of our times and the growth of potential documentation must now call into question the continuing utility of the traditionally impressionistic, *ad hoc* standards of appraisal. The nature of archival work always will call for judgment and discrimination, and a willingness to gamble on the future based on an informed knowledge of the past and the present. That is the nature of archival appraisal, the central core of professional concern, the one area in which mistakes are not redeemable. All research efforts for archival practice must aim at sharpening the awareness of the salient characteristics of document production and use, to help archivists to understand better the role of documents in the historical process.

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<sup>1</sup> While it is fully appreciated that archivists serve a wide range of clientele, the chief orientation here is toward the special needs of historical study. In the widest sense, of course, most archival usage is historical in that the motivating interest is to gain perspective on the present from the past, either remote or more recent. There are, nonetheless, different uses for that historical perspective that characterize different groups of clientele. Those differing uses of the past will make different, and sometimes conflicting, demands on the evaluative skills of the archivist.

### Use-Studies

One way to develop a body of knowledge bearing on decisions about appraisal of records for the history of science, for example, is by studying patterns of use of archival and other historical documentation. Most obviously, perhaps, archival institutions could undertake to study the patterns of use of their own holdings; the results would help to identify the parts of the collection that are frequently used, seldom used, asked for but not present, and the like. Use-studies in institutions can also gauge the degree and nature of use of archival resources by different types of clientele and for different purposes. For example, in an academic archives such use-studies could help to determine the relative use of the facilities by students, advanced researchers, or administrators, and use for different purposes, such as scholarly historical research; research on current social, political, or scientific topics; research for teaching or exhibitions; personal interest research (e.g., genealogical); and so forth. In this article the primary interest is in documentation for historical studies; but institutional use-studies can help to identify the whole range and relative degree of use of archival documentation. Such use-studies should attempt to relate types of use and users to the characteristics of the documentation itself, in order to determine how different categories of records series relate to the needs of different groups.

For maximum effectiveness, institutional use-studies should be carried out, as much as possible, according to a coordinated and standard format. This would create generalizable data on archival use, against which the local archival program could be compared and evaluated.

In addition to institutional studies, study of the items cited in the published literature may produce patterns of use, with potentially generalizable results. This approach is the focus of attention in this paper, limited to a concern only with historical studies in the history of science. I am concerned with both the structure and needs of the history of science as a field of inquiry, and with guidance for archivists in the appraisal of scientific documentation

for historical studies. A formalized study of citation or reference patterns—as a type of use-study—can help to bridge the gap between the concerns of historians and of archivists, useful both for historiography of a field and for appraisal of its documentation.

Patterns of past and present use of documents, whether viewed from the perspective of the archival institution or as evidence of usage as cited in the literature, have important philosophical and operational limitations for attempting to predict future needs or patterns. While these concerns are not addressed at length here, they are questions that must occupy the best minds in the profession before archivists attempt to use the results of such use-studies. In considering the broader issues, historians and other users should be brought into the professional dialogue. There are many reasons why any particular body of records is used by any one researcher. These would include, for example, geographical proximity, listing in standard sources such as the *National Union Catalog of Manuscript Collections*, the extent of description and/or indexing, previous use and citation, ease of access, priority for processing based on the archivist's conception of what is useful, and a number of other variables. Ultimately, as use-studies become more frequent in the archival field, increasingly sophisticated investigations must examine use in terms of many variables. Even given such controls, however, the question will remain of the role of use-studies in predicting future usage, and in appraisal decisions. In this preliminary stage of archival research, it can only be argued that much in the appraisal process always has been based on intuitive conceptions of what has been used and what will be used in the future. Use-studies can formalize such impressions, and objectify them so that archivists can share their usage conceptions with one another. There is no short-cut to appraisal. The archivist still must be as familiar as possible with historical literature and research trends, must try to anticipate future needs, and, indeed, must be willing sometimes to collect records of seemingly little current or foresee-

able future utility. Use-studies, as they develop, should be seen as contributions to the liberal education of the archivist, not tools of management.

