Communication problems in biomedical research

REPORT OF A STUDY

SIX OF THE STUDY PAPERS

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February 26, 1965

MEMO to Task Force Alumni:

Enclosed is a combined reprint of the NAS-NRC report and of the six papers giving the results of studies that contributed to the report. Taken as a whole, it represents the first comprehensive statement of the facts and the problems of communication in biomedical research.

Requests for reprints are coming in at an astonishing rate; the number of foreign requests is particularly surprising. Thus far, almost all are from scientists. After the papers have been abstracted, we can expect to hear from the documentalists and librarians.

Unlike NIH and NLM, the Medical Library Association has paid us the courtesy of providing some "feedback." Dr. Brodman, the President, wrote to Vern Pings, who submitted the NAS-NRC report to MLA for consideration, saying that their Board of Directors had considered the report and asked her to report their conclusions as follows:

"1. We are going to try to work out meaningful statistics for biomedical libraries, as recommended in your paper, and we have already begun, with NLM help, and will see if we cannot include other organizations, such as the American Dental Association, in our deliberations.

2. We have already set up mechanisms for studying the problem of microforms and their control. The Committee on Bibliographical Projects and Problems is being asked to make recommendations on this.

3. Training. This is a subject which the Association, especially the Committee on Continuing Education, and the National Library of Medicine are working on presently, but which we feel sure will require much further work.

We will be getting in touch with you in the future as developments occur."

If you want some more copies, ask Dr. Lee for them. The Federation has 400 copies, of which they will distribute a hundred or so to their lists and sell the others. They gave me 200 to answer "gratis" requests, and it appears that this number will be inadequate.

R.H.O.

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Communication problems in biomedical research: report of a study[1]

DIVISION OF MEDICAL SCIENCES, NATIONAL ACADEMY OF SCIENCES–NATIONAL RESEARCH COUNCIL *in cooperation with*
FEDERATION OF AMERICAN SOCIETIES FOR EXPERIMENTAL BIOLOGY AND INSTITUTE FOR ADVANCEMENT OF MEDICAL COMMUNICATION

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FOREWORD

IN THIS ISSUE is the final report of a broad study of "Communication Problems in Biomedical Research" made under the auspices of the Division of Medical Sciences, National Research Council. The Federation participated in this study, which represents the first such inquiry to be focused specifically on the biomedical research effort, private and governmental. With the approval of the National Institutes of Health, the sponsor of the study, the report, slightly abbreviated, is being published here in the belief that its findings will interest a large number of biomedical scientists. The basic premise is that the biomedical communication system can best be guided by the active and informed participation of those whom it serves. Some of the major recommendations call for changes that only those directly engaged in research can effect through their individual and collective action. Others concern policies and specific services that directly or indirectly influence the major channels of communication in the research community.

The original report was supplemented by a collection of eight staff working papers prepared during the course of the study, seven of which were intended to serve as factual background for the development of conclusions and recommendations. These papers summarized, in rough form, the results of some of the intensive substudies the staff undertook in an attempt to marshal as much relevant data and information as possible with the time and resources available. The staff paper versions of the investigations performed in support of the Academy's study have since been extensively revised and supplemented with additional data and analyses. Four of the articles that resulted are published in this issue, and two more are scheduled for the November–December issue. Although each can stand alone, they share a common conceptual framework; and together they provide an objective, quantitative description of the communication system serving biomedical scientists which, though tentative and incomplete, helps to define more clearly the strengths and weaknesses of this system. The authors of each paper are those staff members and consultants who took primary responsibility for gathering, analyzing and describing the material of the paper.

M. O. LEE
Managing Editor

Introduction

It has been aptly said that new scientific knowledge is increasing much more rapidly than any other product of society. Many scientists have expressed their belief that the present problems of communication within the scientific community are critically different from those of the past. Because this outpouring of information results directly from the great expansion of research that has been instigated and financially supported by society, it is not surprising that society also has begun to be concerned. Specifically, the question is being asked whether the new knowledge is being transferred as expeditiously as it might be to those in a position to use it in the public interest.

Pressures for action to improve communication in science are developing in both the legislative and the executive arms of government. For some time, the Senate Committee on Government Operations has been probing and exhorting. Meanwhile, the Federal Council on Science and Technology has been working to improve the exchange of scientific information among the many government agencies involved in research, and the Office of Science Information Services of the National Science Foundation has been encouraging the systematic study of problems in communication and the search for more efficient methods of processing scientific information, as well as promoting cooperation among all activities, both private and governmental, that handle scientific information. The President's Science Advisory Committee initiated two broad studies that led to reports containing specific recommendations for action.[1] Although these studies attempted to cover science as a whole, their general recommendations were influenced primarily by conditions in the physical sciences and associated technological fields. The Public Health Service issued a report dealing directly with the biomedical sciences and the health professions.[2]

Initiative, however, has not by any means been confined to the agencies of government. Within many quarters of the scientific community there has been a parallel increase in concern and activity. Sessions devoted to the problems of scientific communication,[3] committees to seek solutions, and society action programs have become common.

As an extension of these and other efforts to assess and strengthen the information resources of science, the Director of the National Institutes of Health, in October, 1962, invited the Chairman of the Division of Medical Sciences, National Academy of Sciences–National Research Council, to organize and conduct "a broad examination and assessment of the problem of communication among working scientists in the biomedical area." Subsequent conversations indicated that the Director was thinking of an intensive study that would develop, in the space of a few months, some basic considerations that would be helpful in shaping national policies with respect to improving the biomedical communication complex, i.e., the aggregate of all information activities serving biomedical research. It was therefore agreed that the proposed study should have limited objectives. First, it should be confined to "scientist-to-scientist" communication, recognizing that better communication between working scientists and professional practitioners and between scientists and the public are urgent social needs worthy of separate study. Second, the study should survey the broad potentialities and implications of modern information technology, rather than attempt to evaluate specific applications in information processing that are already being actively investigated by other competent groups. And third, the importance of encouraging the flow of biomedical information across national, linguistic, and cultural boundaries should be acknowledged, but emphasis should be placed on the problems and needs of the generators and users of biomedical information in the United States, and on actions relating to the American biomedical community.

If anything more than a superficial survey were to be made within the imposed time limit, it was evident that the Division would need the help of organizations already knowledgeable in the field of biomedical communication. Accordingly, the cooperation of the Federation of American Societies for Experimental Biology (FASEB) and the Institute for Advancement of Medical Communication (IAMC) was sought and has been given without reserve. The Office of Documentation of the Academy–Research Council has also been most helpful. Dr. Richard H. Orr, Director of IAMC, accepted responsibility for the design and conduct of the project and for the assembly of a small group of expert consultants to undertake special studies on a part-time basis. An outline of a program was quickly developed and the study was formally launched on January 1, 1963, with a target date of the end of October, 1963, for completion of the report.

Shortly after the staff work began, an Advisory Committee was appointed under the able chairmanship of Dr. Maurice B. Visscher. The members were selected to be broadly representative of the biomedical field and on the basis of an avowed interest in questions of scientific

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[1] Task Force to the President's Special Assistant for Science and Technology (James H. Crawford, Jr., chmn). *Scientific Technological Communication in the Government*, April 1962.

President's Science Advisory Committee. *Science, Government, and Information: the Responsibilities of the Technical Community and the Government in the Transfer of Information.* A Report. Washington, D.C.: The White House, January 10, 1963.

[2] Public Health Service. Report of Surgeon General's Conference on Health Communications, Nov. 5–8, 1962. Dept. of Health, Education, and Welfare, Feb. 1963.

[3] One example in the biomedical field is the symposium, Biomedical Information, held by the Federation of American Societies for Experimental Biology in April 1963. *Federation Proc.* 22: 973, 1963.

communication. The function of the Committee was to guide the staff studies, to review the results, and, on the basis of these and of the opinions and judgment of its members, to develop a statement of principles, conclusions, and recommendations.

Within the limitations of time and of staff, the study was designed to achieve the following objectives: *1*) to survey the existing complex of information services, and to consider the degree to which it constituted a coherent, functional system (including not only such formal channels of communication as meetings, journals, indexes, abstracts, and reviews, but also informal, person-to-person communication); *2*) to analyze past and current studies of scientific communication in terms of their pertinence to the biomedical field; *3*) to collect data on the biomedical information services and the communication habits and prejudices of biomedical scientists, and to collate views on ways of improving the existing biomedical communication complex; and *4*) to identify basic principles and derive conclusions, as guidelines for private and governmental agencies responsible for promoting biomedical communication, distinguishing between actions that may appropriately be taken forthwith and those that require further study or testing on a pilot scale.

The findings were summarized in a brief report, supplemented by a compilation of staff working papers, and formally submitted to the Director of the National Institutes of Health. The report is published here with only minor revisions of form. Those who have worked on the project hope that it will be of interest to those engaged in biomedical research and to the specialists in communication who seek to serve biomedical research.

R. Keith Cannan, Director
Division of Medical Sciences, National Academy of Sciences–National Research Council, Washington, D.C.

STATEMENT OF BASIC CONSIDERATIONS

A. NATURE OF THE PROBLEM

1. The Problem is Real and Concerns Both the Public and the Scientific Community

Communication in science, as in most human affairs, has always been and always will be a problem. The past two decades, however, have witnessed changes that aggravate this chronic problem of science. Not only has the output of new scientific information increased, but also the horizons of the traditional scientific disciplines and the ways in which research is conducted and administered have changed profoundly. These developments have combined to impose on the national resources for scientific communication severe stresses that are both quantitative and qualitative.

Most scientists today acknowledge that the communication problem is real and important, but relatively few feel that the situation is so critical as to call for crash programs or precipitate massive innovations. The general demand is for continuing intensive study and experimentation; and the scientific community has, accordingly, approached the problem conservatively by expanding established forms of communication and by evolving and testing new forms.

Today, however, scientific communication is no longer the concern of scientists alone. It is a problem in the public domain. Now that society has adopted research as an important instrument of national policy, the scientific community must accept the obligation to satisfy the public that the massive social investment in research is being soundly managed. Some of those responsible to the public for the nurture and surveillance of the research effort have become fearful that the social returns on the investment are being delayed by inadequate communication of the results of research to potential users. This concern has also been voiced by individual scientists in all fields.

The community of science must examine critically its ability to continue to manage and improve its own communications. Unless the scientific community shows more concern for this problem, it is likely to lose some of its traditional control over the forms of its communication.

2. The Problem is International, but National and Regional Initiative Will Speed Progress

Because science is not constrained by national or cultural boundaries, scientific communication must be international in its scope, and free exchange across geographic and language barriers must be encouraged in all practicable ways. The promotion of cooperation and innovation at the international level, however, is a slow and deliberate process. Progress can be accelerated if functional national and regional scientific organizations will put their own houses in order and take the initiative for international action.

3. The Problem is Science-wide, but the Realities of the Present Organization of Science and its Communications by Disciplinary Groups Need be Considered for Effective Action Toward Improvement

An ideal system of communication would embrace all of science. Science is largely organized and managed, however, by disciplines and in disciplinary groupings, not only professionally and institutionally, but also with respect to sources of support. Inevitably, these disciplinary groups have developed channels of communication to meet their own particular needs. To make the most of the communication resources they have developed, and to prevent disruption of their communications, the disciplinary groups must play an active role in the development of the new and expanded services required to handle the growing volume of scientific information.

4. *The Biomedical Community is a Functional Disciplinary Grouping Appropriate for Initiating Action to Increase the Efficiency of its Communication Channels*

The life sciences constitute a rational segment of science and, within the life sciences, the biomedical sciences are a coherent group identifiable by their own professional and institutional organizations, by common conceptual foundations, and by particular obligations to the health and medical services of society. Like other disciplinary groupings, the biomedical community has evolved its own communication channels. It is appropriate that this community assume the initiative in designing and implementing the changes required to serve its special communication needs. Although it seems best, for practical reasons, to approach the problems of scientific communication at the biomedical and national levels, it is of the utmost importance that means should be developed to improve interdisciplinary and international coordination of these partial efforts so that the intellectual unity of science may be sustained.

B. NATURE OF SCIENTIFIC COMMUNICATION

1. *The Functions of Communication Services are Broader Than Mere Transmission of the Results of Research*

It is sometimes implied that the primary need for good communication services is to ensure that the final product of research shall be expeditiously incorporated into the body of current scientific knowledge. This is a narrow view. Scientific communication fertilizes research at all stages in its conception, development, and fulfillment. The kinds of communication services that the scientist requires change with the progress of his investigation.

2. *Scientific Communication is an Intellectual, not a Mechanical, Process*

The problem of improving scientific communication should not be conceived as chiefly one of finding more efficient means of switching "facts" from points of origin to points of use. The problem is much more complex and elusive than this. Intrinsically, scientific communication is an intellectual interaction between individual minds. It is personal and intimate. It has an evanescent quality and is loaded with value judgments. Conceptual scientific communication in particular requires a degree of resonance between sender and receiver that cannot be ensured by efficient switching devices. Any service that is to aid this process should be so designed as to accommodate these subjective attributes of the process.

