the question. Perhaps we should ask what would Washington's dream be today for the late 20th and the 21st centuries? Perhaps what is needed now is not the university he envisaged, or that Hoyt desired and Eliot feared, but a university designed for the capital city in view of our whole system of higher education.

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BioSciences Information Service of Biological Abstracts

Abstracting and indexing provide input for a dynamic, computer-based information system.

Phyllis V. Parkins

The major abstracting and indexing services of the world are feeling the pressures of enormous changes. New tools and techniques for abstracting and indexing, long overdue, are becoming increasingly available in greater variety and with a wider range of applicability to tasks that have grown to unprecedented proportions. "Big Science," (*1*) "literature explosion," "information crisis," all are now familiar terms and aptly characterize the increased volume of research writings with which each of the discipline-based abstracting and indexing services has had to cope. And until recently, the problems of control of this literature have been approached by each service with tools and methods not vastly different from those available to bibliographers of generations ago.

The scientist, too, is demanding a change. He is finding it ever more difficult to sort out from the world's literature only that portion which serves his interests. The traditional publication of ever greater numbers of abstracts and their respective indexes is annually producing volumes whose bulk and weight alone cause serious problems for both the scientist-user and the librarian. In 1965 *Biological Abstracts*, for example, with its 24 indexed issues plus the first four issues of its new *BioResearch Titles* and the annual cumulative indexes, occupies in an unbound state about 3 feet of shelf space, and the total weighs nearly 79 pounds. When these publications are bound, the amount of required shelf space and weight will go up proportionately. The accumulated publications of Biological Abstracts in 1965 represent something over 130,000 research writings in the field of biology. And in 1966 the bulk will be even greater, for this year we plan to cover at least 180,000 biological articles.

But can the abstracting and indexing services respond effectively to the scientists' clamor for change? If so, what significant changes are taking place? Will they be disruptive? Or can a transition be accomplished smoothly, with no loss of continuity in maintaining the record of scientific research? Can the individual scientist soon hope to satisfy more fully his variety of needs for information? I believe that considerable light can be focused on these questions by a description of how one organization, Biological Abstracts, is adapting its thinking and operations to take advantage of certain new tools and methodology. What follows, then, will be a case history—a brief account of how Biological Abstracts has begun systematically to transform itself from a traditional, discipline-based abstracting and indexing service into a more dynamic and flexible information-processing and disseminating facility.

It should further this purpose to look briefly into the history of abstracting and of Biological Abstracts. I shall also describe the information requirements of the biological scientists and examine the Biological Abstracts information system as it now exists and as it is developing to meet these requirements. Finally, in the light of research in process, we can predict unusual and useful new services that should soon become available.

At this point, however, I should digress to mention one tangible, if superficial, change involving the name of our organization. Lest Biological Abstracts be thought of in terms of a tradition—no matter how beneficent—created over a period of nearly 40 years, it seemed desirable to make an obvious and formal distinction between the organization itself and its principal publication. It was largely to emphasize and project the idea of the increasing flexibility and growing variety of services of Biological Abstracts that the Board of Trustees elected to modify the name. Thus BioSciences Information Service of Biological Abstracts (BIOSIS) came into being in December 1964.

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Background

The history of abstracting goes back virtually to the beginning of the scientific periodical and is an interesting subject in itself (*1, 2*). But here let us consider only general trends in the way abstracting was accomplished. At first, abstracting was individually sponsored. A scientist who sensed the need often managed to bring widely scattered works, particularly those published in foreign languages, to the attention of his colleagues by condensing these contributions himself. He published the results, for the most part, in journals carrying original reports of research as well. In time, however, the volume of papers to be abstracted far outran the capacity of even an exceptional individual.

The second and much longer period saw organized groups of individuals preparing abstracts, usually under the editorial direction and scholarly supervision of the same sort of scientist who had formerly carried the often self-imposed responsibility alone. The organization of individuals into groups devoted to abstracting, informal at first, eventually developed into the hierarchical form in vogue at the time the earliest discipline-based abstracting services were founded in this country. Biological Abstracts, for example, founded in 1926 as a nonprofit corporation through the joint efforts and sponsorship of the AAAS, the Union of American Biological Societies, and the National Academy of Sciences, was headed by an outstanding botanist, J. R. Schramm.