### Citation Studies: General Considerations

Citation analysis<sup>2</sup> has been used often by historians and sociologists of science interested in studying relationships of individual scientists, origins of scientific fields, growth and dispersal of scientific knowledge, and other questions. Also, it is a tool used increasingly in library and information science by researchers interested in examining patterns of use of library materials.<sup>3</sup> These library studies have implications for the relative use of publications in serial or monograph form in different fields, the length of time that library materials need be kept in prime storage space, the generation of lists of most-cited serial and monograph titles, and other results.

Citation studies are controversial and, in regard to methodology, the critics must be heeded. Of central importance is the question of the significance of the citation of one author by another. Lists of reasons for citing works in the sciences have been compiled, reasons including a desire to honor pioneers in a field, to recognize related work, to criticize another work, to substantiate one's own result, and to identify the original place of publication of a fact or concept.<sup>4</sup> In addition, it is said that authors do not cite everything they read, and may not always read everything they cite. Even if honesty in citation is granted, there is still the question of whether the author

used the best or all of the available sources.<sup>5</sup> Nevertheless, reference citations are important, despite the fears there be of careless documentation or ulterior motivation.<sup>6</sup>

### Citation Studies in History of Science

Citation studies generally have been used in studying practices and patterns in current scientific literature. Relatively little has been done in regard to historical literature, and what has been done is oriented toward problems of libraries and the uses of printed material. There are no studies of use patterns of unpublished sources in any field of history.

The earliest, and for a long time the only, citation study in American history was a library science doctoral dissertation by Arthur McAnally, a *reference* study counting each reference only once, rather than every time it was cited. McAnally's study was chiefly of published material, but he did isolate manuscripts as a general source. Based on analysis of historical literature published in 1938, about 10 percent of the references in McAnally's study were to manuscript sources.<sup>7</sup> There were slight differences in use between manuscript and printed sources, depending on the field of American history involved. Authors of general history used a higher percentage of manuscript sources than did those of the history of politics, government, and law.<sup>8</sup> While manuscripts, relatively, do not seem to have been used extensively by American historians in 1938, primary printed and unprinted sources combined accounted for about 63 percent

<sup>2</sup> *Citation analysis* generally is used as a generic term for all studies that attempt to gauge the nature and the pattern of footnoting practices in published works. In the stricter sense, citation analyses would count each bibliographic unit each time it appears in the footnotes of the publication being analyzed. A reference study, on the other hand, would count each bibliographic unit in the footnotes only once (i.e., only the first time it is cited).

<sup>3</sup> Robert N. Broadus, "The Applications of Citation Analyses to Library Collection Building," in *Advances in Librarianship*, Melvin J. Voit and Michael H. Harris, eds. (New York: Academic Press, 1977), pp. 299–335; John Martyn, "Citation Analysis," *Journal of Documentation* 31 (December 1975): 290–97. Both of these publications are review articles, which critically assess the state-of-the-art of their subject.

<sup>4</sup> Martyn, "Citation Analysis," 290–91.

<sup>5</sup> Broadus, "Applications of Citation Analyses," pp. 308–9.

<sup>6</sup> *Ibid.*, p. 328.

<sup>7</sup> Arthur Monroe McAnally, "Characteristics of Materials Used in Research in United States History" (Ph.D. diss., Graduate Library School, University of Chicago, 1951), p. 37.

<sup>8</sup> *Ibid.*, pp. 53–54.

of all references cited by the authors of articles in McAnally's study.<sup>9</sup> A more recent investigation of cited references, those in English history articles published during 1968 and 1969, showed that about 11 percent of the references were to manuscript sources.<sup>10</sup> In music history, about 15 percent of all references were to manuscripts, manuscript letters being only about 2 percent of all references.<sup>11</sup>

In considering the value of citation or reference studies as an aid to understanding the patterns of document usage for the history of science, little has been done that is specifically useful. The available published studies all must be considered background, skirting the main concern but never addressing it directly. All of the studies examined were designed to determine patterns of use of printed items, and their use for library collection decisions. The remainder of this article, therefore, is a preliminary probe to see whether citations of manuscripts can be studied profitably for the education and work of archivists.

