Science and technology

AN INTRODUCTION TO THE LITERATURE

DENIS GROGAN

FOURTH EDITION

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INTRODUCTION

This is a book written primarily for students, not practitioners. For the toiler actually in the field of scientific and technical information there are a host of excellent guides, as chapter 2 will indicate: this work is for the *would-be* practitioner, who has reached an understanding of the general sources of information such as encyclopedias and yearbooks and bibliographies, but now wishes to move on to the sources of scientific and technical information. Ultimately, in the field (or even in the classroom or seminar), he may well be required to concentrate his attention even more narrowly on a specific subject area within science or technology. It is hoped that this text will not only initiate him into the overall structure of the literature of science and technology, but will also prepare the way for just that kind of detailed study of constituent subject parts.

Of course, many experienced scientific and technical information workers were obliged to commence their study of the literature of their subject at the deep end, so to speak, inasmuch as they had to learn on the job, working with the literature and its users in an appropriate specialized library. And for a librarian to master the literature of a particular subject, such daily use is still the best and probably the only satisfactory method. But this haphazard approach is not only unscientific, it is inefficient, dependent as it is on the librarian gaining his acquaintance with the literature in a sequence determined by the random demands of enquirers. It is true that the requisite familiarity with the various documentary sources of information can be attained this way, but it takes far longer than it need.

The information workers of tomorrow, on the other hand, are given the opportunity to embark on the study of the literature in a more systematic fashion. As the students of today, not only do they commence with a basic course in general reference sources before progressing to scientific and technical literature, but they are encouraged to investigate the general structure of that literature before turning to more specific areas within the field. As novice practitioners in the library such students will of course still be faced with the need to come to grips with the detailed literature of their subject, but the hope is that they will be able to accomplish this more methodically and rapidly by virtue of their theoretical grasp of the overall pattern of the literature of science and technology. Perhaps even more importantly, such students should be particularly well placed to meet the challenge that will increasingly confront the future practitioner in all fields: rapid obsolescence of current knowledge and the advent of new physical formats as a result of accelerating technical advance.

It is hoped that there will be at least some practising librarians or information workers for whom this book will have an interest: those for example thoroughly familiar with their own special area, but who might appreciate the opportunity to take a more general view, or those learning on the job but seeking a more structured approach, or those contemplating or already embarked upon a change of subject field, particularly from the humanities to the sciences. Here I have been fortunate enough to be able to draw on my own experience over several years in supervising the day-to-day work of public service staff in a very large scientific and technical library.

The needs of the reader without formal scientific training have been kept especially in mind. A survey carried out in 1965 indicated that over a third of the staff employed in scientific and technical information work in the United Kingdom fell into this category, and the 'swing from science' in the schools and universities suggests that this proportion will increase. To take but one measure: though full-time students taking university courses in the UK in the decade of the 1970s increased by almost a quarter, the proportion studying science and technology (including medicine and agriculture) actually decreased by over 3%. For students (and indeed practitioners) lacking a scientific background it is of particular importance that they have the opportunity of examining the general structure of the literature of science and technology before exploring an area in depth.

It is popularly thought that the way a librarian studies the literature of a subject is to memorize as many authors and titles as possible. Ever since the library catalogue was invented, this has never been really necessary, but even in these days of vast and instantaneous computer memories, many (including myself) have been reluctant to shed their admiration for the traditional reference librarian's encyclopedic knowledge of his stock, and with Goldsmith's village rustics we still marvel 'that one small head could carry all he knew'.

However, a guide to the literature for a student demands a radically different approach from a guide to the literature for the user in the library. The latter is searching for information, and wants his guide to be comprehensive; the former is striving to understand the underlying pattern of the literature and needs a guide that demonstrates this by pointing to particular selected examples worthy of closer study. The object of attention is the general rather than the particular, or more precisely, it is the particular not for its own sake but only insofar as it represents an instance of the general. The zoology student dissects the dogfish not because it is the most important or even the most common of the fishes but because it serves particularly well as a representative of one of the group's two main types.