The operation, housed at first in two rooms in the Zoology Department of the University of Pennsylvania, was small only in terms of size of staff. Although never prosperous, it survived and grew at the expense of a few dedicated staff members, through the support of many biological societies and individual biologists, and often through well-timed subsidy. Financial collapse was only narrowly averted on a number of occasions. Both the staff of Biological Abstracts and the many biologists who contributed abstracts, specialist editing, and even their personal funds at times, came to be resigned to the belief that a comprehensive abstracting and indexing service was a scholarly enterprise that could never be self-sustaining.

Many an academic or academically oriented institution, however, is discovering that without compromising its goals it can apply many of the principles of sound corporate management to its nonprofit, scholarly enterprise. Fortunately for the progress of Biological Abstracts, this more businesslike approach to managing its operations was taken some years ago. Under the direction of G. Miles Conrad for slightly more than a decade beginning in 1953, the organization managed to abandon the common practice of deficit spending; it adopted accounting methods more revealing of details of operating costs; priced its publications more realistically; and instituted economy measures to ensure the maximum achievement in view of the financial and less tangible resources available.

It requires little more than a glance at the chart, shown as Fig. 1, to recognize that from the year 1954 growth in publication output ceased to be irregular, beginning a steady climb at first and then rising quite sharply during the 5-year period from 1959 through 1963. This first rapid increase was made possible by grants from the National Science Foundation in overall support of *Biological Abstracts*, grants amounting to an average of $185,000 per year, an average of 25.8 percent of the annual operating budget of Biological Abstracts. The importance to Biological Abstracts of NSF's timely support during this phase of its development can scarcely be overestimated. It goes far beyond the mere amount of money involved. The organization used its available funds and facilities with very great efficiency and emerged, mature, to take its present strong position among the relatively few major, comprehensive, discipline-oriented abstracting and indexing services of the world. International recognition came in 1962 when Biological Abstracts was admitted to the International Council of Scientific Unions Abstracting Board as the English-language member representing biology.

Since 1963 Biological Abstracts has been building effectively on the substantial base it thus acquired. It has been able to provide full support from earned income (almost wholly from subscription sales) for its principal activity and product, *Biological Abstracts* and its several indexes. (It is interesting to note that almost 50 percent of the circulation of *Biological Abstracts* is foreign.) In both 1964 and 1965, less than 6 percent of the total operating budget was derived from outside sources. Comparison of production and budget figures of 10 years ago with those for the current year provides further evidence of the rapid growth and improved financial position of the organization. In 1956 the organization, with a total budget of $305,000, published 30,080 abstracts. In 1966, at least 120,000 abstracts are scheduled to appear in *Biological Abstracts*; 60,000 additional articles will be represented in *BioResearch Titles*; this year's budget totals slightly more than $1,500,000—an increase over the 1956 figure of about 390 percent. Our experience suggests that a comprehensive abstracting and indexing service, once it has achieved a certain size and stature, can support its central operations—exclusive of an extensive research and development program—largely from earned income.

Orderly growth, however, implies the need for differentiation, internal structural change, and organization, as well as an overall increase in size. Thus at Biological Abstracts rapidly mounting numbers of abstracts and the slow progress of manual indexing pressed us to search for new means and methods of indexing, preferably on a current, issue-by-issue basis. And in 1961, after much self-appraisal and study, we decided to abandon conventional manual subject indexing. In its place we adopted a computer-based index, a kind of editorially supplemented, permuted word-title index, to accompany each semimonthly issue of *Biological Abstracts*. The background and introduction of *Biological Abstracts Subjects in Context—B.A.S.I.C.*—has been described elsewhere (*3*) and need not be repeated here. Details of the application of "vocabulary management" have also been reported (*4*). To provide additional access to the information in *Biological Abstracts*, two other editorially prepared, computer-based coordinate indexes, the *Biosystematic* and *CROSS*, have since been introduced, the former in 1963, the latter in 1964.