### Pilot Citation Study in the History of Science: Procedures and Problems

To shed some light on the above, a pilot reference study in the history of science has been carried out, the chief results of which are based on an analysis of the footnoted references cited in fifty journal articles, most published in 1976 and 1977. (In the discussion below, the term *publication analyzed*—or some variation—will refer to those articles whose footnotes were analyzed and counted, and *reference* or *citation* to the items cited therein. Strictly speaking, this was a reference study rather than a citation study, since a reference was counted in any one analyzed publication only once rather than each time it was cited. However, if the same reference is cited in another article, it is counted there.)

Fifteen journals were chosen for this study, all devoted more or less exclusively

to the history of science and all published in the English language. From each of these journals I chose one number published around 1976, and analyzed the footnotes in all articles dealing with the history of science in Great Britain, Canada, and the United States during the nineteenth and twentieth centuries, that appeared in that issue. I also included any article on international science if an appreciable part of it dealt with science or scientists in one of those three countries. In addition to the fifteen journals, I also analyzed Nathan Reingold's *Science in America Since 1820*, which reprinted selected articles that originally appeared in *Isis* during 1958–76. I also analyzed the references in selected chapters of three recently published books; but for reasons mentioned later, these were excluded from the main analysis.

An ideal way to carry out such a reference study probably would be to extract each reference, write it down, verify it, and, with all the references, to prepare an inductive classification of reference-types which later could be tabulated and analyzed by computer. At no point did this pilot study direct itself to specific titles or collections cited, but only to types of materials cited. For general usefulness to archivists in building their collections, or in helping to formulate appraisal standards, some idea is needed of the categories of materials used in writing the history of science, with an indication of the extent and the ways in which those categories are employed in different kinds of history of science.

The preliminary nature of this venture argued against the procedure of writing out each reference on a separate slip. Instead, I constructed a tabulation form of a single sheet for each publication to be analyzed; each form had blocks for registering and tabulating the various categories of references cited in the publication. The footnote number for each reference was

<sup>9</sup> Ibid., p. 120.

<sup>10</sup> Clyde Jones, Michael Chapman, and Pamela Carr Woods, "The Characteristics of the Literature Used by Historians," *Journal of Librarianship* 4 (July 1972): 139 and 141.

<sup>11</sup> David Baker, "Characteristics of the Literature Used by English Musicologists," *Journal of Librarianship* 10 (1978): 189 and 191.

written in the appropriate category block on the form, and later all of these footnotes in each category were counted and the total registered on the form.

Because of the way this pilot study was carried out, there were built into it certain presuppositions that may have varying degrees of validity for this and for future studies. In certain respects, some of these pre-conceptions or priorities grew out of an awareness of, and concern for, the history of science as a discipline. For example, in so far as the history of science is a division of intellectual history, it is of great interest to know the extent to which historians cite primary published literature, especially references to scientific books and articles. This is based on the belief that the history of science tends to rely on those published sources subjected to evaluative standards of the historical period under study, and so relies to the neglect of unpublished manuscripts. One of the difficult tasks of archivists in soliciting the papers of present-day scientists is to persuade them that anything other than their published papers has any value. Intellectual historians seem to share this bias, and it was desirable to know to what extent this has been true. In other areas of history—including the social history of science—such a concern to gauge the relative use of primary published documents may not seem so important.