3. *The Complex of Activities Contributing to Scientific Communication is Only Partly Formalized*

Studies of the scientific communication complex and efforts toward its improvement have tended to concentrate on the formalized channels and tools of written communication, such as journals, bibliographies, abstracts, and reviews. Recently, the formalized oral communication represented by the structured part of meetings has received some attention. The working scientist, however, does not depend on these formal channels alone. Much of his essential communication, whether oral or written, is informal and is achieved through impromptu exchanges on a person-to-person basis by conversation and correspondence. In the operation of the communication complex and in the design of communication services or "systems," these informal means of exchanging information should be given due weight.

4. *The Need is for Better Rather Than More Information*

The power of science grows by the continuous reordering of knowledge in the light of new information and concepts, rather than by mere accretion of "facts." The mounting output of biomedical information calls for a more rigorous winnowing of the wheat from the chaff—a more severe control of quality—and for greater emphasis on viewing new information in the perspective of the old. Such control and critical evaluation should be exercised at all stages of the communication chain, from generator to user. Only biomedical scientists can perform these vital functions of science.

5. *Communication Requirements Vary With the Individual Scientist, His Role, His Field, His Project, and His Environment; This Variety Must Be Accommodated by the Complex of Information Services*

A scientist may play many roles in the biomedical scene. At one time or another, he may be investigator, practitioner, teacher, evaluator, administrator, or manager. What information he requires and how he wants it will vary with his role as well as with the field of his inquiry, the nature of his problem, the progress of his investigation, and the intellectual environment in which he is working. An effective biomedical information complex must be comprehensive and flexible enough to respond to the changing requirements of the individual scientist and to accommodate the wide variety of biomedical investigations and investigators without imposing on all the patterns peculiar to any one. An information service that attempts to be all things at all times to all scientists is likely to be satisfactory to none.

6. Modes of Communication and Types of Information Service Useful in the Physical Sciences Are not Necessarily Appropriate for Biomedical Research

The range of functions that the biomedical communication complex is called upon to perform is much the same as that in any other area of science. The environment of biomedical research, however, is distinctive in many respects. The fact that biomedical investigation is focused on the nature of living processes imposes unique restraints upon experimental approaches and unique levels of complexity on the ways investigators organize their thoughts and vocabularies and pursue their studies. Large organized programs of research are the exception and the technical report, which plays so important a role in engineering and in areas of the physical sciences that are oriented toward technical development, is a relatively unimportant channel for biomedical communication. Biomedical research, moreover, is conducted mainly in academic institutions and is rooted in individual initiative. For these reasons, new forms of communication and new types of services that serve other scientific communities effectively will not necessarily be appropriate to, or of comparable usefulness in, the biomedical sciences.

C. DESIGN AND MANAGEMENT

1. The Biomedical Community Should Retain Responsibility for Managing its Communication Complex

In the past, the community of biomedical scientists has been largely responsible for evolving and managing its own information services. This is natural inasmuch as the biomedical investigator is the primary generator, evaluator, and user of the information generated by the biomedical research effort. The vast expansion and the professionalization of this effort in recent years has greatly magnified the task of processing documents and information but has not created any critically new situation that justifies relieving biomedical scientists of this responsibility.

2. Today's Communication Problem Requires New Relationships Between Biomedical Scientists and Professional Information Processors in Their Information Services

The traditional handlers of scientific information—editors, librarians, and publishers—have been recently reinforced by new types of information processors between generators and users—documentalists, computer engineers, information system designers, audiovisual experts, document analysts, and other kinds of specialists. Despite the efforts of the most able processors of both the traditional and the newer types, however, the communication complex cannot function efficiently without the active and educated participation of the generators and consumers of the information. The mounting loads and demands on this complex can be met only by intimate cooperation among generators, processors, and consumers. Those who process biomedical information must be integrated into the biomedical fellowship.

3. Tomorrow's Communication System Should be Developed From the Present Complex by Judicious Introduction of Innovations

It is sound policy to build upon the communication complex that now exists and has been proven by experience. Major innovations should be incorporated only after they have been tested for acceptability, efficiency, and compatibility with other components of the complex.

4. Effective Coordination is Necessary to Transform the Present Complex into a System That can Perform as Required at Reasonable Cost

An ideal system for biomedical communication would provide any scientist with the information he needs, when and where he needs it, and in the forms best suited for his use. The existing complex of services comprises many interdependent organizations, activities, media, and languages that must be integrated into a coherent system if these requirements are to be approximated. At present, mechanisms for effective coordination are poorly developed. Both the over-all performance of the complex and its efficiency in terms of returns for expenditure of manpower and money suffer. Better coordination is necessary to ensure complementarity and compatibility between journals, abstracting services, and libraries, as well as among libraries and among abstracting services. The argument for coordination is not, however, an argument for a monolithic master plan. There is need for flexibility and plurality in information services. There is a place for some redundancy and for some services that repackage information to serve particular groups and individuals.

5. A Comprehensive Communication System Requires Services for Information Processing as Well as Document Processing

A comprehensive biomedical communication system must include not only document processing—the systematic distribution, storing, and cataloguing of documents so that they reach those likely to be interested and may be retrieved readily on demand—but also the collection, evaluation, digestion, synthesis, dissemination, and retrieval of items of information selected from documents and other sources. This information processing begins where the processing of documents leaves off and requires a different type of processor. Compendia, critical tables, and review articles represent traditional types of information processing. These are and will continue to be of great value to science. These forms do not, however, completely meet today's needs for specific information on demand. Recently a number of services have been established that provide users, on a continuing or demand basis, with items of information in a narrowly defined field. These services have come to be known as Specialized Information Centers. Those services that also undertake to provide expert evaluation of the quality, validity, and significance of the information proffered qualify as Specialized Information Evaluation Centers of the type recommended in the Weinberg report.

6. Authors and Editors Must Participate to Make Document and Information Processing More Efficient

Efficiency in processing documents and information for ready retrieval and use requires close cooperation between the generators of information and those who carry out the processing operations. Authors and editors must accept a responsibility for presenting new material in forms that facilitate indexing, abstracting, evaluation, and synthesis.

7. Modern Technology Should Be Exploited With Full Appreciation of its Promise and Problems

Modern information technology, including intellectual techniques as well as mechanical and electronic equipment, by saving time and manpower, can contribute significantly to making better services possible. Mechanization of clerical operations can greatly expedite storage and retrieval of documents. Every effort should be made to exploit these new techniques in biomedical communication. Future technological developments hold the promise of automating completely some types of information services, including operations now considered to be intellectual as contrasted with mechanical but it should be recognized that the transition from partial mechanization to complete automation may carry the danger of reducing the flexibility previously provided by men in the processing chain. Efficient mechanization and automation will require a greater degree of coordination and compatibility of services than now exists.

8. Local Biomedical Libraries Are Logical Channels for Access to Total Resources for Document and Information Processing

Services are more readily adaptable to individual needs and are more fully used if they are in immediate contact with the scientist. A coordinated network of strong local libraries and information services, linked to the large national and regional libraries and to other centralized information services, will provide the channels through which a scientist can tap national resources yet retain the advantages of dealing by personal contact with a local service.

D. SUPPORT: FUNDS, RESEARCH, AND MANPOWER

1. The Biomedical Community Previously Exercised Control of its Communication Complex by Holding the "Purse Strings"; Ways Must Be Found to Preserve Control as Public Subsidy Increases

In the past, biomedical information services have not, in the main, been a public charge. This is a healthy tradition that should be maintained as far as possible because it provides the best assurance that the biomedical community will continue to control its own communications. With the great expansion of scientific information in recent years, however, it has proved impossible to maintain some of the essential communication services and to meet some of the demands for new and improved services on the same basis as in the past. The sponsors of research have found it necessary to subsidize many services performed by private organizations and to establish and operate themselves a number of new services, some of which are intended primarily to serve their own managerial needs. The necessity for research sponsors to support communication services will probably increase as biomedical literature and the size and complexity of the biomedical research effort continue to grow. In this situation, it is essential that new mechanisms be developed to preserve control by scientists and ensure that elements of the complex do not become autonomous and poorly related to the community functions they are intended to serve.

2. Research on Scientific Communication Can Speed the Total Biomedical Effort; It Should Be Generously Supported and Recognized as a Scientific Endeavor in its Own Right

Research on the means and processes of communication can make a very significant contribution to the national biomedical effort. Generous support is warranted, both for investigations and pilot projects that seek to exploit advanced information technology for biomedical communication services and for basic inquiry into the functions served by communication processes. Equally important for bringing the best talent to bear on the problems of biomedical communication is the recognition of communication research as an endeavor in the same scientific tradition as the more traditional lines of research.

3. Mounting Demands for Trained Personnel to Provide Services and Conduct Research in Communication Require Recruiting and Training Programs Best Based in Academic Institutions

There presently exists a shortage of trained personnel to man existing biomedical communication services. Any large effort to improve and diversify these services will intensify the demand. A sustained effort in recruitment and in the provision of a variety of training programs is required. There is need to recruit personnel whose major experience has been in biomedical investigation or instruction and to train them in the techniques of handling documents and information. There is need, also, to acclimatize librarians, documentalists, and other types of specialists in information handling to the concepts and practices of biomedical investigation. Both types of training are best provided in an academic atmosphere where education is associated with research in communication. Graduate schools for the biomedical sciences, with their local communication services and their university environment, can supply this atmosphere but will probably need to be subsidized if they are to develop the needed facilities.

Although the required numbers of personnel are smaller, recruiting and training programs for research in communication are equally critical. The ideal atmosphere for these programs is also the biomedical graduate school.

CONCLUSIONS AND RECOMMENDATIONS

A. RESPONSIBILITIES OF THE BIOMEDICAL COMMUNITY

In the catalogue of Basic Considerations that has been presented above, repeated emphasis is laid on the principle that the biomedical community must continue to play an active role in the conduct and management of its communications if the quality and usefulness of the scientific record is to be maintained. These responsibilities should be accepted not only as an obligation to science and to society, but also as a challenge to scholarship. A large segment of the biomedical community does accept this obligation and challenge. Many others, however, are reluctant to serve as teachers, editors, referees, critics, or evaluators of the literature in the fear that these responsibilities will be a burdensome distraction from their own investigations.

1. Community Action

There is a need to diffuse more widely among scientists an appreciation of the principle that the nurturing of good communications is an intrinsic and rewarding part of the advancement of knowledge, a hallmark of scholarship, and a stimulus to creativity. A need exists also to extend greater academic recognition and prestige to those scientists who willingly contribute thought and effort to the improvement of scientific communication and to the members of those professional groups that operate information services for the benefit of scientists. Participation in the communication process should be more widely spread over the expanding biomedical community so that the burden on individual scientists will not be onerous and the fellowship of science will be enriched.

2. Individual Action

Much can be done by individual scientists to improve the existing channels of communication and prepare for the introduction of new types of information services.

a. In their role as instructors, scientists should place more emphasis on training their graduate students in oral communication and the use of visual aids, in the writing of original papers, in editing and abstracting, and in the preparation of critical reviews and bibliographies. There is need also to train students more adequately in the use of libraries and of other information services and to encourage them to explore the potentialities of modern information technology. All these activities should be introduced to students as intrinsic elements in the life of a mature investigator. Instructors should be alert to identify the occasional student who evinces an unusual interest in problems of communication and should encourage him to pursue these problems as worthy intellectual endeavors.

b. In their role as investigators, scientists should seek to cultivate a closer fellowship with the staffs of the institutional libraries that serve them so that a spirit of mutual participation in research by the generators, users, and processors of information may be cultivated. Libraries will be encouraged thereby to seek to improve and diversify their services in ways that will be most responsive to the needs of individual investigators.

c. As members of faculties, scientists can promote the importance of local scientific communication services at the administrative levels of their institutions and can press for more adequate support of institutional library services.

d. As members of national advisory groups, scientists have the opportunity to encourage sponsors of research to promote the study of problems in communication and to explore the potentialities of new proposals.

e. As members of editorial boards, scientists should also seek to improve coordination, to maintain high standards of quality, to accelerate publication, and to reduce costs. They should cooperate with the Conference of Biological Editors and with other private and governmental organizations in seeking these ends.

B. FACILITIES AND SERVICES

The following conclusions and recommendations pertain to improvements and innovations in information services and facilities.

1. Meeting Announcement Services

The Library of Congress, the Department of Health, Education, and Welfare, and other governmental and private agencies provide information on forthcoming meetings of interest to biomedical scientists in addition to the meeting notices printed in many professional journals. *Science* and the *Journal of the American Medical Association* publish particularly extensive lists of future meetings. International meetings are covered by the Council for International Organizations of Medical Sciences. These announcement services are steadily improving but do not cover all meetings.

A national clearinghouse of information on biomedical meetings should be established in an appropriate institution such as the National Referral Center for Science and Technology of the Library of Congress. Those who sponsor or support meetings should ensure that the organizers of these meetings inform the clearinghouse of plans and programs.

a. Open meetings. The proposed clearinghouse would provide any meeting announcement service with information on open meetings to supplement that from their own sources and would also, on request, provide organizers of prospective meetings with information on possible conflicts or duplication.

b. Closed meetings. Attendance at many biomedical meetings is limited to invited participants. Support for many of these closed meetings is sought from funding agencies, which, if they are to program effectively and to avoid undesirable duplication, should have means of learning whether related meetings have recently been held or are under consideration. The proposed clearinghouse would provide this information.