The wide selection of worthy publications enumerating and describing those scientific and technical reference books, bibliographies and data bases that librarians and others find useful makes it unnecessary here even to attempt to list basic titles. This is a teaching tool, and as the essence of teaching is selection, attention is concentrated on *types* of literature, and individual titles are normally listed merely as manifestations of those types. The student should of course endeavour to examine and study them closely as representatives of their class, but since they are merely examples chosen from many possible alternatives, he might gain an even more valuable insight into this particular aspect of scientific and technical communication if he identifies for himself in the library collections or information systems to which he has access similar instances of each type, and devotes his attention to these. Where a guide such as this has to endeavour to be comprehensive is in demonstrating all the *types* of scientific and technical literature a student might meet. Of course, once in the field, his task will be to build on this largely theoretical framework by identifying within each type no longer simply representative titles, but *all* those works within his chosen area which might be of value to their potential users in his library.

It would be superfluous in this book to rehearse the features of many of the titles quoted as examples. This has already been far better done in *Walford's guide to reference material: volume I, Science and technology* (Library Association, fourth edition 1980) and E P Sheehy *Guide to reference books* (Chicago, American Library Association, ninth edition 1976) and *Supplement* (1980), greatly strengthened in the pure and applied sciences chapters and now reinforced, despite the word 'books' in its title, with a separate chapter on computer-readable data bases. However, both of these guides concentrate on reference works, whereas much of the actual literature used by the scientist and technologist is non-reference material such as monographs and textbooks, as well as a whole range of non-book materials such as periodicals, patents, research reports, etc. Obviously, comment in the text on examples quoted from these categories is more appropriate, as it is with certain other groups of reference material such as British directories (covered only selectively by Walford) and reviews of progress (excluded by Sheehy).

It should be emphasized that this is a guide to the *literature*, and it is a mistake to assume that this is synonymous with information. It is an even graver error to underestimate the importance of non-documentary information in science and technology: a number of surveys have shown that 'live' sources (eg consultation with colleagues, attendance at professional meetings, etc) play a large part in communication. After all, in the last analysis, it is people who are the ultimate source of all knowledge. When he was a professor at Princeton President Woodrow Wilson used to advise his students 'I would never read a book if it were possible to talk half an hour with the man who wrote it'. A generation or more later J Robert Oppenheimer is reported to have said 'If you really want to communicate, send a man'. And quite apart from any other reason, the pace of development is such that in many fields any information that has got into print has almost certainly been overtaken by events. It has been rightly said that the main disadvantage of the literature is that it is history and not news. Nevertheless, it is equally foolish to sell short the printed word: this is to throw away cumulative human experience. In Carlyle's words: 'All that mankind has done, thought, gained or been – it is lying, as in magic preservation, in the pages of books'. Science and technology in particular are dependent on the printed word as a means of communication. Surveys have shown a surprising amount of duplicated research and general wasted effort due to disregard of the published literature. In a recent ten-year period 950 new antibiotics were reported in the literature: 250 of them were duplicate discoveries. Some years ago it was reported in Germany that 'Approximately two thirds of all patent applications have to be rejected because the alleged inventions fail to meet the novelty criterion and because the applicants were unaware that the problem they worked on had already been solved and the solution published.' But the lesson is slowly being learned: increasingly, for example, governments are recognizing that the primary scientific and technical literature is one of the few non-consumable national resources. R T Bottle reminds us that 'Measured in terms of the man-years taken to produce it, the chemical literature is the most expensive tool available to the chemist.' The vital role played by the literature has been highlighted in recent years by the mushrooming computerized information systems. These, of course, are 'literature-based', even though the data they store is encoded in digital form. As such it is quite incomprehensible and both input and output must ultimately take the form of alphanumeric characters.