Since 1961, as offspring of the computer-composed semimonthly and annual indexes, there has been a dramatic buildup of keys to the information contained in volumes of abstracts, stored on reels of magnetic tape. (Actually, taped indexes go back to 1959, since a 2-year gap in manual indexing was filled by *B.A.S.I.C.* cumulative indexes for these earlier volumes.) We were amassing a sizable bank of information on which we eventually could draw.

At the same time we were gaining valuable operational information in the form of statistical data—machine-generated figures, a sort of computer-fallout.

We initiated research projects to lead to the mechanization of our own records of the receipt of journals and abstracts, the activity of abstractors, and so forth. We initiated, also, an individualized manual abstract-search service and another service making individual subject sections available on microcards. And over this period we had been consistently increasing our coverage of the biological literature. By 1964 we were satisfied that Biological Abstracts was well stocked and prepared for further innovation and that we were ready to seek out and adopt means whereby we could exploit to the fullest the information assets we had accumulated over nearly four decades. Since the future would bring even greater stores of information to be utilized, it was a time for redefining goals and for systematic planning to meet our more immediate objectives, as well as those classed as intermediate and long-range.

Information Needs of Biologists

What biologists require and want must, obviously, take highest priority in planning by Biological Abstracts. The nature of biology and the broad scope of the information derived from biological research appear to place even heavier demands on a service supporting the life sciences than are placed on a similar service comprehensively covering the physical sciences. The multitude and variety of special interests in biology, many of which overlap, must be met with indexing to provide access to information by multiple and various routes, according to the need of an individual biologist. The problems of vocabulary and terminology are equally complex, reflecting the uneveness of development in research in various subfields of biology and ranging from colorful terms describing distress calls of the bottlenose dolphin to the more exact terminology reporting the physicochemical properties of ribonucleic acids.

With the cooperation and consultation of many biologists, and from our own experience, we have specified what appear to be the most significant information requirements of today's biologists. These are listed below, with no pretense of placing them in order of importance.

1) *Accessibility.* The biologist needs access to that particular portion of the expanding body of biological and related information that pertains to his interests. His interests may gradually or rapidly narrow, widen, or change in character; thus he requires large, comprehensive, and flexible sources of information that can continuously respond to any alteration in his interests.

2) *Speed and ease of access.* When the biologist needs specific information he should be able to satisfy this requirement with a minimum expenditure of time and energy. His information sources should be current and as close at hand as possible.

3) *Scope and depth.* The information needed by biologists ranges from a comprehensive survey of an entire field, or of one special subject, to specific detailed information such as the rate of ion transport of a particular substance across cell membranes, or the location of the type specimen of a certain plant species.