2. *Translation Services* (see also sections B.8.*b.* and *c.*)

a. National translation clearinghouse. Although the past few years have seen the development of several private and governmental centers that maintain lists of existing translations of scientific documents and provide copies of translations on request or inform potential users about where these translations may be obtained, the completeness, speed, and ease of use of the service provided by these centers leave much to be desired.

The Public Health Service (PHS) should assume leadership to ensure that an effective national clearinghouse is developed for the biomedical community by working with the National Science Foundation (NSF) to improve one of the existing clearinghouses. To avoid the expense of paying for translations that have already been made elsewhere, biomedical libraries and information services should be able to learn quickly from such a clearinghouse, by mail or faster means, whether a desired translation is available elsewhere.

b. Local translation coordination centers. All libraries of institutions conducting biomedical research should act as local translation "coordination" centers to which biomedical scientists could turn first when they need translations. Libraries should be organized to perform the following functions in response to a request: find a translated abstract; determine whether any of the institution's staff have the required language and subject-matter proficiencies; arrange for partial translations by local staff; search lists of translations that have been made elsewhere and, if the desired translation is available, obtain a copy; contract with commercial services for translations that cannot be accomplished by local staff, that are not listed as available, or that are urgently needed; and register any translations made or ordered locally with the national translation clearinghouse.

3. *Audiovisual Services* (see also sections B.10.*a.* and *b.*)

For biomedical information recorded in audiovisual form, the National Audiovisual Facility of the Communicable Disease Center of the PHS should be developed to the point where it is analogous to the National Library of Medicine (NLM) as a central resource for such records and a compiler of "tools" for their retrieval.

4. *Specialized Information Evaluation Centers or Services*

The term "specialized information evaluation center" (SIEC), or "service" if decentralized, should be used to designate a service available to scientists on a national or international basis that performs one or both of the following functions for a field of research and development: evaluation of the quality, reliability, or validity of information; and synthesis of information extracted from a number of documents or other sources. Providing this type of service requires the participation of scientists who are themselves actively engaged in research in the given field.

By this definition a number of existing services qualify as specialized information evaluation centers (or services), for example, the *Handbooks of Biological Data* compiled under the auspices of the Federation of American Societies for Experimental Biology, the American Physiological Society's continuing series of *Handbooks of Physiology*, and periodicals devoted to critical reviews, as well as less conventional services, such as the Psychopharmacology Service Center of the National Institute for Mental Health (NIMH). Existing services of this nature should be supported and strengthened once their quality and utility have been established.

Currently there is considerable enthusiasm for establishing new centers to handle unpublished and published information in active biomedical research areas and to provide service that emphasizes currency, speed and responsiveness to inquiries by individual scientists. The value of this type of SIEC, when properly conceived and organized, has been established for certain areas of engineering and the physical sciences. However, since such centers are expensive in terms of both money and research manpower, and since biomedical research has distinctive characteristics, this concept of service should be adopted with caution in the biomedical field pending the outcome of pilot projects. Agencies funding biomedical research should support by contract a limited number of carefully selected pilot projects for a 3- to 5-year period, with built-in provisions for objective evaluation. Special attention should be given to ensuring that such centers utilize to the optimum the services of existing document processing services, such as the Medical Literature Analysis and Retrieval System of NLM (MEDLARS), rather than duplicate their work.

Although not designed specifically to evaluate this concept of information service, experience with the National Clearinghouse for Mental Health Information now being developed by NIMH, and the National Clearinghouse for Drug Information planned by the PHS, will also provide information useful in assessing the promise and problem of SIEC's in biomedicine.

5. *Specialized Information Centers*

This term is currently used very loosely; at one extreme it is used as equivalent to SIEC, at the other it denotes a collection of documents specialized for a particular area of research and organized to provide rather conventional library services to scientists on a national or regional basis. Several hundred services in the United States have been identified, to which this term in the broad sense might be applied. Currently the National

Science Foundation is encouraging the development of objective methods for evaluating the quality and utility of the variety of services offered by such centers. Although there are undoubtedly areas of biomedical research that could profit from the services of centers that attempt to collect all available information in a given area (published and unpublished) and that organize documents so that they may be retrieved in highly sophisticated ways, in general the greatest promise seems to be in centers that process information rather than documents and that make possible true information retrieval, by providing scientists with the specific items of information they want rather than referring to documents that may contain the desired information. This type of service may consist of publishing a "tool" that assists such information retrieval, e.g., the *Index-Handbook of Cardiovascular Agents*, or of answering specific inquiries, e.g., the *Cancer Chemotherapy National Service Center of the National Cancer Institute.*

Like SIEC's, this type of center is expensive in money and scientific manpower. Although scientists actively engaged in research may not be necessary for this type of information processing, a high level of scientific competence is required. Support for existing and new centers of this type should be governed by the same consideration as for SIEC's.

6. Local Biomedical Libraries

The libraries of academic and research institutions represent a vital component of the biomedical communication complex. This component has, however, deteriorated progressively from lack of support while the demands on it have steadily mounted. If institutional biomedical libraries are to function as local information service centers through which the scientist can tap the total national resources for document and information retrieval, and if scientists are to obtain the documents they learn about through the more efficient reference retrieval services that are being rapidly developed, strengthening this key component of the complex must have the highest priority.

An effective program to repair the damage resulting from years of neglect, and to transform biomedical libraries into modern information service centers, will require substantial financial support as well as efforts to train personnel, to develop new and improved types of services, to establish standards of service, and to elevate the status of libraries in the academic environment. (see sections B.2.*a*., C.4, D.2.*a*., and E.1.) For the short term, this support should be in the form of direct grants-in-aid to academic libraries in amounts sufficient to enable each to improve substantially and rapidly the quality and scope of its services and to enable all to meet certain minimal standards of service. This aid should supplement, not replace, regular institutional support. For the long term, means must be found to ensure that these libraries are adequately and continuously supported so that they may provide a high level of services to biomedical scientists. This may require the routine allocation to library services of a set percentage of research funds received by biomedical institutions.

7. Interlibrary Loan Services

The load on the interlibrary loan network of the biomedical information complex has been increasing steadily and promises to mount sharply with the imminent advent of new and improved reference retrieval services. The capacity of this network is seriously strained at present and is grossly inadequate to meet the loads of the next few years. Pending the results of a special study (see sec. C.4.*b*.) of ways to improve this network and the establishment of effective monitoring of the traffic in this network, immediate steps should be taken to provide short-term support for this network by subsidizing the interlibrary loan services of academic and other nonprofit institutions.

8. The National Library of Medicine

As the central resource for the network of biomedical libraries and information services, and as the major indexing service in the biomedical field, NLM is the hub of the entire document retrieval component of the biomedical communication complex. NLM is to be congratulated on the careful planning that has gone into the MEDLARS program and into increasing the coverage, currency, and quality of *Index Medicus*. The biomedical community and all agencies concerned with biomedical communication should give NLM full support in its efforts to improve its services, which are indispensable to the effectiveness of the present complex and to its future development.

NLM is at present considering many plans for new types of bibliographic services. The following represent endeavors worthy of special attention:

a. It is essential for the biomedical sciences to have a single, master bibliographic tool that is truly comprehensive and sensitively reflects the changing scope of biomedical research. NLM should be encouraged to broaden the coverage of *Index Medicus* and MEDLARS to encompass the total output of U.S. biomedical research, beginning with that supported by National Institutes of Health (NIH) and other governmental agencies, regardless of whether the form of publication is a journal article, book, technical report, or other type of document, and irrespective of whether the document is covered by another indexing service. Indexing performed by other services could be accepted if compatible with MEDLARS and suitable for the biomedical community.

b. NLM, in consultation with the National Federation of Science Abstracting and Indexing Services, should be encouraged to seek out gaps and deficiencies in the abstracting coverage of biomedical literature and to assume leadership in seeking to close these gaps and correct any deficiencies. (see section B.9., C.3., F.2.) Particular effort should be made to ensure that all substantive foreign literature is being abstracted with reasonable promptness. The current NLM program to improve abstracting coverage of Russian literature as well as that in other languages commanded by few American scientists is an excellent step in this direction. Eventually, it may be desirable to include for each biomedical document stored in the MEDLARS system either an abstract or information on where abstracts of the document may be found.

c. NLM currently supports the publication, in widely circulated journals, of translations of Russian articles carefully selected by editorial referees. This program is an excellent way of introducing to the U.S. biomedical community relatively unfamiliar and neglected segments of the foreign literature. NLM should be encouraged to extend this concept to other foreign-language material that is also unfamiliar to American scientists.

d. NLM should utilize the full resources of the Federal Library System (the Library of Congress, National Agricultural Library, etc.) and endeavor to fill, in this way, requests by libraries for biomedical documents not held by NLM.

e. Although, in the MEDLARS program, the terminology of requests for subject searches will be used as a guide for revising and updating the subject headings used for indexing and producing *Index Medicus*, NLM should be encouraged in its efforts to establish continuing mechanisms whereby the community of research workers can participate directly in developing new subject headings and revising outmoded terminology.

f. NLM should ensure that the biomedical community and its libraries are aware of recent changes in the policy of the Defense Documentation Center (formerly the Armed Services Technical Information Agency, ASTIA) that make available to all grantees and contractors of the PHS the center's services for searching the technical report literature and supplying copies of reports.

g. Depository for unpublished documents. There is a growing need for a mechanism whereby voluminous tables and other details too lengthy to include in published papers can be made available to the relatively few who need this type of material. Pilot trials of new forms of publication, in which copies of documents are furnished on request (e.g., see sec. B.10.*c.*), also require a similar mechanism. Therefore, NLM should examine the question of a proper depository for such "unpublished" documents that would deliver the documents rapidly and inexpensively, and should decide whether the biomedical field should use the present depository service provided by the Library of Congress or establish one elsewhere.

9. Specialized Abstracting and Indexing Services

Aside from the broad, inclusive abstracting and indexing coverage recommended in sections B.8.*a* and *b.*, the most pressing need is for a special study to develop standards for abstracting and indexing services (see sec. C.3.) and for a program to continuously monitor biomedical abstracting and indexing (see sec. F.2.). In the meantime, support of conventional types of abstracting and indexing services by agencies funding research should be limited to relatively narrow fields where a special need can be convincingly demonstrated. Any such specialized services should make maximal use of the output of the major broad services and should be supported by short-term contracts. Continuing support should be dependent upon objective and systematic evaluation of the quality and utility of the service.

10. Pilot Trials of Nonconventional Types of Services

The evidence accumulated in other fields of science and from studies of scientists' information habits and requirements is adequate to justify carefully designed and selected pilot trials of several nonconventional types of information services. Agencies funding biomedical research should support by contract, for limited periods, such pilot trials to test the feasibility, value, and acceptability to the biomedical community of these types of services, and to assess their compatibility with existing conventional services. These pilot trials might include: *a:* making available quickly, on request, informal records (in the form of documents or audiovisual materials) of oral reports given at meetings; *b:* using telephone, radio, television, and motion pictures to bring the benefits of active or passive participation in meetings to a broader segment of the United States and international biomedical community; *c:* publishing, by established journals, of abbreviated versions of papers, the full texts of which are supplied on demand in full-size or microform copies and are processed by abstracting and indexing services; *d:* using advanced techniques in the publication of established biomedical journals, e.g., computer composition, phototypesetting, microform editions, author composition, and methods for obtaining continuous "feedback" from readers; *e:* screening computer tapes that list new documents, such as the magnetic tapes produced in the MEDLARS program, to provide individual biomedical scientists with a current awareness service specially tailored to their interests, habits, and preferences; and *f:* providing thesauri of current terminology in major areas of biomedical research suitable for use by authors and editors in choosing indexing terms to be published with journal articles or supplied to appropriate abstracting and indexing services. Such thesauri should be compatible with and complement those of the major, broad indexing services, such as *Index Medicus* and *Chemical Abstracts*.

C. SPECIAL STUDIES NEEDED FOR POLICY DECISIONS

It is recommended that further study of the areas outlined in this section be undertaken before certain policy decisions are made regarding support of information services. Other investigations of a more general nature are recommended in section D.

1. Prepublication Channels of Information

a. Meetings, conferences, and symposia. The contemporary biomedical scene is characterized by a heavy calendar of meetings varying widely in purpose, form, and size. Some follow traditional patterns of scientific assemblies while others take forms improvised to cope with the expanding population of biomedical scientists and the changing horizons of the disciplines. The sponsors of research are being increasingly called upon to support meetings of all sorts and varieties and are embarrassed by the lack of criteria by which wise decisions may be made. In the absence of an agreed set of principles, there is danger that choices may be made on the basis of the uncoordinated decisions of many independent advisory groups or simply on a policy of "first come, first served."

There is need for a deliberate study leading to the development of an acceptable set of criteria to guide those responsible for programming and funding the national biomedical research effort. The study should include a survey of current practices in the organization and conduct of meetings, of the extent to which duplication occurs and is justified, of the purposes served by different types of assemblies, and of the views of the biomedical community on the informational functions of various types of meetings. Consideration should also be given to the question of how the products of meetings should be placed in the printed record. The study should be under the direction of a representative group of biomedical scientists in consultation with officers of organizations experienced in the planning of meetings and with representatives of research funding agencies.

