Medicine

ESTELLE BRODMAN
AND
MIWA OHTA

THE PERIOD SINCE WORLD WAR II has seen two especially important influences impinging on medical bibliography. One stems from the change in medicine from discipline-oriented research to problem-oriented research; the other from the growth of new technologies, such as electron microscopy, transistorized computers, or the use of radioactive isotopes. Medical bibliography, naturally, has been responsive to the new needs of medical research and practice; indeed, it has sometimes reacted automatically, without being aware of its new forms until they have become *faits accomplis.*

Problem-oriented Research and Medical Bibliography

Problem-oriented research. From the very beginning of medicine emphasis must have been placed on diseases, their cause, course, and treatment—if for no other reason than that the patient presented himself with a series of symptoms which could be called a disease. Yet simultaneously, from the very beginning, some minds must have sought the fundamental causes of all disease, the principles which governed the body at all times and at all places. Thus Empedocles and Democritus searched for the basic element or groups of elements which constituted all of life, and the quest for the Philosopher's Stone was an attempt to find the inward unity within the outward diversity of natural forms. From the Greeks to the present these two opposing views have held sway, with now one and now another of them being in the ascendant. It is curious also that this dichotomy should also appear in the two most widespread classifications of books: the Dewey Decimal System, which is "problem" oriented, and the Library of

Dr. Estelle Brodman is Librarian and Professor of Medical History, Washington University School of Medicine, and Mrs. Miwa Ohta is Reference Librarian, Washington University School of Medicine, St. Louis, Mo.

Congress system, which is "discipline" oriented. Thus, in the DDC the parts of the body are listed first (e.g. nose) and the disciplines by which these parts are studied (e.g., anatomy, physiology, pathology) are subdivisions under the anatomical parts; while in the LC classification the major breakdown is by discipline and the subdivision is by part of the body.

The change in emphasis in medicine from disease as an entity in itself to fundamental knowledge was due in large measure to the success of the German scientific method in the nineteenth century, and there is a distinct correlation between the importance given to this concept today in countries (like Japan) which accepted the German theory and countries (like England) which still cling in some measure to the older methods of clinical medicine. The nineteenth century German theory, that the proper study of disease was to be found in the autopsy room, the physiology laboratory, the anatomical theater, and the biochemical research institute, was successful in a pragmatic way. It could explain the symptoms in a meaningful way. Moreover, it could change the course of a disease or an epidemic, which the older studies of systems ("On fevers," for example) could not do. Its success brought it fame and disciples, until the pendulum swung so far away from the concept of disease as a problem of humanity that a reaction was inevitable. The past twenty years have seen such a reaction, one that does not deny the value of the method against which it has reacted, but merely changes its emphasis.

Problem-oriented medical bibliography. Bibliography in any field must, of course, follow the pattern of study in that field, and it is, therefore, not surprising to find that the nineteenth century medical bibliographies were aligned with the disciplines being studied at the time. Thus we had the *Zentralblatt für allgemeine Pathologie und pathologische Anatomie* (Berlin, 1890–), the *Berichte über die gesamte Physiologie* (Berlin, 1922–) and the *Ergebnisse der Anatomie und Entwicklungsgeschichte* (Berlin, 1892–). Just as inevitable today is the gradual evolution of *Excerpta Medica* (Amsterdam) from its earlier sections oriented to specific disciplines (e.g., Section 1, Anatomy) to its later sections (e.g., Section 16, Cancer, or Section 18, Cardiovascular Disease) which are oriented to disease entities. Other recent bibliographies which bear out this theory are *Mental Retardation Abstracts* published by the National Institute of Mental Health (Bethesda, Md., 1964–); *Leukemia Abstracts*

(Chicago, 1953–), *Multiple Sclerosis Abstracts* (New York, 1956–), and *Birth Defects; Abstracts of Selected Articles* (New York, 1964–). Using the potentialities of the MEDLARS computer, such indexes as the *Cerebrovascular Bibliography* (Bethesda, Md., 1961–) and the *Index of Rheumatology* (New York, 1965–) have followed the same pattern.