A straightforward reference study such as has been undertaken for this paper cannot be expected to delve into questions of the content of the items cited, and must rely chiefly on surface characteristics of the documentation. Future studies will have to go beyond this preliminary concern with mere form, and evaluate the special nature and significance of documents in a more qualitative sense. This study was intended to investigate the feasibility of examining footnotes for their references to manuscript sources and to see what characteristics and problems one is likely to encounter in doing so. At the same time, it was felt that if such studies are to be undertaken, there is no sense in looking only at the needs of archivists. If citation studies are broadly enough defined, it seems likely

that they will permit the investigator to sketch a broad, if rough, picture of the total documentation of the field of study under review, encompassing manuscript and also published sources and perhaps artifacts as well. Therefore, in addition to its exploratory concern with the nature of manuscript citations, this study attempted also to look at the larger picture of documentation for the history of science, a concern that should be of interest not only to archivists but also to librarians and historians. The forms used for this pilot study attempted to encompass these more general considerations while leaving room for special categories (especially of manuscripts) that could not be entirely anticipated.

Atop the form was a space to indicate whether the analyzed publication was to be considered internalist or externalist history of science, or a combination of both. All but three articles fit either the internalist or externalist approach. These two terms are not easily defined, and my criteria were largely impressionistic. Internalist history of science is concerned chiefly with the development or relation of scientific ideas or concepts, as such. Its parameters are more-or-less limited to the technical aspects of scientific thought and experiment, treated as a special and insulated activity. Externalist history of science, on the other hand, is concerned with science as a social and cultural phenomenon. Its interests range from the study of professionalization, scientific organization, education, and politics, to questions relating to science and literature, the effects of science on social thought, and so forth. Efforts to integrate the two approaches do not seem to have advanced far, and there is some question whether they can, without resorting to a distorting determinism.

On the forms, I also registered the general subject area of each analyzed publication, its geographical locus, and whether it was chiefly early nineteenth, late nineteenth and early twentieth century, or twentieth century (post-1914) science.

The chief categories for the references (items cited) were *primary-unpublished*, *primary-published*, and *secondary*. Under un-



published primary sources (manuscripts), I used the sub-categories: *personal*, *corporate*, and *data-records*. I soon abandoned the last sub-category in favor of miscellaneous groupings subsumed under both personal and corporate. There were other, finer divisions under both published and unpublished, primary and secondary, but these need not all be mentioned here. Under personal papers, however, I separately tabulated correspondence, and diaries and memoirs; and under corporate records, I listed minutes, correspondence, and reports. Both the personal and corporate classes also had slots for unspecified or miscellaneous reference-types, with room on the forms to list specific types or examples when necessary. Again, it must be emphasized that this exploratory study was concerned chiefly with the external form of the items cited, and not with their substantive content (although some aspects of the latter are inherent in attempting to differentiate records of a corporate and personal nature). The strong argument can be made that the appraisal process itself begins (after the question of provenance) with considerations of physical form, which in themselves often connote function (e.g., the form and function of correspondence files, compared to accounting ledgers or to laboratory notebooks). In general, I concluded that the fewer specific preconceived categories the better, and some that I anticipated using and put on the form did not work out well in practice.

Before the brief summary of the outcome of this study, some of the special problems encountered must be mentioned. These problems need to be considered among the general methodological concerns. In some instances, the difficulties encountered were too tedious or technical to review here, but others are important toward determining how accurate and how useful any such reference study in the history of science is likely to be. Without certainty on this level, considerations of the broader questions are futile. Below are listed some of the leading problems, and the general comment should be added that

some of these difficulties might not pertain to a study in which each reference was written out separately. It should be kept in mind also that most of these concerns were not preconceived, but grew out of involvement with the analysis itself.

1. One of the first questions was in defining an unpublished source. The "life and letters" volumes of the nineteenth century are good examples. Generally, when a letter in such a volume was being cited, I counted it as an unpublished primary source; if the reference seemed to be to the editor's commentary, the reference was counted as a secondary published work. In general, primary items published subsequent to the historical period under review were counted as unpublished sources. Thus, references to primary documents taken from letter press or microfilm editions were counted as *primary unpublished*, but were differentiated on the count sheets by the special mark (x). The problem of how to count such sources is interesting in itself, in so far as the *general* picture of the documentation of the history of science is concerned. It also is of special utilitarian interest to archivists, editors, and funding agents, who need to be aware of the impact of primary source publication projects on the practice of history. Involved is the question of the degree to which scholars will prefer the use of published letters, for example, to the use of unpublished ones, and the impact this has on historical study. It certainly bears on the question of accessibility as a factor in use.