4) *Check on accuracy and reliability.* The biologist may need to know

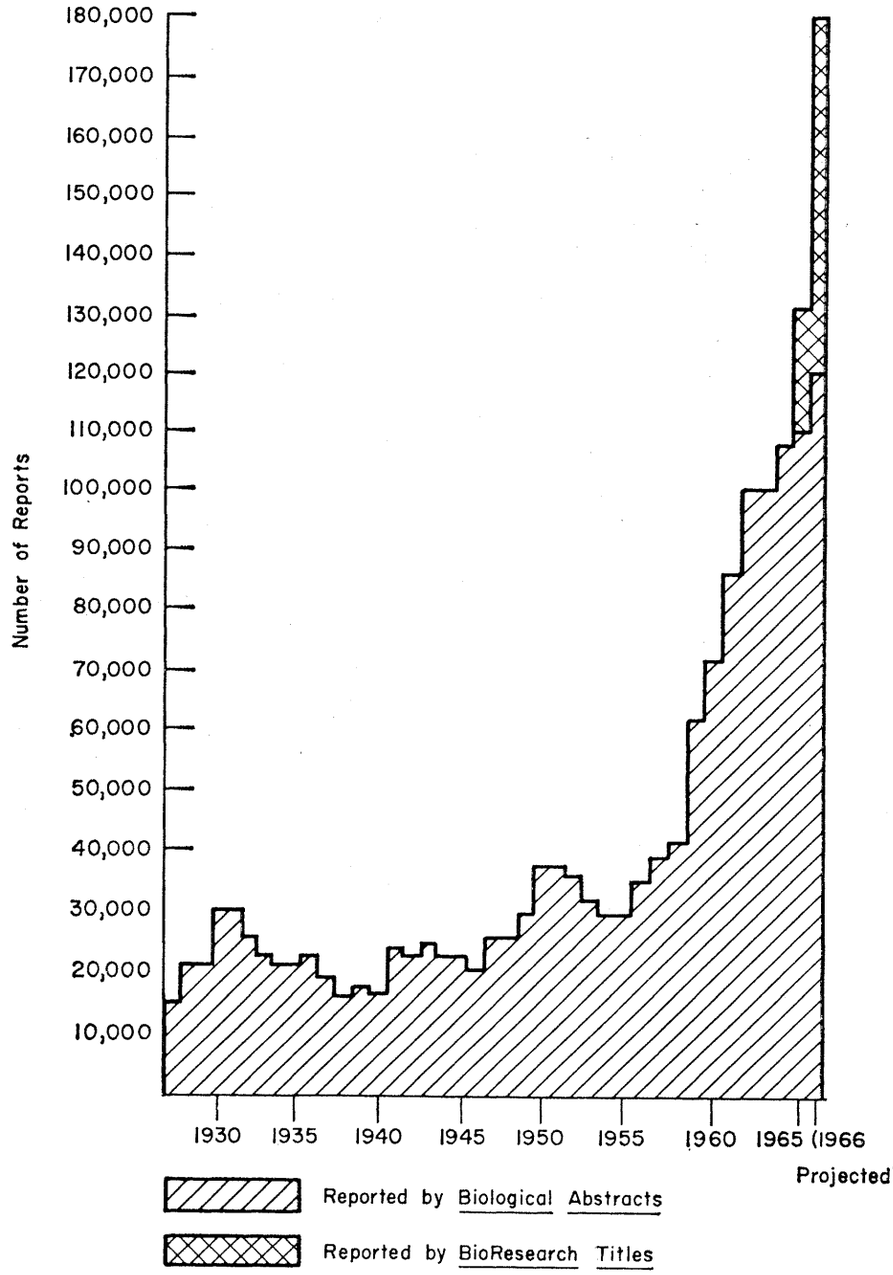

Fig. 1. Graph showing the number of research reports abstracted or indexed by BioSciences Information Service since 1926.

who obtained specific information and how it was obtained in order to evaluate its validity and soundness. He needs to know whether the information is hypothetical or speculative, or is demonstrated by unbiased, adequately controlled experimentation.

5) *Freedom in phrasing questions.* The biologist wants to pose his inquiries within the framework of his own technical language. He should not be asked to conform to fixed or unnatural terms or codes set by the system.

6) *Links with other disciplines.* The biologist frequently needs information routes into other disciplines; for example, as he chooses to use measurement techniques of the physical sciences in solving biological problems or to study biological phenomena by application of standard methods of other disciplines. Likewise, nonbiologists frequently need biological information in overlapping areas of interest. Since no sharp lines separate scientific disciplines one from another, the biologist should not be confined within sharply drawn disciplinary boundaries in his comprehensive information system.

7) *Sophistication in the procurement and use of information, and insight into his own information processes and requirements.* The biologist needs to understand what is currently available in the system as it evolves, what he can expect from it. He must be willing to participate by helping to evaluate its effectiveness or lack of it. He must make his reactions to the developing information system known, if the system is to conform to his requirements. Otherwise, he will find himself forced to tailor his requirements to fit the system.

Services in Operation

The next important question is what we are doing at present to satisfy the biologist's requirements. The answer is implicit in the services we make available but depends also upon the scientist himself, his ability and willingness to utilize what is provided. In effect, in our publications we are putting before him what might be termed a vast and varied information buffet or smorgasbord. It is at present left to the scientist to select and put together what pleases him and satisfies his appetite for information. The following, briefly described, comprise the services now available.