International congresses and international meetings of more limited scope provide unique channels for formal and informal oral communication between American scientists and those in foreign countries. Judicious support of these assemblies by funding agencies is fully justified by the substantial contribution that they make to the advancement of biomedical knowledge and to the encouragement of international cooperation in research. International biomedical meetings are, however, increasing rapidly in number and in variety of sponsorship and subject matter. Such international bodies as World Health Organization, International Council of Scientific Unions, and Council for International Organizations of Medical Sciences should be encouraged to intensify their endeavors to improve the quality of international meetings, to experiment in new forms, and to minimize undesirable duplication.

Requests for the support of the organizational costs of international meetings and for travel funds for participants continue to mount. The investment of U.S. funds is already substantial and could become disproportionate to the scientific returns if wise discrimination is not exercised in allotting funds. The efforts of funding agencies to develop criteria for administering the funds available to support international communication should, therefore, be endorsed by the scientific community.

b. Directories and registries of ongoing research. Some agencies (e.g., National Aeronautics and Space Administration and Atomic Energy Commission) have extensive services to inform individual participants in their research programs of the existence of other contemporary work related to their own. Recently, NIH began publishing an annual subject index of all its extramural grants. A service with more comprehensive coverage is offered by the Science Information Exchange (SIE). This organization seeks to maintain as complete a registry of all ongoing research as possible and a file of summaries of all active research projects. SIE is prepared to make searches of this file for responsible scientific organizations and individual scientists. It is to be commended for the services it provides and should be encouraged to increase its coverage, particularly with respect to intramural research in government institutions and to projects that are not included in the program of major granting agencies.

These kinds of services are available to those responsible for the administration of funding programs and those who direct mission-oriented programs. They are also helpful to those who wish to explore current trends in the national research effort. As yet, however, there is little evidence bearing on the extent to which working scientists use services such as SIE or the *NIH Research Grants Index*, or on the potential value of these services for the conduct of research. A study of these questions would be helpful in guiding policy with respect to modifying or expanding these kinds of services.

2. *Publications*

a. Page charges. The expanding output of original papers, coupled with the increasing costs of publication, has forced up subscription rates of many journals close to or beyond the point of diminishing returns. Journals that are unable to command large advertising revenues or do not receive some other form of subsidy are threatened with insolvency or restrictions on the volume of material they can publish. A form of support coming into increasing use is the page charge. Insofar as funding agencies accept these charges as part of the costs of research, they are obviously providing an indirect subsidy to the journals that use this device.

The problem is not simply an economic one. If the practice of page charges is not to be abused, funding agencies must develop criteria for determining whether the charges of a particular journal will be accepted. The costs of an indiscriminate policy will be high and difficult to assess, and such a policy will tend to encourage uneconomic practices and to perpetuate journals that have outlived their usefulness. A policy of discrimination, on the other hand, will have the effect of withdrawing from the biomedical community a measure of control over its channels of primary communication.

There is urgent need to study the question of page charges before this device becomes a generally accepted practice in the biomedical field. The study should examine in depth the anticipated effects on the standards of primary publication in the biomedical field of this and other forms of subsidy.

b. Economics of publishing separates. From time to time it is suggested that the user of biomedical information would be better served if he received only those articles that interested him rather than bound issues containing all articles accepted by journals in his field. The usual proposal is that a journal circulate to its subscribers a list of titles of accepted articles. Separates of all articles would be printed and distributed to libraries while individual subscribers would be entitled to receive the particular articles they selected from the list of titles.

As a preliminary to any pilot trial of this form of publication, it is recommended that a study of costs be undertaken. It should be possible from the unit costs of the various operations involved to derive a formula that would predict costs in defined situations to the user, the publisher, and those who would have to process the documents, e.g., librarians, and abstracting-indexing services.

3. Abstracting and Indexing Services

The development of consistent policies for support of abstracting and indexing services is hampered by lack of approved standards and criteria. As a basis for the development of standards, a careful study should be undertaken of duplication, promptness, accuracy, compatibility, and users' needs. Any proposed standards should be reviewed by representative groups of biomedical scientists and operators of abstracting and indexing services.

4. Library Services

a. Standards. It is increasingly evident that institutional libraries will require additional public support if they are to meet the needs of the expanding research activities of their institutions (see sec. B.6.). Subsidy is, however, justified only if acceptable standards of service are met.

The present standards for service by institutional libraries vary widely and are not defined in terms of the needs of the user. A study is needed to establish minimal standards and optimal goals for the operation of the various services that local libraries offer. These standards will provide valuable guides in developing a long-term program for the support of biomedical libraries.

b. Interlibrary loan system. The present informal system of interlibrary loans is perilously close to breakdown. Short-term measures to preserve this vital service are recommended in section B.7. Several plans have been suggested for the long term: *1*) a new centralized system might be developed around the National Library of Medicine, which would undertake to meet all demands for interlibrary loans of biomedical documents throughout the nation; *2*) regional loan centers might be established to serve restricted areas; or *3*) local biomedical libraries might be so strengthened as to become self-sufficient. Each of these proposals would involve large commitments in funds. A systematic study of present and future needs and of the relative advantages of these and other alternatives is required before a course of action is chosen.

D. RESEARCH AND DEVELOPMENT

Systematic research and development in scientific communication is relatively new. The biomedical sciences can profit from lessons learned in the physical sciences, where research and development in scientific communication first became a major endeavor. Although activity in this new field has recently expanded rapidly, the promise that such research offers for increasing the effectiveness of the entire scientific effort has only begun to be realized. Up to now concentration on the problems of storing and retrieving documents and information and of mechanical translation has led to relative neglect of large areas equally fruitful for study. A balanced, long-term program of research, including behavioral studies and new conceptual approaches to communication, as well as exploitation of mechanical and electronic devices, is required for major improvements in biomedical communication.

1. Specific Research Projects

A number of specific studies and projects have been recommended elsewhere in this report. Here attention is called to broad areas that have special promise for research and development.

a. Meetings: improvement of the design and conduct of meetings of all types;

b. Journals: assessment of quality control by refereeing and other means, publication habits of authors, foreign distribution of U.S. biomedical publications;

c. Linguistics: languages for facilitating man-machine exchanges, spoken languages to facilitate international communication;

d. Microforms: applications to publishing and document storage, studies of acceptability and economy;

e. Media other than the printed word: uses of film, video tape, computer tape, sound recordings, and other nonprint media in biomedical communication;

f. Behavioral studies: habits and prejudices of biomedical scientists as generators, evaluators, and users of information; relation of creativity to use of information resources; and

g. Potentialities of future technologic developments: probable implications and impact of practical associative electronic memory banks, machine translation, and high-speed character readers and telefacsimile transmission upon biomedical communication.

2. Centers for Research and Development

SIC's and SIEC's, although functioning primarily as national services, must maintain active programs to develop their services if they are to maintain quality and efficiency and meet the demands of increasingly sophisticated scientist-users. Two other types of centers, however, are also needed in the biomedical community to provide appropriate environments for developing the entire spectrum of document and information processing services, to exploit the potential of audiovisual media, to improve methods of oral communication, and to conduct research on the fundamental processes of biomedical communication.

a. Centers for development of local document and information processing services. Local Development Centers associated with enterprising biomedical libraries should be established as "grass-roots laboratories" for assessing, with a local population of users, the utility of conventional types of library services and for testing new ways to supply scientists with the documents and items of information they need. This kind of practical development must be conducted in the realistic setting of an institution engaged in biomedical research, inasmuch as success can be determined only by continuous, intensive feedback from actual users of the services proffered. Academic institutions are particularly good settings for such centers, because the development program could be a cooperative endeavor of the library, the departments active in biomedical research, and other parts of the university, e.g., an engineering or library school.

Proposals for establishing these centers should be judged competitively, with no prior decision as to how many centers should be established. As particular centers prove outstandingly productive, they should be encouraged to expand their programs. Where the associated library provides regional as well as local services, a Regional Development Center can evolve.

b. Centers for broad research in biomedical communication. In addition to the library-centered development programs described above, there is an urgent need for research centers where all the processes of biomedical communication can be studied at a broad conceptual level and all communication media and techniques can be explored. This type of center should be established as a Department of Biomedical Communication within a graduate biomedical school. Its primary function would not be to act as the development arm of the school's library or of other local communication service activities, such as photographic and illustration services, but rather to provide a combination of teaching and broad research, like any of the usual departments of biomedical schools.

Each of the three types of research and development programs described as appropriate for SIC's and SIEC's, for Local and Regional Development Centers, and for Departments of Biomedical Communication can, when conducted separately, make a significant contribution. Some academic institutions, however, offer opportunities for establishing more than one type of program. A single school might have research and development programs associated with a SIC that serves an international population of scientists, with its local library, and with a Department of Biomedical Communication. Such a combination would be synergistic and constitute a major resource for research, for training specialists in information services, and for preparing scientists for careers in communication research. Only when the kinds of centers for research and development recommended in this report have been established in universities and have begun to provide intellectual leadership will the full contribution of communication research to the biomedical effort be realized.

E. TRAINING

A major obstacle to expansion and improvement of information services for the biomedical community, and of research and development in biomedical communication, is the lack of qualified personnel, which is already critical.

1. Training for Biomedical Information Services

Information services require numerous types of personnel with a variety of skills, knowledge, and experience; and programs for training such personnel must be correspondingly varied. Knowledge of the subject matter of the biomedical sciences, competence in foreign languages, understanding of the functions of communication media and of the principles of processing documents and information—all these are required in greater or lesser degree for the different types of positions to be filled. The special training needs of photographers, illustrators, manuscript editors, and experts in telecommunication should also be considered.

The various types of research centers proposed in section D. offer favorable environments for training personnel for biomedical information services. Other settings in which valuable training can be secured are library and engineering schools, indexing and abstracting services, and SIC's and SIEC's. Establishing and conducting training programs will, in many cases, require financial support for teachers and trainees and for other operating costs. The experience of the National Science Foundation in evaluating proposals for training programs should be drawn upon by other sponsors of programs.

2. Training for Research in Biomedical Communication

Diversity in the backgrounds of candidates for careers in communication research is desirable. The main qualification would seem to be a strong motivation for research, supported by graduate training in some scientific field or substantive experience in a scientific information service. A doctoral degree in medicine or in a biomedical science is desirable but not essential. The National Institutes of Health are to be commended for recognizing the importance of this type of training and for sponsoring pilot programs.

For graduate training of the type and quality required to prepare candidates for investigative careers in biomedical communication, an academic environment is especially important.

F. COORDINATION OF THE BIOMEDICAL INFORMATION COMPLEX

One of the main purposes of the study summarized in this Report was to delineate more clearly how each type of service in the biomedical communication complex contributes to the dissemination of information and to the exchange of ideas and experience. In general, each service came into being because some group of biomedical scientists identified a need and sought to fill it. It is natural, therefore, that more thought and effort have gone into the nurturing of the individual services than into the task of integrating them into a functional coherent system.

1. Journals

The editorial boards of journals have a responsibility to monitor the efficiency with which their journals are fulfilling their intended purposes. This they do with varying degrees of diligence in respect of such ponderables as rejection rates, backlog, speed of publication, circulation, and costs. Less thought is given to coordinating the policies of a particular journal with those of others in respect of subject coverage, duplication, uniformity in terminology and citations, and possible savings in printing and publishing overhead that might result from group action.

The establishment of the Conference of Biological Editors in 1956 reflected a realization of the need for a larger measure of coordination in the management of the journal literature. This organization serves as a forum for the exchange of experience and proposals. The efforts of the Conference and of other professional associations, such as the American Medical Writers' Association and the Association of Dental Editors, in which biomedical editors also meet to share their experience and develop common approaches, are to be commended.

NSF has pioneered in collecting data that may be used to monitor the general state of journal publication for science as a whole and to detect where serious problems exist. To promote coordination of effort among biomedical journals and of policies for supporting journal publication, objective data on trends and on adequacy of publication outlets for the various fields of research are essential. The PHS should encourage an appropriate organization to undertake the development and maintenance of a continuing monitoring program to collect data on journal backlogs, speed of publication, costs, circulation, numbers of articles and pages per issue, births and deaths of journals, and other objective indices.

2. Abstracting and Indexing

Formation of the National Federation of Science Abstracting and Indexing Services was stimulated by NSF to promote coordination of effort, to correct gaps in coverage, and to improve the general quality of the services. This organization now encompasses 20 of the major U.S. abstracting and indexing services, both governmental and private. A certain amount of work sharing has been achieved, and a start has been made toward developing an entity with which a group desiring abstracting coverage for a narrow field can negotiate for a "package" service that draws upon the abstracts produced by two or more members of the Federation. The potential value of this organization has only begun to be realized.

The biomedical field is fortunate in having a single indexing service (*Index Medicus*) that provides relatively fast and uniform coverage for most of the substantive literature; however, in respect of abstracting coverage, the situation is less satisfactory. Although many services exist, their combined coverage has significant gaps and quality and promptness are uneven. To promote coordination of effort among abstracting services and of policies for supporting abstracting services, it is essential to have the same kind of over-all picture of trends and adequacy as for journal publication. The PHS should, therefore, encourage an appropriate organization to develop and maintain a similar monitoring program for continuously collecting data on gaps and overlapping in the coverage of biomedical literature, on growth in the number of services and of documents processed, unit processing costs, currency, and other objective indices.