2. An attempt was made to count each individual letter, and each reference to minutes of meetings, so long as they were minutes of different meetings (even if for the same organization). I also sometimes counted each reference to a journal or notebook, even when it was to the same volume or item; but I never worked out any routine or systematic approach to sources of this type. In the study of references in English history, referred to earlier, the authors counted entire manuscript collections as single references.<sup>12</sup> This un-

<sup>12</sup> Jones et al., "Characteristics of the Literature Used by Historians," p. 140.

doubtedly accounts for the low percentage of only 11 percent manuscript references in that study compared to the higher percentage in my own. The question of countable units, of course, is a fundamental problem that must be answered before any constructive work in reference studies of manuscripts can be carried out. In my study, I could not always be certain I was not counting the same letter more than once, although I took some precautions not to do so. Individual documents must be counted, and counted accurately, if citation studies of manuscripts are to be successful or useful. In this sense, I maintain that a single letter ought to be equated to a single journal article when counting, and when comparing the relative use of published and unpublished sources. One possible solution to some of these problems could be to count all citations rather than just the initial reference to a document. The reference study, however, seems more straightforward and more to the point in terms of creating a measure of types of items cited. Nonetheless, this is a point for further discussion among archivists, and there certainly is room for disagreement.

3. Varying citation formats are a problem, but not entirely insurmountable. In some instances, the person conducting the citation study may have to refer back for clarification to the repository holding the documents. (Information on this problem ought to help researchers and editors to standardize their methods of referring to manuscript sources, which frequently are not specific or descriptive enough. For example, sometimes references to unpublished materials are collectively cited; e.g.,

the reference may be to an entire collection or volume of manuscripts rather than citation to a specific document. In this instance, not only is an accurate citation count difficult, but the general reader is not able to tell the source of an interpretation, quotation, or fact. There is a need for more standardization in manuscript citation practices.)

4. The differentiation between personal and corporate documents is a difficult problem, one which I did not solve. In part, I used the manuscript-archival repository distinction, so that organizational records in a manuscript collection were counted as personal papers rather than corporate archives (e.g., papers of President Woodrow Wilson in the Library of Congress were counted as personal). This is not an entirely satisfactory solution, and it is complicated by the fact that it is not always possible to determine whether a particular document is personal or corporate, even if one can so categorize the collection in which it appears.<sup>13</sup>

#### **Pilot Citation Study: Results**

Following is a brief summary of the rather crude statistical results of my count of references. It cannot be too strongly stressed, however, that these results are preliminary only, and that the chief intent of this study was to explore the methodological problems involved. Nonetheless, these figures do have some interest as suggesting general patterns and as an indication of what might be possible with more sophisticated techniques involving a larger sample and an in-depth analysis.

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<sup>13</sup> There are several other points of perhaps less general interest but bearing on the results given below of the pilot study. It was not always possible to determine whether or not a cited source was published. There also was occasional difficulty in determining whether primary documents such as speeches or reports cited with a recent publication date are to be interpreted as reprints or as first printings of previously unpublished items. This can have some slight effect on the statistical result. It also lends a certain ambiguity to the historical account as well (i.e., the uncertainty as to whether a speech, for example, was published for contemporary distribution or only for later and retrospective interest).

In cases where entire manuscript collections or volumes were cited, rather than specific documents, when it seemed warranted the reference was counted each time it appeared, on the assumption that different individual documents were being cited in the successive references to the general collection or volume. To the extent that the same document actually was being cited, the statistical account will be affected.