The reader will not find here any advice on how to use libraries and library catalogues, or any account of classification schemes. No attempt will be made to instruct him in the answering of reference enquiries or in the compilation of bibliographies. He will not be taught how to carry out a literature search or construct a retrieval profile or interrogate a computerized data base. It is true that such assistance is given in many guides to the literature, and they are useful and indeed indispensable accomplishments of the 'compleat' librarian. This book, however, is written in the belief that personal service to the users of our libraries can best be improved by a more sophisticated approach to the literature by the librarian, allied to a more refined awareness of the user's needs. A much deeper understanding is required of the types of literature and of the special role of each type in the network of scientific communication. This has become an even more essential requirement with the advent of computerized data bases as part of the literature. Compared to the conventional sources in printed form, individual data bases are much more difficult to evaluate with regard to coverage, arrangement, indexing, accuracy, reliability, up-to-dateness, and all the other criteria of judgement that a librarian uses in studying an information resource. Their true role, too, *vis-à-vis* the printed literature, has still to be assessed. Of course the literature is only part of the pattern, but it is that part peculiarly within the librarian's domain and he should understand it fully. Merely to match subjects is to operate far below the optimum level of service. To provide 'something on' the topic the user is interested in is not enough. In their striving to satisfy user needs librarians have much to learn here from the scientific and technical publishers, commercial and otherwise: they do not just produce 'books' and 'periodicals' on a subject. They (and their authors) direct their productions at particular groups of consumers, personal and institutional: although somewhat similar to the casual glance, textbooks are really quite different from monographs, research journals quite different from technical journals.

The student will find that practically all of the examples chosen are in the English language: he will appreciate that this is a mere matter of convenience and that in many subjects there are vital works available only in other tongues. Again, for reasons of convenience, if no place of publication is cited with the publisher's name, it means that London appears in the imprint. Medicine has not been rigorously excluded: where a point can best be illustrated by a medical example it has been used. The lists of further reading appended to the chapters are deliberately highly selective, being confined to items thought to be of real value to the student, not too inaccessible, and capable of being read during a course of study. Although I have drawn extensively on the writings of others no attempt has been made to document every reference and quotation in the text: the reader's attention will not be distracted by what a *Times* reviewer once called 'the perpetual patter of tiny footnotes'; such excess of bibliographical scruple is out of place in a textbook for students.

It has been assumed throughout that the user of this book is familiar with *general* reference and bibliographical sources and the relevant terminology. He will not find, therefore, his attention drawn in the chapter on biographical sources to *Who's who* or the *Dictionary of national biography*, even though both works contain their share of scientists and technologists. *The British union-catalogue of periodicals* is not mentioned among the lists of periodicals for the same reason, although it contains the locations of thousands of scientific journals. And so on.

I owe a great debt to the authors of those classic guides to the literature of the various sciences and technologies, some of which are noted in chapter 2. They have been constantly consulted over the years during my own exploration of the field. It should be added, however, that practically all the works mentioned in the text I have personally examined, and in most cases made use of.

In the introduction I have written for each successive revision of this work I have had occasion to remark that such has been the pace of change in the literature of science and technology, even in the few years since the previous edition, that scarcely a page of the earlier text has remained unrevised – a minor instance, in fact, of that rapid obsolescence of current knowledge about which the student was warned in the introduction to the first edition. If anything this pace has accelerated over the last five years. To select only three of the more striking changes: by Act of Parliament the British patent system has been transformed; the quite amazing capacity of the videodisc is already being exploited for the storage of scientific and technical information; and the lethal combination of world recession and soaring inflation has placed the scientific journal in great jeopardy. Indeed, in the area where we have seen the greatest advances made, the computerization of abstracting and indexing services, the multiplication not only of data bases but also of producers, suppliers, vendors, hosts, brokers and intermediaries is rapidly nearing the point where it will no longer be possible to see the wood for the trees.

And while the scientists and technologists continue to be responsible for the proliferation of their literature, and indeed for new forms of literature, the systematic bibliographers, many of them librarians, attempt to keep pace as they have been striving to do since the sixteenth century.

I have been increasingly encouraged in my own strivings by the adoption of this work as a textbook in universities over five continents, which would suggest that its particular approach to its subject still fulfils a real need. I have been especially heartened by the many readers who have written from all over the world to express their appreciation, and I would like to take this opportunity to thank them.

Aberystwyth, August 1981 D J GROGAN

Chapter 1

THE LITERATURE

Einstein believed that 'The whole of science is nothing more than a refinement of everyday thinking'. The way this refinement has been achieved has been through the discovery and perfection of the experimental method – possibly the greatest contribution science has made to human progress. Indeed, several writers have claimed that science is no more than this method – the scientific method as it is sometimes called. Karl Pearson, the founder of the twentieth century science of statistics, claimed that 'the unity of all science consists alone in its method, not in its material'. This method holds good for all the sciences, and the technologies also, and is of course widely applied in other disciplines.