A further development of the problem-oriented bibliography is to be seen in the specialized "information centers" which have been growing up recently. These institutions are predicated on several bases: (1) that all literature must be looked at from the axis of the particular subject field involved;[1] (2) that the kind of bibliographic service needed by research workers in specialized fields requires subject specialists for analysis and synthesis; and (3) finally, that more individualized bibliographic service is required by a scientist than he can obtain under traditional conditions. In these information centers there is a mixture of the usual science librarians and laboratory and clinical science workers, with the librarians performing the traditional work and the more superficial bibliographic tasks and the scientists taking over where depth of bibliographic work and judgment not to be found in anyone except those engaged in research in the field is necessary. Examples are the Parkinson's Disease Center at Columbia University, the Brain Research Center at UCLA, and the Center on . . . Communications at Johns Hopkins University, among others.

In these centers the issuance of personalized "current awareness" services, bibliographies, reviews of the literature, and reports of meetings are a regular part of the work. By contract, a certain percentage of the time of the scientific investigator is supposed to be given to such tasks as abstracting pertinent articles, acquiring new literature, writing reviews, preparing thesauri and glossaries, and conducting seminars and meetings with other investigators. In many cases greater or lesser use of machine methods and commercial indexing and abstracting services is made. The great problem encountered by all who run such information centers, as reported at a recent meeting at UCLA and in a survey from Battelle Memorial Institute,[2] is to get the continuing cooperation of the scientists. These scientists apparently feel strongly that such centers are needed, that the more traditional bibliographic methods have broken down, that only scientists can find the answers to the dilemma—but consistently they themselves do not wish to be disturbed from their primary tasks of research and investigation

to do the more unglamorous jobs of bibliographic research, indexing, or abstracting on a continuing basis. They thus point up the demands set forth in the Weinberg report, that scientists themselves must take more responsibility for information handling. "We shall cope with the information explosion, in the long run," says the report,[3] "only if some scientists and engineers are prepared to commit themselves deeply to the job of sifting, reviewing, and synthesizing information . . . ." What many scientists seem to be saying is that such immersion in the information problem by scientists is needed, but it ought to be some other scientists, not themselves, who should be immersed.

Information centers on medical problems have been set up on a large scale so far only with the aid of government funds, primarily the National Institutes of Health, and it will be interesting to see if these institutions consider their worth great enough to continue to support them from their own funds, should the governmental aid be withdrawn.

It should not be forgotten, however, that many scientific societies in the past have attempted to set up less elaborate clearinghouses in their own fields, and have struggled valiantly over the years to provide scientists, practitioners, and laymen with pertinent information in their fields. Examples are the American Cancer Society, the American Diabetes Association, and the Mental Health Society. Over the years groups like these have produced bibliographies, "state of the art" reviews, newsletters, brochures, and pamphlets, some edited by staff at headquarters (using already existing libraries as bases) and some written by the scientists themselves. Because these voluntary agencies tend to work on shoestrings, they have not received the same publicity as the information centers, but over the past quarter century they have pioneered the way for transmission of much subject-oriented scientific information.

This change in the manner of looking at man's knowledge of health and disease has naturally placed new demands on medical bibliography, and new ways to meet those demands have been set up. Since both discipline-oriented work and problem-oriented work continue to be undertaken today, indexes to the literature have had to be provided from both axes. The old, large, well established, comprehensive tools, such as *Index Medicus*, *Biological Abstracts*, or *Chemical Abstracts*, have been continued to provide the first "cut" in knowledge in their fields. From them, portions of the totality of the literature have been extracted, however, which are then oriented to a particular problem