1) *Biological Abstracts,* published twice a month, is the chief publication. Each issue is accompanied by four computer-composed indexes, also cumulated annually: (i) the *Biological Abstracts Subjects in Context* (*B.A.S.I.C.*), which is a subject index to the contents of *Biological Abstracts.* The most important feature of this index is its reliance upon the author's own choice of terms for titles, supplemented by terms editors include, when necessary, to provide information in a number of specified categories. (ii) *Computerized Rearrangements of Special Subjects, CROSS,* coordinates all abstracts pertinent to each of 503 major and subordinate subject headings used in arranging published abstracts throughout an issue of *Biological Abstracts.* (iii) *Author Index* is an alphabetical listing for every author of papers abstracted or cited. (iv) *Biosystematic Index* groups all studies, regardless of their methodology or purpose, according to the taxonomic position of the organisms investigated.

2) *B.A.S.I.C.*, semimonthly, the subject index to *Biological Abstracts,* is available separately.

3) Microform publication. Each subject section of *Biological Abstracts* is available on microcards, issued semimonthly.

4) *Biological Abstracts* is available on microfilm on an annual subscription basis to subscribers to the printed edition.

5) *BioResearch Titles,* which is issued monthly, reports articles not abstracted in *Biological Abstracts.* It includes a permuted title index, a bibliographic section, and an author index to about 5000 titles per month.

6) One other, customized, information service is currently offered: abstracts on 3- by 5-inch cards. These abstracts may be ordered according to numbers specified by users, or may be supplied as the result of searching on certain words or subjects submitted by users.

Printed information tools, we have concluded, fill most of the biologists' information needs to some extent, and for some biological scientists they may be sufficient. And we must continue to publish *Biological Abstracts* and its indexes as long as their usefulness can be demonstrated. But in addition, the biological scientist needs more flexible, more responsive, and more readily accessible sources of information, to match his individual interest or combination of interests as they may change with time or circumstance. How could we make available in an even greater variety of ways and forms the content of the literature being abstracted and indexed for the published *Biological Abstracts*? We realized that we must increase our use of computer capabilities to extend still further the skills of our editorial staff.

The New Concept

By the end of 1964 we at Biological Abstracts had clearly envisioned a relatively simple system, schematically represented in Fig. 2, that could operate to make full use of the richly varied and sizable bank of information in the life sciences already accumulated and perpetually expanding with the publication of each abstract issue. By this time, indexes (averaging 15 entries per abstract) to nearly half a million abstracts that had appeared in *Biological Abstracts* were stored on magnetic tape. The number and variety of aspects of biological information being indexed represented important computer-references or files that could be manipulated by machine in numerous ways and combinations to enable us to prepare highly specialized or more general compilations of abstracts. This system provided the flexibility we had been searching for, the means by which we could further utilize our investment in *Biological Abstracts* to provide, as by-products, special publications and services to match special interests. It would enable us to provide future access to information, the need for which is not yet even foreseen.

This marks the point in the history of Biological Abstracts when the more descriptive name BioSciences Information Service of Biological Abstracts (BIOSIS) was adopted. The BIOSIS system concept, also, was formally accepted by the Board of Trustees at this time, and the decision was made to take the steps necessary to bring the system to its maximum operational capacity.

Developments within the BIOSIS system since these decisions were made in 1964 are highly encouraging, but they still remain in the planning and experimental stage. The first specialized *published* service, scheduled to be launched before the end of 1966, is a monthly abstract bulletin, *Abstracts of Mycology.* (The decision to publish this was reached after consulting with a number of leading mycologists.) Perti-

nent abstracts are selected editorially, as an integral part of the analysis that routinely produces the computer-composed *Biosystematic Index* to *Biological Abstracts*. From the abstracts appearing in each issue of *Biological Abstracts*, those dealing with Fungi will be sorted out by the computer, to be "repackaged" as a separate publication. What, in this case, is involved in sifting the literature of biology for a specific field may be illustrated by some figures. From a sample of only 18 issues of *Biological Abstracts* in 1963, a total of 3170 abstracts of mycology papers were printed under various subject headings such as enzymology, biochemistry, medical mycology, genetics, plant pathology, industrial microbiology, and chemotherapy. The papers abstracted were originally published in 651 different journals, a great many of them foreign.