The implications for the literature of science and technology are so far-reaching that it is essential for the student librarian to grasp the elements of the method. The first step a scientist (or technologist) takes towards solving a problem is to collect all the information that may have a bearing on the question: this is the *observation* stage. He then formulates a tentative theory as to how such facts are to be interpreted: this is the *hypothesis* stage. He then designs and carries out a series of controlled tests to try to confirm his working hypothesis: this is the *experimental* stage. If findings of the experiments prove his theory correct he formulates his answer to the problem: this is the *conclusion* stage. Of course, it frequently happens that the working hypothesis does not stand up under experiment; T H Huxley called this 'the great tragedy of science – the slaying of a beautiful hypothesis by an ugly fact.' When this occurs the scientist must go back as often as necessary until he achieves a hypothesis that not only accounts for all the observed facts but can be confirmed by controlled experiment. This is the classic *inductive* theory of scientific method 'still taught to every generation of students'.

J H Poincaré, the French genius who dominated the world of mathematics in the late nineteenth century, once wrote: 'Science is built of facts, the way a house is built of bricks; but an accumulation of facts is no more a science than a pile of bricks is a house'. These facts, deriving from observation and experiment, have first to be communicated to the scientific community and then consciously integrated into the structure of knowledge. As John Gray and Brian Perry have recently reminded us, 'Science would not be science without scientific communication'.

Then, when a later scientist comes along, wishing to advance knowledge in his field, it is clearly vital for him first to discover what has already been achieved. He turns therefore to those records of observations and experiments left by his predecessors, the 'long avenues of carefully reasoned logical thought', to the literature, in fact. And when he in his turn adds to the archive by communicating his findings in a book or article he indicates the extent of his indebtedness by the references to previous work that he cites in his bibliography. As the Royal Society has proclaimed, 'Science rests on its published record', and it is this characteristic that allows Max Gluckman, the anthropologist, to define a science as 'any discipline in which a fool of this generation can go beyond the point reached by the genius of the last generation'. A century earlier Ernest Renan, the French philosopher, said much the same thing: 'The simplest schoolboy is now familiar with truths for which Archimedes would have sacrificed his life'. Even the great Sir Isaac Newton acknowledged: 'If I have seen further than most men it is by standing on the shoulders of giants'.

It should be pointed out that the classic description of scientific method just outlined is not universally accepted. Though the accretive, proven-fact view is still the most widely held conception of science, it has not remained without challenge from some philosophers of science, such as Thomas Kuhn, and especially Karl Popper with his 'searchlight' analogy of the human mind and his theory of conjectures and refutations. We must not forget the role of imagination and even intuition in science: J D Bernal pointed out that 'It is characteristic of science that the full explanations are often seized in their essence by the percipient scientist long in advance of any possible proof'.

The primary sources

The original reports of scientific and technical investigations make up the bulk of what is known as the *primary* literature. Some of these records may be largely observational (eg reports of scientific expeditions), or descriptive (eg some trade literature), or theoretical (eg much mathematics and physics), but most of these are accounts of experiments with findings and conclusions. A piece of research is not regarded as complete until the results are made available publicly, and it is a basic principle of scientific investigation that sufficient detail should be given to enable the work described to be repeated (and therefore double-checked) by any competent investigator. Before being added to the corpus of science all advances have to be critically assessed by a worker's peers. It was the irreproducibility of the experimental results published by Dr William Summerlin, an American immunologist, that led to his unmasking in 1974 in what has been described as the 'medical Watergate'. He was said to have inked black patches on white mice to simulate successful transplants.

These contributions then represent new knowledge (or at least new interpretations of old knowledge) and constitute the latest available information. They are published in a variety of forms:

1 Periodicals (many of these are solely devoted to reporting original work)
2 Research reports
3 Conference proceedings
4 Reports of scientific expeditions
5 Official publications
6 Patents
7 Standards
8 Trade literature
9 Theses and dissertations.

They also form the archive or permanent record of the progress of science, available to all, whenever they should wish to see it.