under investigation, or are reworked into different patterns or depth of coverage. Thus, the American Dental Association, the American Rheumatism Association, the American Cancer Society, or the Study Section on Cardiovascular Disorders of the National Institutes of Health can obtain recurring bibliographies from MEDLARS, which are in fact compilations of items found under specific constellations of subjects. These categorical groups can then index the items received to greater depths than is possible in the over-all index, can abstract all or a part of the items called to their attention, can publish review articles based on the material in these recurring bibliographies, or send out newsletters derived from them. We thus see side by side both the generalized overview of the entire universe of the science, for the use of those who need access to a wide conspectus of the literature from the point of view of discipline-oriented research, and the specifically designed medical bibliography, often derived from the first, which has a problem-oriented axis and a small group of users to satisfy. Only with the development of high speed computers, however, has it become economically feasible to do the search of the total literature once for two different groups, and this leads logically into the next section of this paper.

Automation

At the end of World War II, scientific reporting, which had been curtailed by military and economic necessity, resumed its earlier pattern. The number of new periodicals in the field of the biomedical sciences at first followed the growth curve of the 1930's, but within a few years several new factors arose to change the slope of this curve markedly. One factor was the shift in research, already discussed in this paper. When new disease entities were investigated as unitary problems, there came into being such journals as *Gut* (London, 1960–), *Nephron* (Basel, 1964–), *Circulation Research* (Baltimore, 1953–), *Thrombosis et Diathesis Haemorrhagica* (Stuttgart, 1957–) and *Arthritis and Rheumatism* (New York, 1958–) which attempted to focus on the needs of scientists in individual disease fields.

A second factor was the growth of science in countries which had not previously published much in these fields. Sir William Osler in the last decade of the nineteenth century commented on the dearth of scientific literature from Australia; [4] he would have been completely dumbfounded to learn of the burgeoning biomedical literature ema-

nating today not only from there and from Russia and Italy, but from such countries as Japan, Thailand, India, Argentina, or Nigeria. Here the multiplication of scientists united with pride of nationality to bring about the appearance of many new journals. In some countries where foreign exchange was difficult to obtain, also, scientists and scientific institutions sometimes published journals with indigenous currency, to use as exchange media for foreign titles which they could not otherwise obtain.

Finally, the enormous growth in federal research grants in the United States made many bits of research possible which might otherwise not have been undertaken or would have been carried out at a slower pace, had they been sandwiched in between other duties, such as teaching or medical practice. This put a large burden on already existing periodicals, which developed lengthy backlogs of accepted papers awaiting printing. Pressure was thus reinforced for the founding of new journals. Together with the natural tendency of groups working on the same topic to wish to form societies and communicate with each other, and with the growth of nationalism, the number of biomedical journals rose remarkably in the decade after the cessation of hostilities. *Biomedical Serials,* published by the National Library of Medicine in 1962, was able to identify 5,700 titles then in existence, probably a 100 percent increase from 1930. At this Library, also, 1,000 new journals were added to the collection each year from 1950 to 1960.[5]

Such a tremendous increase in so short a time soon overwhelmed the existing bibliographic apparatus and a number of ancient and honorable indexing and abstracting tools either fell so far behind they were not useful for current research, or else they ceased publication completely. New methods of coping with the "eternal flood of the literature" had to be designed; since this was the time when unit record systems were being enlarged and when the first generation of computers was growing out of wartime machines, it is not surprising that such methods began to be employed in biomedical bibliographical work. As early as 1948, under a contract from the then Army Medical Library, the Welch Medical Library at Johns Hopkins University was working on punched card control of medical journal titles. The *Current List of Medical Literature* in the 1950's and the early volumes of the present *Index Medicus* were interim attempts to mechanize the production of indexes to medicine, using Flexowriters and Listomatic cameras. It was not until 1960/61, however, that a totally new and

revolutionary method, employing electronic computers for composition, storage, retrieval, and printing of references for the *Index Medicus* was worked out. This new system was gradually put into operation, but it was not until May 1964 that the final piece of equipment, GRACE, the electronic printing device, was delivered and August 1964 that the first *Index Medicus* was printed on it, to finish the first phase of the original plan.