Table  
SUMMARY OF CITATION STUDY IN HISTORY OF SCIENCE

Categories	All Articles	Internalist Articles	Externalist Articles	Book Chapters
ALL REFERENCES (Citations)				
Primary—Unpublished* . . . . .	28%	12%	41%	47%
Primary—Published . . . . .	46	62	33	32
Secondary . . . . .	26	26	26	21
	100%	100%	100%	100%
*PRIMARY UNPUBLISHED REFERENCES				
1. Personal . . . . .	[59%]	[99%]	[50%]	[69%]
a. Correspondence . . . . .	48%	63%	45%	61%
b. Diaries . . . . .	1	—	1	2
c. Writings (also in ‘Other’) . . . . .	0.1	—	0.1	0.3
d. Other . . . . .	10	36	4	5
2. Corporate . . . . .	[41%]	[ 1%]	[50%]	[31%]
a. Minutes . . . . .	11%	—	14%	3%
b. Correspondence . . . . .	20	—	25	15
c. Reports . . . . .	4	—	5	5
d. Other . . . . .	6	1	7	7
	100%	100%	100%	100%
GENERAL CHARACTERISTICS				
Number of Articles . . . . .	50	26	24	9
Number of References (Citations) . . . . .	3635	1566	2069	788
Average Number of References per Article . . . . .	73	60	86	88

Based on some 3,600 references in fifty journal articles, about 28 percent of the references were to unpublished sources. This is nearly three times the percentage of manuscript references in McNally's study of footnotes in United States history, and in the study of British history referred to earlier. There are real problems in comparing these various studies—e.g., the British study counted only collections rather than documents. Any kind of accurate comparison between areas of history must await studies that count the use of manu-

script sources in a more or less standardized manner. Such comparability will be imperative if such studies are to have general educational value for archivists.

Of the unpublished references in my study, nearly 59 percent were to personal papers (although this figure must be qualified because of the as yet unresolved problems of how to count personal and corporate references). Of all the manuscript references, about 68 percent are to correspondence. There are few references to unpublished diaries. Eleven percent of the



manuscript references are to minutes of meetings, in which each reference to a different meeting was counted separately.

Items falling within the category of corporate reports and miscellaneous personal and corporate documents constituted about 20 percent of all manuscript references. This category should be a focus of archivists' attention. Without attempting to quantify the result, the following are some of the items that I classified in the personal miscellaneous manuscript category: drafts of a report and list, referee's report on a paper submitted for publication, manuscripts of scientific papers, laboratory and scientific notebooks, journals, lectures, data, notes and drawings, receipts, museum labels, circular, petition, statements and position papers, memorandum on conversation, and others.

Among the miscellaneous unpublished items categorized as corporate records are the following: notes, memos, by-laws, membership lists, orders, financial records, draft report, and others. I have not undertaken to analyze these varied references systematically; indeed there probably are not enough such references in this study for such analysis. Nevertheless, the analysis that has been done leads to the impression that even in citing miscellaneous unpublished sources, preference is given to more-or-less structured, prose documents, while items such as lists, data registers, unassimilated notes, and the like are less likely to be cited. One particular and significant problem in analyzing miscellaneous documents for the history of science in this way is the fact that notebooks, constituting an important segment of the general group, can take a number of forms or can serve several functions. Their essential characteristics are difficult to discern and to classify unless the notebooks themselves actually are described in the source. Scientists' notebooks, for example, can be merely registers of experimental or field data, or they can be running accounts of experimental procedures and their results. They also can

be scientific or intellectual journals or diaries in which the scientist makes note of ideas, copies quotations or bibliographical references, works out theoretical problems or experimental designs, and the like. "Notebooks" as a general category were not extensively used in the articles analyzed; but when they were, they sometimes appeared as central documents without which an article might not have been written at all. As might be expected, such notebooks are used chiefly for internalist history.

Of all the references in this study, about 46 percent are to published primary sources and only about one-quarter are references to secondary sources.