3. Over-all Coordination

The Weinberg report[4] recommended that, for each area of mission-oriented research, a single agency within the Federal Government be made the "delegated agent" for information in that area, with responsibility for "supporting and otherwise carrying out information activities," and that "each agency should establish a highly placed focal point of responsibility for information activities that is part of the research and development arm, not of some administrative arm, of the agency." It will not be simple to implement these recommendations in the biomedical field, but some means must be developed to ensure that government policies regarding biomedical information services are coordinated effectively and are sensitive to the needs of the biomedical community.

The total biomedical communication complex with its government and private components comprises a chain of processes in the reordering and refinement of information. There must be a continuous effort to fashion the operation of these phases so that they will be as complementary to and compatible with each other and with the communication services of contiguous scientific disciplines as possible. This is a task that only the biomedical community can execute intelligently.

It is recommended that an appropriate scientific organization that commands the respect and support

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[4] President's Science Advisory Committee. *Science, Government, and Information: the Responsibilities of the Technical Community and the Government in the Transfer of Information.* A Report. Washington, D.C.: The White House, January 10, 1963.

of biomedical scientists be encouraged to establish a representative deliberative body to maintain surveillance over the whole field of biomedical communication. A forum would thereby be provided in which the views of the academic, industrial, professional, and governmental contributors to the national biomedical effort in research could be ventilated and examined; resources, needs, and opportunities could be evaluated; and emergent problems could be identified and analyzed. Such a group should not have operational responsibilities, but should be available for advice on planning and programming.

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The biomedical information complex viewed as a system[1]

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Orr, Richard H., Gregory Abdian, Charles P. Bourne, Edwin B. Coyl, Alice A. Leeds, and Vern M. Pings. *The biomedical information complex viewed as a system.* Federation Proc. 23(5): 1133–1145, 1964.—To aid in visualizing and understanding the heterogeneous aggregate of interdependent operations, activities, and services that handle the information generated by, and used in, biomedical research, this complex was analyzed as a system from a viewpoint of the functions it performs. The result was a qualitative model with the following major functional components: *1*) generation and use, *2*) oral communication, *3*) recording and distribution, *4*) document processing, *5*) information processing, and *6*) control. Between generation and use, the flow of information through components (*2*), (*3*), (*4*), and (*5*) depends upon parallel and sequential chains of processing operations. The operations of each component depend, in general, upon the prior accomplishment of the operations of the preceding component. The capacity of a given component is limited to that of its slowest operation except where alternative paths exist. The costs of operating this complex are met by government, private foundations, industry, academic institutions, and user fees for services (such as subscription fees). The present trend is toward increasing dependence on government support. This crude model can serve as a framework for collecting the data required to develop a quantitative model and is useful in considering the problems of biomedical communication, determining their relative importance, and assessing possible solutions.

A DYNAMIC COMPLEX of interrelated processes, operations, activities, and services handles the information that the community of biomedical scientists generates and uses. An understanding of how this complex functions would seem to be as essential for identifying and attacking the communication problems of the biomedical research community as a knowledge of physiology is for diagnosing and treating disease. This paper represents an attempt to describe and analyze the complex as a functioning whole.

APPROACH

The biomedical information complex can be considered a "system" in the same sense that a living organism is a system. Both have evolved in response to needs and both are self-organizing; neither system was designed. Approaching the complex as a system facilitates analysis of the basic functions performed by this heterogeneous and seemingly amorphous aggregate and aids in visualizing the processes that underlie its operation. The goals are those of physiologic research: to correlate structure with function and to understand dynamic and interdependent processes.

Broadly defined, a system is a bounded complex of elements—men, machines, or objects—interrelated by processes and responding to events to achieve an objective. In the case of the biomedical information complex, the generators and users of the information must be considered parts of the system, as well as the men and devices handling biomedical information between its generation and its use. The objects in this system are "documents" in the most general sense of the term, i.e., all records of information on paper, film, magnetic tape, or on other physical media. The system's immediate objective has been aptly stated by Shaw (9): "The end product . . . must be the information needed by and usable to each scientist, wherever he may be and whatever his needs may be at the moment." Its ultimate purpose is to further the accumulation and application of biomedical knowledge.

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ASSUMPTIONS

Analyses of dynamic, complex systems usually require the adoption of simplifying assumptions and viewpoints. In the present instance, several decisions facilitated the analysis. First, we elected to view the biomedical information complex as a separate system, although it is actually a part of a larger system that serves all of science. Second, we chose to follow only the more important channels for the flow of information through the complex and to emphasize the sequence of operations occurring between generation and use. Third, since the terminology usually applied to organizations, activities, services, and people engaged in handling information often obscures their common features, the system's operations were to be described largely by function, rather than by performer, using terms selected for generality and for freedom from unwanted associations. Last, although the complex handles two kinds of information, we concentrated on one. If information resulting from scientific observation, experimentation, and reasoning is called "scientific" information, then information about research (i.e., news about scientists, support, equipment, and supplies, or messages related to the administration of research) may be termed "parascientific" information. Here the concern is primarily with the flow of scientific information.

FORM OF PRESENTATION

Our analysis is presented chiefly as block diagrams. The value of this type of diagram in physiology was recently emphasized by Gray (2):

> The engineer has developed one device for enforcing an elementary rigorousness that is refreshingly simple and general. This is the block diagram, a qualitative mathematical model which conveniently displays, without distracting detail, all the components and variables of a system together with their circuitry. . . .
>
> On several occasions I have had the opportunity to watch a fellow physiologist attempt to represent in this simple form, and at this elementary level, the system on which he is an expert. He is usually flabbergasted to discover that his ready knowledge is unequal to the task. He finds he is uncertain about numerous items suddenly revealed for the first time to be of key importance. The usual result is a period of cerebration more intense, novel, and cogent than any he had previously accorded the system, punctuated by trips to the library to find answers to questions never before asked. If a workable diagram is eventually formulated, the light it sheds may be truly exciting. One can suddenly see physiological flesh and blood as a coherent, determinate, functioning system . . . .

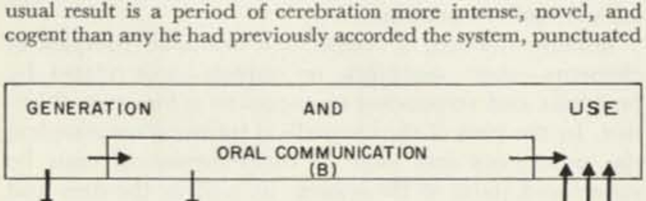

FIG. A. Over-all view of biomedical information complex. NOTE: In this and subsequent diagrams, the parenthetical letter-number combination in a box refers to another diagram that provides a further breakdown of the given operation.

We found this device to be equally valuable for studying the metabolism of biomedical information.

MAJOR FUNCTIONAL COMPONENTS OF THE SYSTEM

In Fig. A, five major functional components of the system are depicted:

1) Generation and Use—operations in which scientific information is generated and used, considered here as two phases of a single component.

2) Oral Communication—operations entailed in transmitting information orally.

3) Recording and Distribution—operations associated with the recording of scientific information and the distribution of the records thus produced.

4) Document Processing—operations performed in the collection; analysis and announcement; and the storage, retrieval, and delivery of information records (i.e., documents) after their production and initial distribution.

5) Information Processing—operations by which information is extracted from documents, evaluated, modified, or synthesized.

A sixth major functional component, which cannot be similarly depicted in this scheme, comprises the operations by which the system and its parts are controlled. Important operations related to system control and management are: *a*) maintaining the quality of "messages" handled by the system, *b*) improving the system, and *c*) supporting the system. Direct quality control is exercised in two ways—by evaluating the information in a message to see if it merits further processing and by improving the form or the content of a message. The more important points at which quality control is commonly exercised are identified in subsequent diagrams. Improving the system so that it functions more effectively and efficiently to achieve its immediate objective and ultimate purpose requires research on how the system works and development of improved methods for carrying out its various operations. Communication research and development cannot be localized in this scheme but will be covered briefly in the discussion of the system's support.

GENERATION AND USE

In Fig. A, the box labeled "generation and use" represents the thought processes of scientists engaged in biomedical research. These internal processes do not lend themselves to the approach of this analysis, and we have not attempted to analyze this component in detail.[5] The other components transmit information in the form

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[5] In Fig. G we do, however, suggest some general relations between successive stages in a research project and information generation and use.

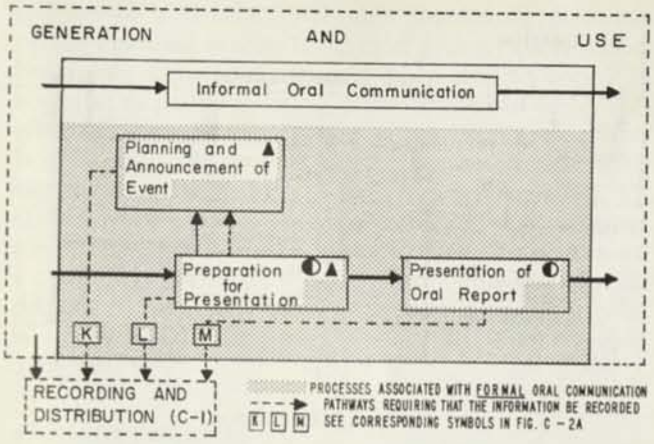

FIG. B. Formal and informal oral communication. NOTE: In this and subsequent diagrams, boxes with broken outlines and broken-line arrows represent, respectively, operations and processes that are outside the focus of the particular diagram. A small square enclosing a letter indicates that processes have been omitted to simplify the diagram and refers to the point in another diagram where the omitted processes are shown. Points at which quality control is commonly effected are designated by the following symbols: ▲ where a message may be evaluated and a yes-or-no decision made as to whether or not it will be processed further; ◐ where the content or form of the message may be modified by feedback from the generator's colleagues or from processors in the chain of operations required for transmission.

of unrecorded messages (oral communication), or of various physical records, from one scientist to another.

ORAL COMMUNICATION

The processes of formal and informal oral communication are analyzed in Fig. B. Informal oral communication comprises all face-to-face or telephone exchange other than that structured by the formalities of an "event" planned for oral communication, such as a scientific meeting, lecture, seminar, etc. The processes of formal oral communication include the planning and announcement of an oral communication event, as well as the activities of generators in preparing for and presenting oral reports. Quality control may be exercised during the planning of an event by selecting active participants (generators) on the basis of their past work or of an abstract of the oral report they wish to present. In most cases, some of the scientific information to be presented at the event is transmitted in oral or written form to the planners, who may incorporate this information in a written "announcement" of the event, e.g., as "abstracts"[6] in a meeting program (broken-line arrow designated K). In preparing to present an oral report, a scientist may have to get a decision from his institution as to whether his work is considered ready to be reported, and his presentation may be modified by feedback from institutional associates. Preparation for an oral presentation usually entails either making notes or writing out the full text. (The broken-line arrow designated L symbolizes these recording processes as well as that of preparing an abstract.) At the event, the presentations may be recorded (broken-line arrow designated M) verbatim or may be summarized by listeners who intend to give an oral or written account of the event later. Thus information transmitted by formal oral communication is recorded, in whole or part, by several routes, which will be covered in Fig. C-2A.

RECORDING AND DISTRIBUTION

Figure C-1 summarizes in broad terms the complete sequence of basic operations entailed in the recording of scientific information and the distribution of the records produced. Only channels within the specific focus of this diagram, i.e., those that are parts of this component, are shown. The details of processes required for recording, publication, and distribution are shown in Figs. C-2, C-3, and C-4, respectively.

Recording

The focus in Fig. C-2 is on the processes involved in the operation of recording. Informal documents include data and work sheets, photographs, notes or texts for oral presentations, manuscripts, letters, and any other form of recorded scientific information not intended for distribution outside administrative or personal channels. (Production of informal documents is shown in more detail in Fig. C-2A.) Some informal documents are used only by the generator; some are distributed as such; and a few are reviewed by the generator and his institution for publication and wide distribution to the scientific community. This intramural review may include a quality-control decision as well as other considerations, including protection of proprietary interests in industrial institutions and selection of the appropriate form for publication—a journal article, book, or technical report.

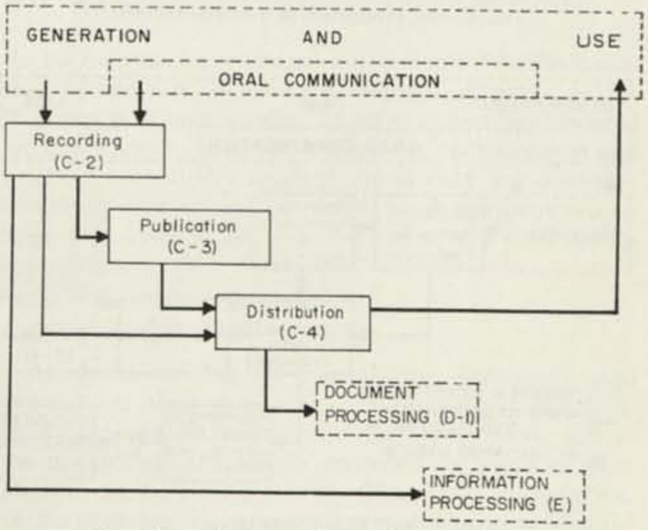

FIG. C-1. General scheme of recording and distribution.

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[6] Although commonly used in this sense, the term "abstract" is inappropriate and misleading, since the existence of a full report is implied. In reality, it usually represents only a summary of what the prospective speaker thinks he will say, or hopes he can say.