The system worked out for the *Index Medicus,* given the acronym MEDLARS (Medical Literature Analysis and Retrieval System), had as its basis the production of a printed index, with subsidiary goals the production of a number of recurring bibliographies, and the possibility of doing searches for individual scientists as demanded. In all cases it was designed to produce a printed list of references which the scientist could then study. The final product (a list) was thus the traditional output of all bibliographic services in the past: it was not designed to do new things, but to do old things better.

Earlier in this paper we mentioned the influence of new technologies and new instrumentation on medical bibliography. The electron miscroscope, for example, was an instrument which allowed scientists to look at the world from a new point of view, quite different from any which had been possible earlier. Just as the introduction of the light microscope in the seventeenth century excited contemporaries with the wonders of all about them, so in the 1950's scientists tended in some degree to follow the path of Leeuwenhoek, whose insatiable curiosity, assurance that there were wonders to behold in everything seen through the microscope, and delight in a new instrument, made him examine whatever happened to present itself to his eyes or his mind at the moment, with no discernible order or logic. In the mid-twentieth century it almost seemed as if the scientist with an electron miscroscope did not really care what he looked at, since all things, when viewed with his new technical device, would give him new insights into the unanswered questions of life. The result for medical bibliography was that journals appeared with the device as the unifying axis (for example, the *Journal of Ultrastructure Research*). In its pages were articles on tumors of all parts of the body, heart muscle, mitosis in somatic cells, and kidneys in health and disease, all held together by the use of the electron microscope. The subsequent publication of the *International Bibliography of Electron Microscopy* by the New York Society of Electron Microscopists (New York, 1950/55–1956/60) is an example of how medical bibliography

responded to new demands placed on it. Other unifying forces were to be found through biochemical methods for studying life, especially the use of the knowledge of RNA, DNA, and the genetic code.

To present scientists working with one technique with all the literature in which they might be interested, and obversely to see that knowledge of all the techniques available was passed on to those studying individual problems, became the concern of medical bibliography, and for this purpose it began to make use of a new technology (computers) in its own work.

Perhaps three areas stand out particularly in computer-based medical bibliography. The most important was undoubtedly the MEDLARS system, which was important both for what it did and what it did not try to do and for the lack of knowledge of many people of its goals. The second important facet of computer work in medical bibliography had to do with the production of indexes to abstracts through the use of KWIC (Keyword in Context; permuted title) indexes, which provided quick and fairly adequate interim guideposts to the literature encompassed in the basic tool. And finally, the third important area of medical bibliography touched by computers was the production of catalogs of single libraries in book form. The back-up use of computers for regular library routines such as serial check-in, circulation control, or fiscal accounting is not specifically oriented toward bibliography, and therefore will not be discussed here. The question whether future bibliographic tools will be reels of magnetic tape or disks with cathode ray display screens is still moot.

MEDLARS. The staff at the National Library of Medicine designed MEDLARS to produce the *Index Medicus* faster and with more depth of indexing than was possible by other methods. It was also planned so that it could do simultaneous searches for individuals better and more quickly than was possible by manual search of the printed indexes. Finally, it was meant to provide a series of recurring bibliographies for scientific groups to refine and to rework as they needed. It was never meant to produce data, only references to the data, and the philosophy behind it was that the published index was the primary purpose of its being and all else secondary to that. It was felt by the designers that centralized indexing and decentralized searching was the best pattern for medical bibliography's attempt to reach the largest number of scientists wherever they happened to be situated. Moreover, the traditional mission of the National Library of Medicine

since its real founding as the Surgeon-General's Library in the 1860's (to provide bibliographic control of the medical literature) was still felt to be operative. Unfortunately, however, these facts seem not to have been understood by many scientists, and may indeed have been slightly subverted by the need to obtain financial support from the government for continuation of the project.