Many of course remain unpublished, and outside the mainstream of scientific progress, but do occasionally become accessible later in their original form, and are often consulted for their historical interest, eg

1 Laboratory notebooks, diaries, memoranda, etc
2 Internal research reports, minutes of meetings, company files, etc
3 Correspondence, personal files, etc.

By its very nature the primary literature is widely scattered, disconnected, and unorganized. It records information as yet unassimilated to the body of scientific and technical knowle . Although of vital importance, it is difficult to locate and to apply, and over a period there has therefore grown up a second tier of more accessible information sources.

Secondary sources

These are compiled from the primary sources and are arranged according to some definite plan. They represent 'worked-over' knowledge rather than new knowledge, and they organize the primary literature in more convenient form. By their nature they are often more widely available than the primary sources, and in many cases more self-sufficient:

1 Periodicals (a number of these specialize in interpreting and commenting on developments reported in the primary literature)
2 Indexing and abstracting services

3 Reviews of progress
4 Reference books, eg
  a encyclopedias
  b dictionaries
  c handbooks
  d tables
  e formularies
5 Treatises
6 Monographs
7 Textbooks.

In addition to repackaging the information from the primary literature many of these have the further useful function of guiding the worker to the original documents. In other words, they serve not only as repositories of digested facts, but as bibliographical keys to the primary sources.

Tertiary sources

It is possible to distinguish a less well-defined group of sources the main function of which is to aid the searcher in using the primary and secondary sources. They are unusual in that most of them do not carry 'subject' knowledge at all:

1 Directories and yearbooks
2 Bibliographies, eg
  a lists of books
  b location lists of periodicals
  c lists of indexing and abstracting services
3 Guides to 'the literature'
4 Lists of research in progress
5 Guides to libraries and sources of information
6 Guides to organizations.

Non-documentary sources

All the sources so far listed, primary, secondary and tertiary alike, take the form of physical documents. But neither information nor its communication require such material embodiment.

Not least because talking and listening are more congenial than reading and writing, such 'paperless' sources form a substantial part of the communication system in some disciplines within science and technology, as investigations by the Centre for Research in User Studies at Sheffield University have shown: 'personal communication is one of the most important means of transmitting information'. This is particularly the case during the innovation process: a classic example can be studied in the remarkable case history by J D Watson *The double helix: a personal account of the discovery of the structure of DNA* (Weidenfeld and Nicolson, 1968). A major investigation of physicists found that personal communication, at around nine hours per week, far outweighed all the other sources of information put together, a total of less than four hours. One classic United States survey found that more than half of all scientific communication is 'informal', prior to formal publication. More recently the Physics Information Review Committee confirmed this unequivocally: 'Informal communication is the means used for "first disclosure" of any sort, usually to close colleagues within a subject area or company. This can take place months, or even years, before publication'. It is clear that oral sources provide something that the others do not (and perhaps cannot):

1 Formal, eg
   - a government departments, central and local
   - b research organizations
   - c learned and professional societies
   - d industry, private and public
   - e universities and colleges
   - f consultants

2 Informal, eg
   - a discussions with colleagues, visitors, etc.
   - b 'corridor meetings' at conferences, etc.
   - c casual conversations, social gatherings, etc.
   - d telephone calls, which with direct dialling are increasingly replacing written correspondence.

Such oral communication is often more concentrated, more exclusive, more up-to-date, and more within the control of the actual participants. It can therefore be tailored to match the hearer, with the bonus of instantaneous feedback. The fact that it is so widespread has led Robert Fairthorne to conclude: 'This means that at any time the bulk of scientific knowledge is not yet recorded.' It is a fact that a lot of practical research 'know-how' could never be written down, such as special techniques, hints on the use of apparatus, or warnings about pitfalls in the application of certain methods. We are told that 'Every good laboratory has its wise man, who can tell you the answer to a practical question that may never have been discussed at all in the official literature'. Studies in Sweden have shown that young scientists commonly know fewer fellow-workers than their senior colleagues, and so they are warned how important it is to build up a personal contact network as soon as possible.

The price paid of course for the flexibility and convenience of these word-of-mouth sources is their varying reliability. Constraints of time and place impose limits on the actual amount of such communication,