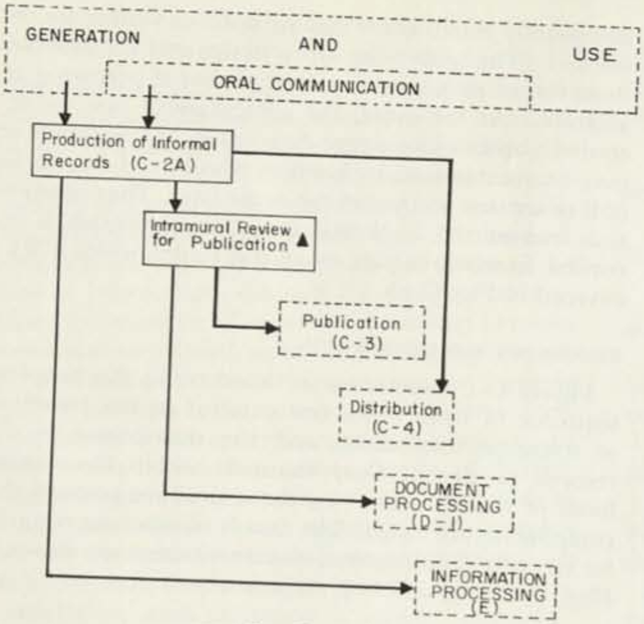

FIG. C-2. Recording.

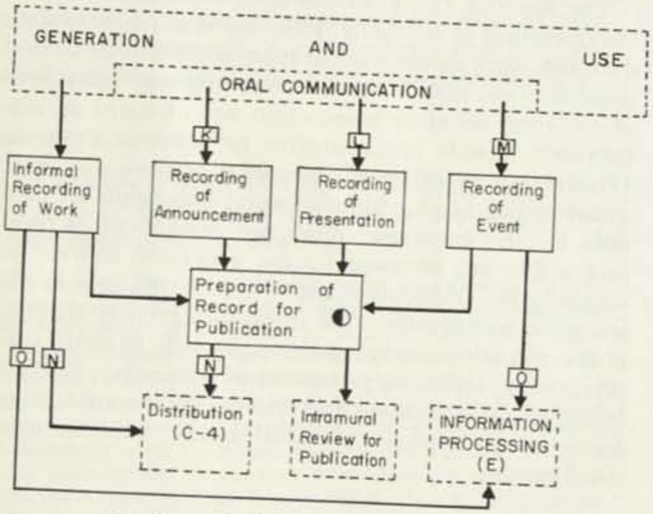

FIG. C-2A. Production of informal records.

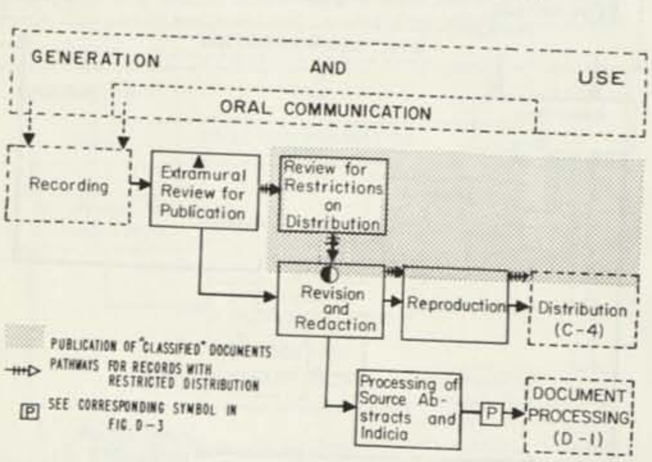

FIG. C-3. Publication.

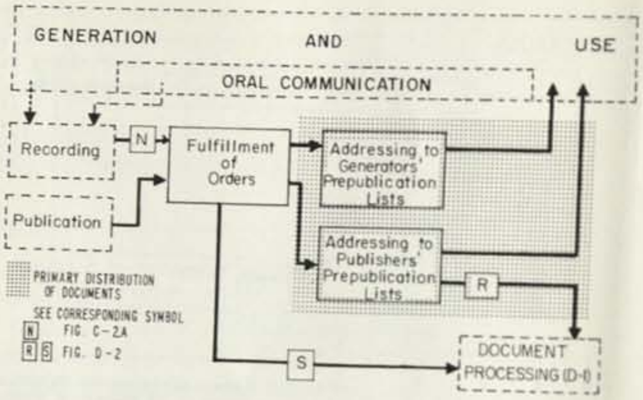

FIG. C-4. Distribution.

Production of informal records. Different types of informal documents created as by-products of formal oral communication are depicted in Fig. C-2A, together with those produced for other purposes. Although all the routes are not shown, any of these types of informal records may be distributed through administrative or personal channels. For example, a scientist may provide colleagues with his data sheets, with the abstract or notes for his oral presentation, or with a summary account of an event he has attended. If publication is contemplated, a certain amount of preparation is usual before committing the record to a definitive, intramural review. Drafts may be distributed to obtain opinions from local and distant colleagues, and feedback may modify successive drafts.

Publication

The operation of publication shown in Fig. C-3 converts informal documents, e.g., manuscripts, into forms suited for wide distribution and for storage and retrieval. We refer to the products of publication as formal documents. The manuscript is submitted for extramural review to a publisher (for a book), editorial board (journal article), or the agency that sponsored the work reported (technical report). For technical reports, this review includes a consideration of reasons for restricting distribution. If a report is classified for reasons of national security, all subsequent processes in the entire complex entail special precautions and special channels parallel to those for nonclassified reports. During revision and redaction, the form and content of the record is modified by feedback from publication processors, e.g., editorial reviewers and copy editors, to the generator. Multiple copies are then reproduced (printed, photocopied, etc.) for distribution.

Distribution

Figure C-4 analyzes the distribution of documents. For formal documents, the publisher, e.g., of a journal, fills prepublication orders for any copies that the generator (or his institution) distributes automatically to a standing list of colleagues or institutions, and that the publisher sends to a list of regular recipients, e.g., sub-

scribers to a journal. All such automatic, predetermined distribution may be termed primary distribution. Secondary distribution (arrow designated S) occurs in response to postpublication orders (requests) for a specific document, e.g., a reprint of a journal article, and is analyzed later as part of the document processing component. Informal documents (arrow designated N), though often given to only one recipient, e.g., a letter, may receive wider primary distribution by the generator. In addition, some secondary distribution of informal documents may occur to meet requests from those who have heard of the document in some way, often by word of mouth.

DOCUMENT PROCESSING

The major operations of document processing (document collection; analysis and announcement; and storage, retrieval, and delivery) are summarized in Fig. D-1 and analyzed in detail in Figs. D-2, D-3, and D-4. Both formal and informal documents are handled; however, conventional document processing services, e.g., libraries and abstracting-indexing services, usually consider informal documents having no historical value as "ephemera," and either discard them during the collection operation or store them without the extensive processing that formal documents receive. Other document processing activities, such as those represented by scientists' personal files and by specialized information evaluation services, may not make this distinction.

Document Collection

The processes in Fig. D-2 occur in building the small, personal collections of scientists as well as the extensive collections of great libraries. In acquiring documents by either primary or secondary distribution, quality-control decisions are usually made, i.e., the collector chooses to order only those documents considered likely to meet his quality standards. After receipt, a scientist collecting for his own use may discard a document if he finds that the information it contains, though relevant to his interests, is of poor quality. In large collections intended for many users, however, documents once ordered and received are usually retained unless they are obviously irrelevant or in a form not suited for subsequent processing. Decisions to discard documents are difficult for committees.

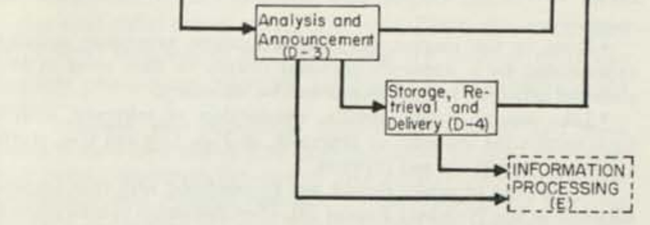

FIG. D-1. General scheme of document processing component.

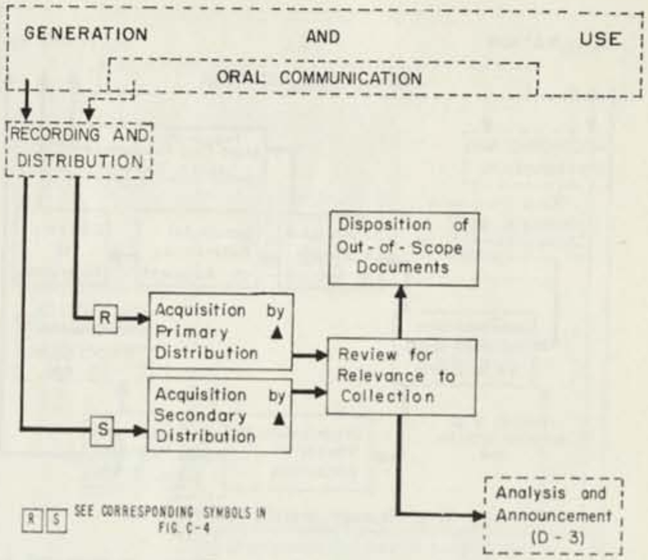

FIG. D-2. Document collection.

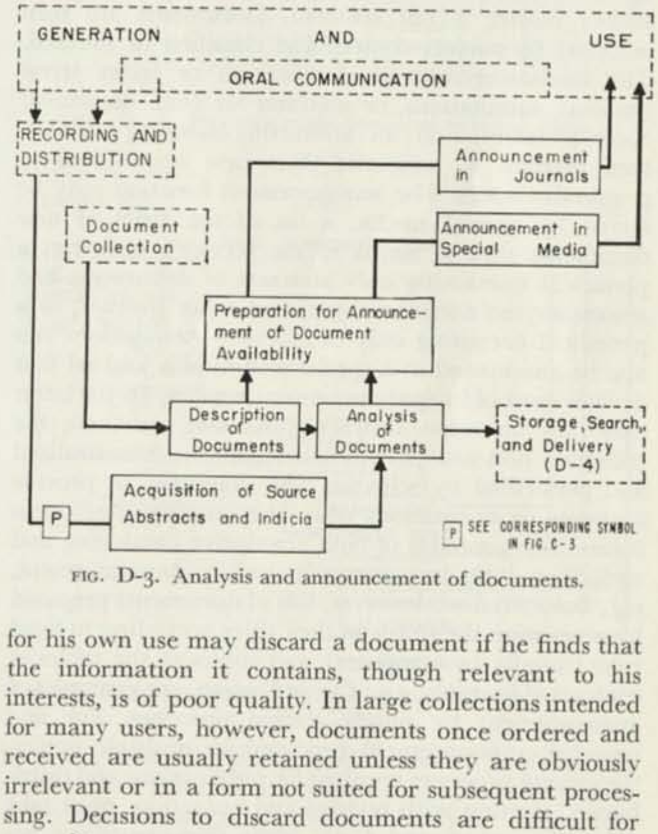

FIG. D-3. Analysis and announcement of documents.

Document Analysis and Announcement

As shown in Fig. D-3, analyzing documents and announcing their availability entails several processes. Before storage, in collections of any size, descriptions of the documents are usually recorded in terms of their physical form, issuing source, title, date, authors, etc. In libraries and document centers this process is called

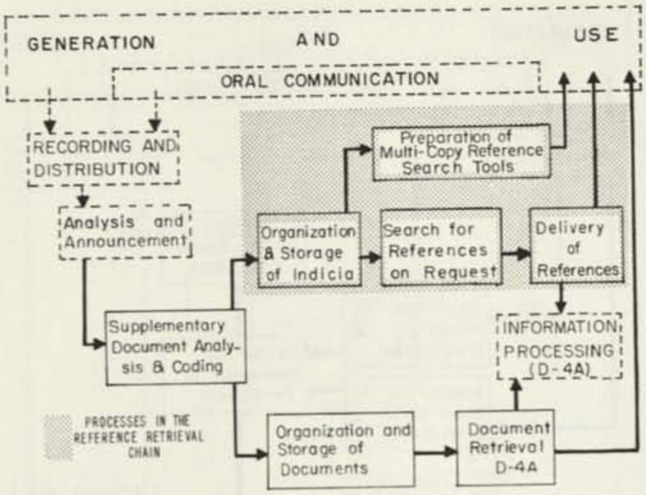

FIG. D-4. Storage, search, and retrieval.

descriptive cataloging and is essentially a "clerical" operation, in that an understanding of the documents' subject matter is not required. Documents are then analyzed by subject content and classified or indexed. This analysis results in classification or index terms (indicia), annotations, or abstracts for each document. Some libraries, and all abstracting-indexing services, then prepare to announce their new acquisitions to prospective users. The announcement function may be served by special media: a list of the titles of new documents that is issued to the service's clientele; a periodical containing only abstracts of documents and accompanying author, subject, and other indexes; or a periodical consisting only of indexes.[7] Acquisitions can also be announced in a special section of a journal that devotes most of its space to original articles. In the latter case (also in some abstracting-indexing services), the collection and analysis operations may be decentralized and performed by scientists who volunteer to provide abstracts or annotations when they receive new documents. The products of both descriptive cataloging and subject analysis are commonly used in announcement, e.g., *Index Medicus;* however, lists of documents prepared by permuting the words in their titles according to fixed rules (usually by computer), and copies of the tables of contents of journals, e.g., *Current Contents*, are examples of announcement by purely clerical processes. For any recorded announcement produced in multiple copies, the general processes required for publication and distribution, starting with revision and redaction, must take place (Figs. C-3 and C-4). Some documents are accompanied by "source" abstracts and indicia prepared either by the generator or by the publisher, e.g., journal articles prefaced by an abstract or synopsis. Source abstracts and indicia can also be acquired separately (input arrow designated P in Fig. D-3) by arrangement with the publisher, e.g., *Biological Abstracts* receives author abstracts on separate forms supplied to authors by cooperating journals.