The naive belief that in the very near future "computers will be performing library duties now done by human catalogers and researchers, not only in finding information but 'reading' books and teaching from their contents,"[6] unfortunately was accepted by many of the users of MEDLARS, and consequently their disappointment at its very substantial actual accomplishments has been great.

In addition, MEDLARS has itself had some very serious problems, which have slowed down its work greatly and hampered its complete development. Primarily, it was found that the caliber of indexing was not good enough for the sophisticated manipulation required by the system, and consequently lengthy attempts had to be undertaken for revising its subject heading list, finding new indexers with adequate scientific and linguistic backgrounds, and training those who were to become part of the system (whether for the National Library of Medicine itself or for the groups who would re-work the total product for their own needs).

Another problem resulted from the delay in the production of GRACE, the printing device which could take many fonts of type and many foreign languages; but more important than that was the apparent difficulty in finding money and personnel to do the demand searches envisioned for the system. Even now such search requests can only be accepted on an experimental basis, and they often take several weeks to complete. Whether money and position ceilings will be given to the Library for this purpose, as well as for the purpose of geographically widespread (8-10 in the United States has sometimes been suggested) satellited MEDLARS search centers, which would tend to alleviate the shortage of searchers in Bethesda, is, of course, unknown. The influence of the Vietnam conflict on the budgets of non-military governmental agencies is, however, likely to be important, and only time will show how serious will be the results.

Permuted title indexes. The computer has been used in scientific bibliography recently to help solve still another problem. Many abstract journals are read through completely by specialists in the field

they represent, or else the abstract journal is arranged by large subject areas, so that the reader can regularly scan the field of particular interest to him. This method of using the abstract tools is, of course, useful only for contemporary searching: the so-called "current awareness" needs of scientists who must keep up with the work being done in their field. When there is need to do a retrospective search—to learn what has been done in the past rather than what is being done in the present—then the abstract tools must be provided with indexes to their regular issues.

Under all the old systems, the production of author and especially of subject indexes of abstract journals was extremely time-consuming and costly, so that the index to the largest of these tools sometimes appeared only a number of years after the original and was extremely expensive when published. Naturally, this hampered research greatly, and in the early 1960's the computer began to be employed to provide an interim index for scientists.

Author indexes printed by the aid of computers were the first, and easiest, production. By the use of a system originally designed by Hans Peter Luhn, and which he named KWIC (the acronym for Keyword in Context), titles of the articles in the abstract were permuted and printed under each significant word. Perhaps the largest permuted title index has been published in conjunction with *Biological Abstracts;* in a world which delights in initialized words, it was probably inevitable that this should be named BASIC, to stand for Biological Abstracts Subjects in Context. *Bibliography of Chemical Reviews* and *Chemical Titles* are similar productions in the field of chemistry, and smaller permuted title indexes occur in other fields, such as the index to electroencephalography published by Elsevier. A whole series of computer-based keys to the literature is being projected by the American Chemical Society.

A natural question must have occurred to many users of these KWIC indexes and to those responsible for providing aids to the interchange of scientific information; namely, what relationship exists between automatic indexing done by computers in the above fashion and human indexing done in the traditional manner. Borko attempted to study this, using *Index Medicus* as his test case.[7] *Index Medicus* is made by humans who read (or at least scan) the articles under consideration and assign to them appropriate subject tags from a controlled vocabulary (MeSH, Medical Subject Headings). What Borko did was to take a portion of the same articles and index them by the

KWIC method, and then compare the results. He thought that he found a high degree of agreement between the two indexes, although some others in the field have not felt certain that the results were as meaningful as Borko thought. All agree, however, that as an interim index—until more complete, more consistent, and deeper indexing can be done—this method has proved to be a very valuable tool.