Some of the more interesting results of this preliminary investigation become evident when the analyzed publications are separated into those classed as internalist and externalist history of science. The difference, if not unexpected, is striking. The internalist articles had only 12 percent references to manuscripts, while 40 percent of the externalists' references were to manuscripts. The internalists, of course, are essentially intellectual historians, or historians of ideas, and they are commonly recognized as relying heavily on published sources.<sup>14</sup> They derive nearly two-thirds of their references from primary published documents, such as journal articles and books contemporary with their subject. When the internalists use manuscripts, they are more likely to cite documents among personal papers than are the externalists, whose references to unpublished material come equally from personal and corporate collections. Among forms of manuscripts, the use of correspondence is about equal among internalists and externalists. On the other hand, more of the internalists' manuscript sources fall within the miscellaneous (or 'Other') categories, especially from personal papers.

Finally, looking again at all the articles, those working on twentieth-century topics made the most use of manuscript sources,

<sup>14</sup> Walter Rundell, Jr., *In Pursuit of American History: Research and Training in the United States* (Norman: University of Oklahoma Press, 1970), pp. 101-2; Kendall Birr, "What Shall We Save? An Historian's View," *The Conference on Science Manuscripts, Isis* 53 (March 1962): 75.

56 percent of all their references. The great use of manuscripts by historians working on the twentieth century was due largely to the externalists. In fact, the twentieth-century internalists made slightly less use of manuscripts than did the entire group of internalists. These figures on twentieth-century science, however, are tentative, in that only eight articles analyzed for this study dealt with twentieth-century topics. This is, of course, particularly unfortunate, in that much of the concern of present-day archivists is with twentieth-century science. It is not clear what relationship nineteenth-century studies will have to the evaluation of twentieth-century documentation use, and again, this will be an important topic for future study by archivists and historians interested in scientific documentation and its uses. A study of differences in reference patterns for the history of different time periods would be of great interest, but must await a larger statistical base than there is in this pilot study. In addition to studying contrasting characteristics over time, it would be interesting also to study differing patterns of documentation in the history of different scientific disciplines, and in different aspects of externalist studies such as institutional history, history of religion and science, science and public opinion, and the like. Too few publications were analyzed for this study to allow any such detailed analyses, but these are questions that should be pursued, along with more analytical studies to examine the ways in which cited references actually are used in writing historical pieces.

### Questions of Historiography and Documentation: Some Speculations

It is generally agreed that internalists largely dominate the history of science field.<sup>15</sup> Despite attempts to bridge the gap,

internalist and externalist history still is in a state of co-existence rather than integration.<sup>16</sup> The divisions that characterize the historiography of science also appear to characterize patterns of use of historical materials as well. Without a revolution in the historiography, archivists are likely to go on serving two kinds of histories of science, both with quite different needs.

As part of this study, I analyzed also the references in three chapters in each of three recent books on the history of American science: Daniel Kevles's *The Physicists*, Margaret Rossiter's *Emergence of Agricultural Science*, and Garland Allen's biography of *Thomas Hunt Morgan*. My intention was to include these works with the general analysis of references, but when I realized that usually I had characterized the approach of these book chapters as a combination of internalist and externalist, they could not be counted in one category or the other. I cannot account for this categorization in terms of any prior bias of mine, and can only suggest that the combination of the externalist-internalist approach in the same work may be more likely to characterize book-length studies than articles. If more books are published, we may get more works linking the two approaches. It should be pointed out that the books analyzed cited manuscript sources more frequently than did either the internalist or the externalist articles. Possibly relevant may be the fact that both the Allen and Kevles books deal with twentieth-century topics, a manifestation of the same phenomenon tentatively suggested above, of greater use of manuscripts by authors of twentieth-century articles.

Projections for the future, or even identification of relations, at this stage are tenuous, perhaps premature. Nonetheless, in more extensive and sophisticated studies along the lines outlined here, investigators

<sup>15</sup> Thomas S. Kuhn, "The History of Science," in *International Encyclopedia of the Social Sciences*, David L. Sills, ed., 14 (1968), p. 76; Charles E. Rosenberg, "On Writing the History of American Science," *The State of American History*, Herbert J. Bass, ed. (Chicago: Quadrangle Books, 1970), p. 183.