Storage, Search, and Delivery

The operations of storage and retrieval, i.e., search and delivery of desired items on demand, are shown in Fig. D-4. Before storage, to insure efficient retrieval later, a more detailed subject analysis of the documents may be performed to supplement the analysis that sufficed for announcement purposes. Also the document descriptions and indicia may be coded or abbreviated. From here on, two processing chains exist in parallel: one stores document descriptions and indicia and retrieves, from this store, references, i.e., bibliographic descriptions of documents that may contain the information desired. The other chain stores the documents themselves and retrieves them once the desired references are specified. Any document processing activity or service must develop both chains to some degree,[8] but formal services usually devote more effort to one or the other.

Reference retrieval chain. Abstracting-indexing services concentrate on the reference retrieval chain. They prepare multiple-copy, reference search "tools," e.g., *Chemical Abstracts.*[9] Typically these services do not themselves maintain extensive stores of documents. Some specialized libraries, particularly those of industrial concerns engaged in research, develop their reference retrieval capabilities in narrow subject fields to a high degree. They supplement the standard reference search tools obtained from abstracting-indexing services with special tools produced by their own more detailed analysis of selected documents, which is tailored for their users. Such libraries also process informal documents, e.g., internal reports that are not handled by standard abstracting-indexing services. Their document collections are highly specialized and relatively small, and they must augment their document retrieval capabilities by calling on major, conventional libraries for loans or photocopies of documents. When a library builds an exhaustive or unique collection in a narrow field and provides outstanding reference retrieval services for research workers, it is sometimes called a "specialized information center" if its services are available to scientists who are not associated with the library's parent organization.[10]

Document retrieval. Conventional libraries, which serve a heterogeneous clientele and relatively broad subject interests, e.g., biomedical libraries in academic institutions, typically allot a large part of their effort to building large stores of documents, with the goal of becoming

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[7] A simple type of informal activity performing the function of announcement is one scientist telling another about an interesting document.

[8] Even in the modest, informal document processing activity represented by a scientist's personal library or files, most of the essential processes in both chains can be identified.

[9] Like announcement media, production of reference search tools entails the sequence of processes, in Figs. C-3 and C-4, starting with "redaction and revision."

[10] This type of center should not be confused with that recommended in the Weinberg Report (8). (See discussion of information processing, page 1139.)

more self-sufficient in providing their users with documents on demand. They purchase the standard reference search tools for journal literature from abstracting-indexing services rather than performing their own subject analysis of this type of document. Although most libraries undertake some descriptive cataloging and subject analysis of books, they also depend on the "ready-made" reference search tools for books that are produced by the large government libraries and by commercial services, e.g., the catalog cards distributed by the Library of Congress, the *National Library of Medicine Catalog*, and *Books in Print* (Bowker Co.). Document retrieval (see Fig. D-4A) employs search tools analogous to those for reference retrieval; given a reference, these tools indicate where the document referred to may be found. Library "shelf lists," which indicate the physical location of documents, are an example. Multiple copies of document retrieval tools may be produced; "union lists" of library holdings are prepared and published as regional or national efforts. These lists indicate which libraries have a given document and are used when a library wants to borrow a document that it does not have.

The secondary distribution of a document, i.e., delayed distribution to requestors who were not covered by the primary, or automatic, distribution of the document, depends on the document processing component in general, and on the document retrieval chain in particular. An activity or service that attempts to supply documents on request usually acquires and stores at least those in frequent demand. If the collection contains many different documents, storage must be organized for retrieval. The larger the collection and the more frequent and varied the requests, the more elaborate the operations of document processing become. In the large general library serving hundreds of research workers, the document retrieval chain must be highly developed.[11]

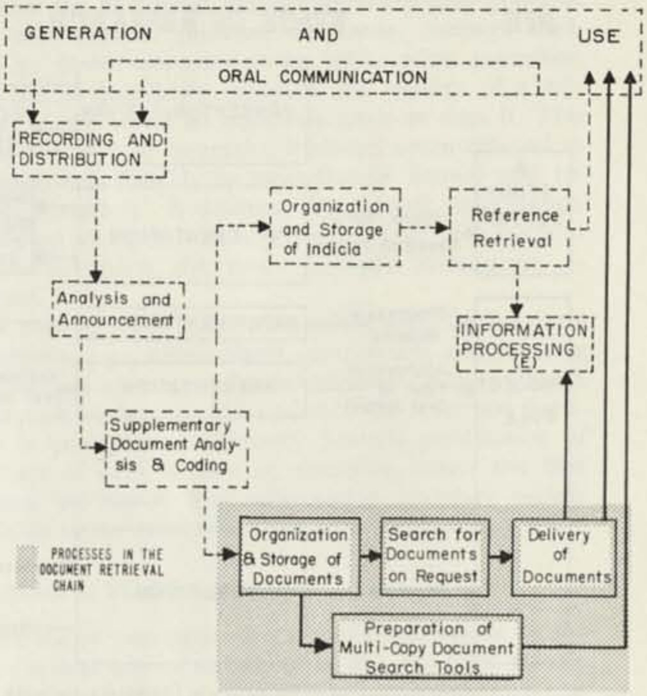

FIG. D-4A. Processes in the document retrieval chain.

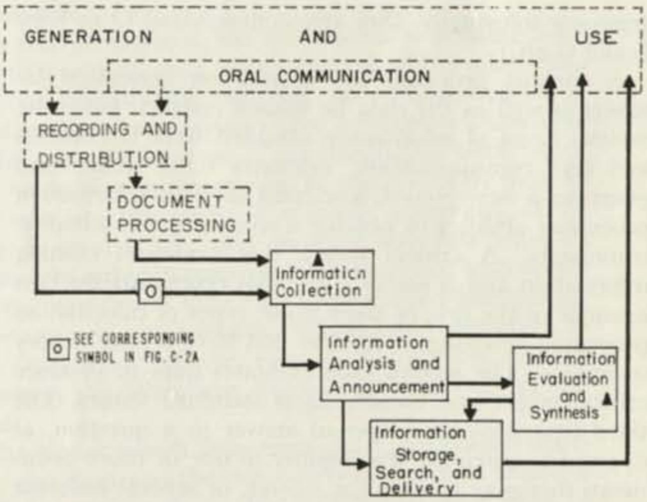

FIG. E. General scheme of information processing component.

INFORMATION PROCESSING

The function of information processing is to "metabolize" information and produce knowledge (11). It is, therefore, central to the growth of science. Figure E depicts the basic operations of information processing. Most of these operations are analogous to those of document processing, but the unit processed is an item of information rather than a document. In general, information processing starts where document processing leaves off and depends upon prior accomplishment of the basic operations of document processing. (Documents must be collected, analyzed, stored, and retrieved before the information they contain can be processed.)

Several differences exist, however. First, the processes of critical evaluation and synthesis are unique to information processing. Second, information processors must have the scientific background necessary to judge the quality and value of the information in a document, rather than having to depend completely on "screening" by subject-matter experts, such as is included, at least ideally, in producing formal documents (publication). Information processing services, therefore, can handle informal records and are less handicapped by the time lag inherent in publication. Third, an information processing service may itself record new scientific information rather than wait for scientists to produce and make available records of their work. For example, such a service may have an observer record oral presentations at scientific meetings, or may obtain oral data from a

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[11] Publishers, and individual scientists who order and store copies of their own papers and send reprints on request, represent, respectively, important formal and informal services for secondary distribution that perform basically the same document retrieval processes as libraries. Because the collections are relatively small, however, the store need not be elaborately organized.

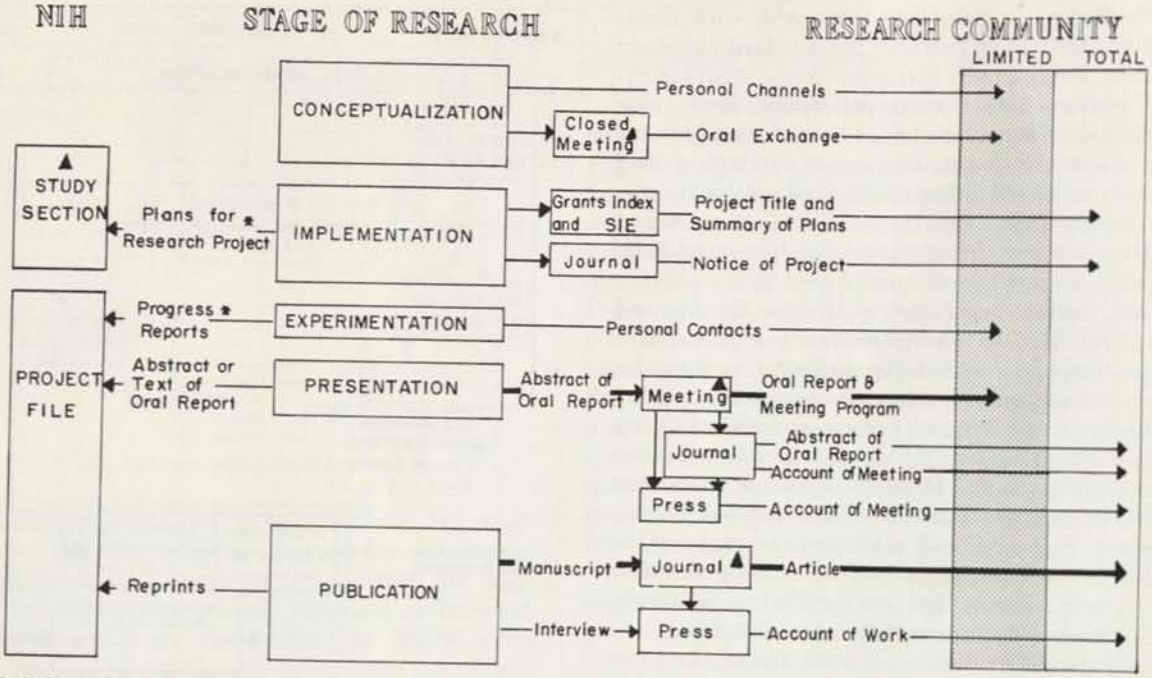

FIG. F. Information output of NIH projects. Asterisks indicate privileged channels. Thick arrows designate the more important channels carrying substantive reports of research results.

generator informally. (See arrows designated O in Figs. E and C-2A.)

A scientist processes the information generated by others as well as the data he himself collects. When he reviews items of information obtained from documents and oral communication, evaluates these items, and generates a new record, a scientist uses his information processing abilities to provide a service to the scientific community. A critical review that evaluates existing information and achieves a synthesis represents the best example of the first of three major types of information processing activities or services that have a long history in science. The second type evaluates data to produce critical tables and handbooks of standard values. The third type provides a factual answer to a question, as opposed to referring the inquirer to one or more documents that may contain the answer, or several different answers. Scientists have always answered colleagues' questions, using their own experience to sift available, often conflicting, information and arrive at the "best" answer; but until fairly recently, such an activity was not commonly formalized or "institutionalized" as a service capable of meeting a large volume of demands from a sizable group of research workers. Currently the trend is toward increasing numbers of institutionalized services that produce critical reviews, critical data compilations, and authoritative answers in specialized fields (8). Services that provide any or all of these products may be termed "specialized information evaluation services,"[12] to differentiate them from document processing services, such as conventional libraries, document centers, and other activities that do not involve evaluation and synthesis. Some, but not all, of the "specialized information services" that have recently been identified (4) qualify as information evaluation services.

During the process of information collection, documents are reviewed, and relevant information is extracted. Some services (e.g., the Cardiovascular Literature Project, which produces the *Index-Handbook of Cardiovascular Agents*) extract, analyze, and store items of information to produce multiple-copy, search tools that can be used for either reference or information retrieval, but leave it for the user to evaluate and synthesize the information he retrieves.[13] Such a service falls somewhere between the typical document processing services (those that concentrate on reference or document retrieval) and the specialized information evaluation centers.

QUALITY CONTROL AND CHANNEL LIMITATIONS

The major points at which the output of a typical project of the National Institutes of Health (NIH) may be subjected to quality control decisions, and the limitations of various output channels, are summarized in

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[12] Or centers, if the information processors are gathered in one location.

[13] In so far as an abstract may contain all the data or information needed to answer certain types of questions, without recourse to the source document, an abstracting publication can also be used for information retrieval. Information retrieval in this sense should not be confused with the more common usage of the term. One often hears of "information retrieval" machines, systems, and services that, more precisely, retrieve only references and/or documents.