Science Citation Index. Up to recent times in the history of bibliography the only feasible way for a search of the literature to be made was from a retrospective point of view; that is, it was possible to go back in time to see what had been written by a particular subject, not forward. With the advent of the computer, however, the time-consuming task of listing the references at the ends of articles and sorting the articles on the basis of these references became reasonable. By doing so, it was possible to learn who had cited a particular person or publication, and thus one could go forward in bibliographic time. Given a key reference, for example, it was possible by this technique to learn of later references which cited (and therefore in some way depended upon) the key reference. People, and work done subsequent to the key item, could thus be identified and it was possible to follow an idea or the work of a man through the subsequent men or publications which expanded, added to, changed, or refuted the original idea.

Garfield,[8] who developed this idea, first attempted to produce such a citation index in a small field, genetics, and after that attempt was found to yield useful results, expanded it in 1962–63 for the publication of *Science Citation Index,* now appearing quarterly and indexing some 2,000 journals and books of multiple authorship in the manner described above. In addition, this material is re-used to provide continuous reporting of the pertinent references. Under the ASCA (Automatic Subject Citation Alert) system, all articles being entered into the *Science Citation Index* are searched under a key reference or a key author for a subscriber. When matching citations are found, the information is printed out and sent to the subscriber, who thus obtains the data within approximately two weeks of publication, instead of having to wait for the quarterly issues of *Science Citation Index* to appear. It is yet too early to evaluate this system, but work concerning it is being done by the Research Project at the Washington University School of Medicine Library and will be reported when enough data has been collected.

Miscellaneous. The bibliography of medicine has now become so large in itself that means must be provided for controlling it. New librarians and information scientists in biomedicine must be made aware of the rich background they inherit and the newer works being produced. As the group most responsible, the Medical Library Association has taken two steps recently which are meant to provide this aid. For some years now it has presented a series of refresher courses under its Committee for Continuing Education, one of which is devoted to new reference tools. It has also decided recently that it will bring out separately and quickly successive editions of the bibliography of reference tools and histories of medicine which have appeared in its various editions of the *Handbook of Medical Library Practice* previously. In this way new bibliographical tools will be called to the attention of its readers promptly and medical librarians will have a source of continuing data available to them.

In October 1965, the Congress of the United States passed the Medical Library Assistance Act of 1965 (P.L. 89-291). Provisions of the bill would lead to the hope that more and better bibliographical tools, especially reviews of the literature, will be forthcoming in the future. Even more hopeful, perhaps, is the money which might be provided for research into the methodology of biomedical bibliographic control, not only through the traditional printed form but through forms using newer technologies, such as the computer and the teaching machine. Although not bibliography in the narrow sense of the word, perhaps, research in the provision of original sources ("hard copy") for a reader at a distance—the end result of knowing where desired information is stored—may yield as much or more revolutionary results than producing bibliographies by means of computers. At present, such projects as long-line Xeroxing between two campuses of the University of California are being watched with great interest. Educom's work in this field should also be noted.

Conclusion. Medical bibliography has always been responsive to the needs of the group it is set up to serve. A study of the development of medical bibliography is, therefore, in a sense a study of medicine itself, particularly the way in which medicine has looked at the universe about it and viewed the means for increasing and using the store of man's knowledge. In the past quarter-century medicine has swung away from the static disciplines of past years to regroup its

forces on another basis, and medical bibliography has of necessity followed only a short distance behind.

Since medical biolography deals with the very stuff of life about it, it is influenced by and makes use of the materials, methodologies, and technologies around it. Ever since World War II the machines which have been developed for doing certain tasks faster or more automatically than had been done in the past have gradually been introduced into the work of medical bibliography. Continuing work on this matter is being undertaken, with some triumphs and some disappointments.

Even with all these machines, however, the knowledge of which one to use, of which product to search, and the best strategy of search must be learned by humans. In a changing world, the information gathered as a student cannot suffice for the rest of life, and with a realization of this fact, the Medical Library Association has accepted its responsibility for presenting continuing information to workers in the field of biomedicine. What influence the recently funded Medical Library Assistance Act of 1965 (P.L. 89-291) will have on medical bibliography is not yet clear, but much is to be hoped for in the next decade.

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