The literature of mycology shows the highly diffuse distribution pattern typical of any subfield of biology. It is costly and difficult to locate the widely scattered sources of a specialty if one combs the world's literature for this field alone. It is altogether more efficient and economical to sort out reports pertinent to a special field when the literature in biology is already being comprehensively covered, as it is for *Biological Abstracts*. Thus, as the need and opportunity arise, we can and will publish a variety of additional special abstract bulletins as a by-product of *Biological Abstracts*.

By the same token we can sort out the contributions of biology to interdisciplinary problems; and as other discipline-based abstracting and indexing services are prepared to add their respective contributions, the special interdisciplinary or multidisciplinary fields can also be supported by information services.

The BIOSIS system's potential for providing *unpublished* information services is equally great and perhaps even more significant for the future. Consequently, much of our present research is being focused on this area. We believe that this type of service, based on a large and comprehensive bank of stored information, and developed so that an individual's request for information can be rapidly filled, offers the bioscientist his best hope for solving his information problems. It may take considerable time to achieve the volume of information output as well as the volume of use that will bring costs down to the level an individual scientist can afford. But for groups of scientists in industrial laboratories, in research institutes, or in academic insitutions, the general availability of services on a "demand" basis may be expected, by a conservative estimate, within the next 5 years. We are encouraged in this belief by the results of an unusual experiment that we have now been carrying on for more than a year.

The experiment, a limited one, was designed and is being conducted in collaboration with members of a research institute located at some distance from Biological Abstracts. A research staff of approximately 150 scientists whose biomedical interests vary widely can communicate directly, by means of special equipment, with a research and development team at Biological Abstracts. In reply to a question, phrased in the scientist's own terms, a search—partly manual, partly computerized—begins for pertinent abstracts. The search is based on the taped indexes from current issues as well as those published over the past 6 years, and corresponding abstracts on microfilm. Abstracts whose numbers identify them as pertinent to the question are quickly reproduced from microfilm and mailed to the requestor, usually within 24 hours of receipt of the question by Biological Abstracts.

In the course of this experiment, both the scientist-user group and we at Biological Abstracts are gaining much valuable knowledge and experience. Interestingly enough, the scientists have gained a new appreciation of the value to current biomedical research of information that can be gleaned from literature of the past. As a consequence of their discovery, in some instances, of the need to look even