<sup>16</sup> In 1968, Thomas S. Kuhn wrote that "Putting the two approaches [the internalist and the externalist] together is perhaps the greatest challenge now faced by the profession," Kuhn, "The History of Science," p. 76.

should consider the possibility that future book-length studies in the history of science may be more likely to integrate the externalist and internalist approach than have the more numerous journal articles. It is worth asking also whether work on the history of twentieth-century science might rely more on manuscripts than has earlier history, at least insofar as externalist aspects are concerned. On the other hand, the greatly increased bulk of published scientific literature could make internalist history, in its purer forms, even less dependent on unpublished sources. These are not conclusions of this study but merely thoughts generated by undertaking it, and are left for future investigation.

Whether or not any trend toward integration of externalist and internalist history of science is evident, insofar as historians of science have taken such a union as one of their primary goals archivists must contemplate inferences of such a union. Externalists traditionally use manuscripts more extensively than the internalists; if a closer union of the internalist and externalist approaches comes about, we should expect a greater use of manuscripts by the historians who would have confined their interests to narrowly defined internalist history and therefore to internalist sources alone. One task of archivists charged with the care of scientific archives must be to gauge how such a revolution in the historiography of science would affect the use of sources. Archivists also must consider the ways in which their practices can further the revolution itself.

### Final Arguments

In this paper I have tried to present the results of, and my reflections on, a preliminary probe with ramifications in several directions. Above all, the goal has been to explore the application of a research technique, used with benefit elsewhere, to the special problems of archivists and historians concerned with documentation for the history of science. The study has grown out of a concern both for history and for the work of archivists. The result shows that citation or reference analysis, applied to unpublished sources, has some unexplored

special problems. Some of the problems of definition and technique have been outlined above, and it is hoped that archivists will address them with care. Other considerations will emerge. Such reference or citation studies must relate in constructive ways to other kinds of investigations based on documentation use in institutional settings. It is irresponsible to consider only previous use when making appraisal decisions. But it is equally irresponsible to dismiss use-studies with the incontestable argument that appraisal decisions cannot be based solely on use. Our personal conceptions of use are factors, among many, on which appraisal decisions are made, whether we admit it or not. It is more constructive to try to give these conceptions some firm, objective base than it is merely to depend on individual impressions.

To maximize the effectiveness of reference analysis for the history of science, we need to see it as a dialogue, a bridge, between archivists and historians. Historians can learn something of professional craft by observing the ways other historians have consulted the universe of documentation and have integrated it into their historical studies. Archivists need to have a finger on the pulse of historiographical trends, to know what has been done and what the future seems to be. It is more than merely reacting. If we know what is used, and how, by knowing our collections or the universe of documentation, we also know what is not used. Archivists can never merely react to historians' demands. Citation analysis of manuscripts, if its special problems can be worked out by the mutual good judgment of archivists and historians, will help us to know better where our efforts should be placed, and will increase our opportunity to play a creative role in promoting the use of documentary sources that have not been of interest to historians in the past.

The archival profession, let us hope, will take up this challenge. In so doing, we need to expand greatly the breadth and depth of citation and other use-studies, well beyond anything presented here. We still know next to nothing, for example, about the ways in which manuscript sources actually are used when cited. Future stud-

ies will have to consider modes of use, the role of the reference in developing the story the author wants to tell. We also need to know what things the author read but did not cite, and the things he or she might like to have seen but did not, and why. Answers to some of these questions may come from studies of repository user-records, and to others perhaps by way of questionnaires or interviews with historians and archivists. Citation studies would play an important part in such a research program. Perhaps the chief contribution of citation or reference studies would be to help archivists and historians to understand better than we have in the past what the nature of scholarly research and writing truly is, and, especially, what part documentation and the custodians of documents play in the historical enterprise. Armed with these insights, we then can face with greater collective confidence those urgent demands beckoning the archival profession from an ever-growing mountain of scientific and technological records.

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