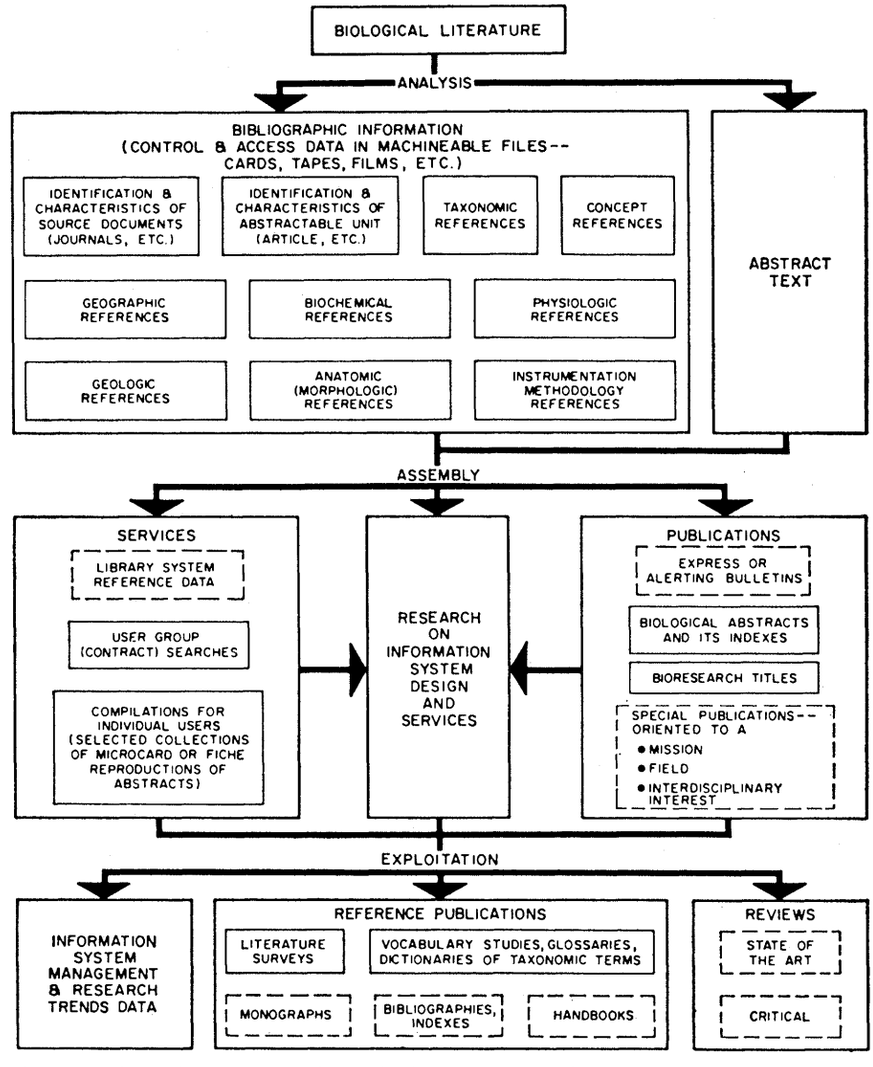

Fig. 2. Schematic representation of the system of information services proposed by the BioSciences Information Service. The elements shown in solid boxes are already in use. Those surrounded by dashed lines have yet to be implemented.

farther back—beyond 1959, where computer-based indexes to *Biological Abstracts* begin—we now intend to produce similar indexes to all abstracts, more than a million and a half, published from the start of Biological Abstracts in 1926. It may even be desirable to prepare such indexes for our forerunners, *Botanical Abstracts* and *Abstracts of Bacteriology*, which go back to 1917.

Finally, again referring to Fig. 2, let us consider the variety of services and reference works of more lasting value that may be derived from or based upon the periodic abstract publications and services that are more highly valued for their currency. It is obvious that we can give substantial aid to those who prepare state-of-the-art or critical reviews, by saving them from the time-consuming, exhaustive searches essential to their project. As natural by-products of computer operations, word lists, frequency counts, and summary numerical data of many other kinds are generated. With proper programming, many revealing correlations and coordinations can be made by the computer. Compilations of references or of abstracts and indexes pertaining to a given subject are also possible, and might be profitably issued on an annual basis, for example. As is true for the current published and unpublished services, what is ultimately produced, with what frequency, and for how long, must be dictated by the needs of the scientists whom it is our mission to serve.

The Present Era

Thus the third era in abstracting and indexing is upon us today. An organized abstracting and indexing facility, serving one of the major scientific disciplines, must now view its entire operation, present and future, as constituting a subsystem of the total communications system that supports the discipline as a whole. Futhermore, since disciplinary borders are becoming less and less distinct, each separate, discipline-based information system must be prepared to interact at its boundaries with any other comparable disciplinary systems. It is in part the growing realization of the implications of this that is stimulating the thinking, planning, operations, and research efforts of traditional discipline-based abstracting and indexing services. Pressures, both internal and external, are increasing for more rapid development of plans and programs to make possible the eventual integration of disciplinary information systems to comprise an information network as broad in scope as science itself.

Summary

The major abstracting and indexing services of the world exist today in an environment of constant change as they tool up, plan for, test, and to some degree already put into effect new and untried projects and procedures. They see the necessity and the opportunities for playing a larger and more active role in the dissemination of scientific information. The publication, in the traditional manner, of ever greater numbers of abstracts, reflecting the explosive growth of scientific literature, is providing, also, a basis for a wide variety of information services, tailored to fit group or even individual requirements. We at Biological Abstracts are seeking and finding new and more active means to draw upon the large inventory of information that rapidly accrues in the abstracting and indexing of the world's biological literature. Our active research and development program has as its objectives the further development and refinement of an information system for biology—dynamic, more flexible, responsive to changing needs of biologists, and combining the scientific skills of a competent staff with the capabilities of computers. This system, we believe, must have as its goal the capability of reacting readily with similar information systems supporting other scientific disciplines, not only in this country but throughout the scientific world.

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