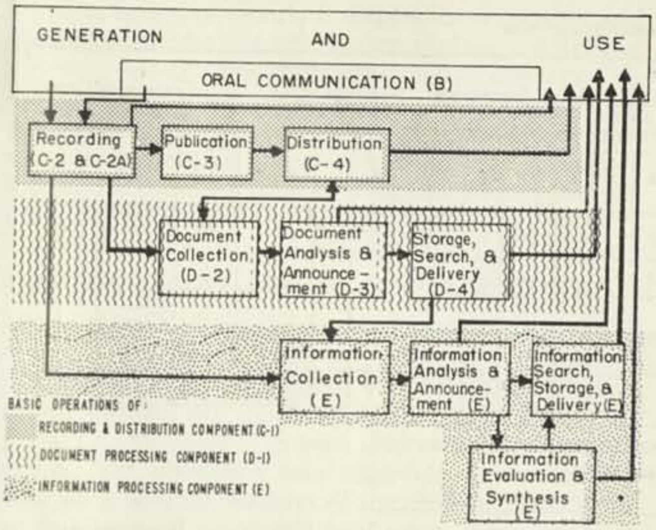

FIG. G. Recapitulation of major components and basic processes.

Fig. F. Administrative channels are shown on the left; major channels to the scientific community are on the right. NIH Study Sections exert quality control over the dissemination of information regarding a scientist's research plans, in that only approved projects are listed in the *NIH Research Grants Index* and disclosed by the Science Information Exchange (SIE) on inquiry. Quality control is exercised by the scientific community at three main points. First, when an investigator is formulating a project and wants to discuss his concepts and plans, he will not have the forum provided by small, closed meetings of leaders in his field unless he qualifies for inclusion in the group and is invited to their meetings. Second, his paper will not be accepted for presentation at a meeting unless the abstract he submits to the meeting planners fulfills their criteria for acceptable quality. Finally, a journal will not publish his manuscript if it does not measure up to the editorial board's standards. Some measure of quality control is exerted by most meeting planners[14] and most journals; however, with enough persistence, a scientist can usually find some meeting at which he can give his paper and some journal that will publish his manuscript. For each of the two main output channels (meetings and journals), therefore, the quality filter can be pictured as having holes of varying size that collectively pass almost all the material presented to them.

These three mechanisms for quality control, and the several others suggested in Figs. B, C-2, C-2A, C-3, and D-2, are not the only ones that maintain the quality of scientific messages flowing in the system over the long term. Two less direct and slower, but more effective, mechanisms operate before and after the messages are generated and initially distributed. First, by selecting and training new generators, the scientific community increases the likelihood that the messages they generate will meet certain minimal standards. Second, each scientist, in his capacity as an information processor, explicitly or implicitly evaluates the quality of a colleague's work when he comments on it or cites it. This evaluation acts as corrective feedback when relayed to the generator directly or indirectly by formal and informal channels. Evaluation by formal information processing services is only a special case of a general process in which the entire scientific community is engaged.

All channels for oral information and for informal documents, e.g., unpublished manuscripts and meeting programs, reach only a limited segment of the research community; whereas, the audience for a formal document is potentially unlimited. Journal publication of abstracts of oral reports is, therefore, often the first channel by which new information becomes widely available to the biomedical research community.

The System as Viewed by the User

The major components and basic operations of the entire system are recapitulated in Fig. G. Thus far the system's channels have been viewed only from the generation end. At this stage it is interesting to reverse the viewpoint and look at the system very briefly from the use end.

In this perspective, the information processing component is seen as using the products of all the other components. Information processing, as we have defined it, requires that the processors have substantive knowledge of the scientific content of the documents with which they work. Key processes must be performed by individuals who are the peers, in scientific judgment, of the clientele served, i.e., they must be scientists who are themselves active in research. Such scientists, who devote varying portions of their time to processing information for others, are the scientific "middlemen" described as the "backbone" of the type of information center[15] on which the Weinberg Report (8) placed great emphasis.

The model, which these diagrams of the system represent, also illustrates the rich variety of channels available to the user. To obtain the information he desires, a scientist may utilize the products of any or all of the four components. The system is highly redundant, but in a useful way. The information on a given subject carried by different channels varies in currency, quality, condensation, specificity, etc. He may choose the channel best suited for his individual needs and habits. His freedom of choice is, however, limited somewhat in that, at the time he wants it, the information may be available through only a few channels; and no one component can meet all of his needs. For example, if he wants to know what a colleague has done in the previous few months, he must usually rely on oral communication or on ac-

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[14] Limiting presentations at society meetings to members (or individuals sponsored by members) is a means of quality control if the members are selected for scientific achievement.

[15] In our terminology, such centers would be called specialized information evaluation centers (or services).

TABLE 1. *Performance and support of functions of biomedical information complex*

	Generation plus Recording			Oral Communication (Formal only)		Publication and Distribution		Document Processing* Local Services			Document Processing* General Services			Information Processing (Extramural † services only)				Communication Research and Development				
PERFORMING ORGANIZATION	A	I	G	A	P	P	C	A	I	G	P	C	G	A	G	P	C	A	I	G	P	C
SOURCE OF SUPPORT: Government (G)	▨	}}}	▨	▨	}}}	}}}	?	?		▨	}}}		▨	▨	▨	}}}	?	▨	}}}	▨	▨	▨
Foundations ‡	}}}			}}}	}}}	?		?										}}}			?	?
Industry (I)	}}}	▨		}}}	}}}				▨										▨			
Academic (A)	}}}			}}}				▨								}}}						
User Fees §	X	X	X	}}}	▨	▨	▨				▨	▨		?		▨	▨	X	X	X	X	X

▨ PRIMARY SOURCE OF SUPPORT FOR GIVEN TYPE OF PERFORMING ORGANIZATION
}}} SECONDARY SOURCE (PROBABLY > 10% OF TOTAL SUPPORT)
? POSSIBLY QUALIFIES AS SECONDARY SOURCE
X NOT APPLICABLE

A = Academic institutions and nonprofit research organizations. I = Biomedical industrial organizations, principally pharmaceutical companies. G = Federal Government. P = Professional societies. C = Commercial organizations: publishers, information services, and companies performing contract research and development in scientific communication. * "Local" services are those intended primarily for local biomedical communities, e.g., institutional libraries; whereas, "general" services are for the entire biomedical community, e.g., abstracting-indexing services, National Library of Medicine, etc. † e.g., Psychopharmacology Service Center of National Institute of Mental Health, review publications, handbooks of biological data, etc. ‡ Includes voluntary health associations. § Subscriptions, meeting registration fees, membership dues, and other direct charges on users of information services.

quiring informal documents by correspondence, since a time lag is inherent in the production of the formal records handled by document processing services. If all he wants is a simple answer to a specific, but unusual, question, such as "What is the LD_{50} dose of morphine for salamanders?", it is unlikely he will find an information processing service that can quickly meet his need from its data compilations. He will probably have to try the document processing services and attempt to find the answer somewhere in the documents they will supply. Finally, he may find that, with a reasonable expenditure of time and effort on his part, the system will not be able to supply this information. In which case, if the information is important to his work, he may decide to establish the dosage himself by experiment.

THE SYSTEM'S SUPPORT

Table 1 presents a rough and tentative estimate of the relative importance of the different sources from which the system draws support. The data required for a definitive assessment are not available. This analysis is in terms of immediate, rather than ultimate, sources of funds, e.g., although scientists may use federal grant funds to pay for journal subscriptions, the immediate source of support is classified here as "user fees."

Federal Support

In recent years data on expenditures by federal agencies for scientific communication have improved. It is now possible to get some idea of the federal contribution to the support of the scientific information complex. For fiscal 1963, total federal obligations for scientific and technical information activities amounted to some $125 million (3).[16] About 40 of the $125 million went to private organizations (including commercial corporations) as direct support for information services and activities. The Public Health Service alone provided almost $7 million for "extramural" information services performed by private organizations. (Expenditures for "intramural" information activities of the Public Health Service were around $15 million.) Of this $7 million, approximately 15% went for activities we have classified as formal oral communication, 12% for publication and distribution, 46% to document and information processing, and 28% to research and development in scientific communication. An unknown but significant proportion of certain other federal agencies'[17] intramural and extramural expenditures on scientific information activities also represents direct support of the biomedical information complex. Their contribution to support of the biomedical complex is probably of greatest relative importance in the area of research and development in scientific communication, where many of the findings apply generally to all fields of science.

Other Sources of Support

Data on sources of support other than the Federal Government are largely lacking, and the various pub-

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[16] This figure does not include research grant or contract funds that were used by grantees or contractors for information services, e.g., to attend meetings or to purchase journals. It represents only the readily identifiable portion of the Federal Government's financial contribution as an immediate source of support and is known to be a low estimate.

[17] Agencies sponsoring considerable amounts of biomedical research, such as the Atomic Energy Commission, National Science Foundation, Office of Vocational Rehabilitation, Department of Agriculture, National Aeronautics and Space Administration, and Department of Defense.

lished estimates of total U.S. expenditures (private and governmental) for scientific communication are difficult to relate to the biomedical information complex. Although the total cost of each or all of the system's components is not known precisely,[18] it is possible to rank roughly the relative importance of different sources of support for the major types of organizations that perform the system's functions.

Support for Generation, Recording, and Oral Communication

The pattern of support for the operations of generation and recording is, of course, identical with that for biomedical research itself. The support pattern for oral communication can be assessed only for its formal aspects, i.e., for planned events; informal oral communication, like generation and recording, is inextricably associated with the conduct of research. At present, for ad hoc research meetings[19] held under the auspices of academic or professional organizations, the major source of support is probably federal funds; whereas, for regularly scheduled meetings of professional organizations, registration charges (user fees) are still the major source.[20]

Publication and Distribution

The Federal Government supports the operations of publication and distribution directly by subsidies to publishers and, more recently, by paying page charges levied by journals on authors. Although page charges by commercial publishers of journals are not generally allowable as direct costs on government grants and contracts (10), publishing companies receive some federal support as subsidies for publication of proceedings and as charges for excess illustrations, tables, etc., paid from research grants and contracts. Industry contributes primarily by buying advertising space in journals.

Document Processing

At present, the operations of "local" document processing services (primarily institutional libraries) are not receiving direct federal subsidy; but an unknown proportion of overhead funds on research grants and contracts is used to support these services. Although the percentage of overhead funds allotted by research institutions to their libraries may be small, the total contribution from this source may well cover a significant fraction of the total operating costs of academic libraries. Industrial and academic institutions contribute importantly to supporting the "general" document processing services (in particular, abstracting-indexing services) through the payment of subscription fees.[21] Institutional subscriptions account for most of the subscription revenue of the more expensive services. Although not depicted in the system diagrams, translation activities may be considered a special type of document processing. Both the Federal Government and industry currently spend large sums for translations provided by professional societies and commercial services.

Support for Information Processing

A recent compilation (4) lists approximately 50 U.S. services that may meet our criteria for biomedical information processing services, or specialized information evaluation centers. About half are associated with academic institutions or professional organizations. It is obvious, from the descriptions given in this compilation, that most of the 50 services are actually by-products of intramural research programs and are not supported primarily for providing service to scientists not affiliated with the parent organization, although such extramural services are provided to the extent possible. Not included in the compilation are biomedical review publications issued by professional societies and commercial publishers, and services that are strictly intramural, as are most pharmaceutical company services.

Support for Communication Research and Development

Private and governmental support for research and development aimed at improving scientific communication may currently total as much as $25 million a year (12). The result of much of this work is directly or indirectly relevant to the biomedical information complex. The Federal Government seems to be the major source of support for work of this type, other than that undertaken by industrial concerns, many of which have embarked on major programs to improve their intramural information services. In fiscal 1963, about $12 million were expended by Federal agencies for such research and development (3). The major sponsors were: Department of Commerce ($1.6 million), Department of Health, Education, and Welfare ($2.8 million), Department of Defense ($3.8 million), and National Science Foundation ($2.7 million). With the exception of the Council on Library Resources,[22] which was set up expressly to support the development of better information services, private foundations apparently provide relatively little support for communication research, at least in the area of scientist-to-scientist communication.

Trends in Support Patterns

The annual cost of operating the entire biomedical information complex has probably increased, in recent

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[18] Cost estimates for certain operations of the complex have been reported (5, 6, 7).

[19] Convened for a purpose that can be served by one meeting, or a short series of meetings.

[20] Only the costs to the performing organization (i.e., the organization arranging and conducting the meeting) are being considered here, not travel expenses borne by the participants.

[21] Current subscription rates for *Chemical Abstracts* are $500 for ACS members and educational institutions, and $1000 for all others; for *Biological Abstracts*, $260 for individuals and nonprofit educational institutions, and $325 for others.

[22] In fiscal 1963, the Council spent almost $1 million on such projects (1).

years, more rapidly than the number of biomedical scientists;[23] but any conclusions based on the inadequate data now available must be very tentative. Even the data on federal support are unreliable for assessing trends, since the methods used to obtain these data have been changing and the completeness with which agencies report expenditures for information activities has been increasing (3). However, trends in the over-all pattern of support are clear. As government sponsorship of biomedical research has grown to its present dominance, the operations of the biomedical information complex have become, in general, relatively more dependent on federal support and less dependent on user fees and academic institutions. All indications are that this shift is accelerating. If the system's users have, through direct payment of user fees, played an important role in managing the system, it would seem that a substitute for this control mechanism should be developed.

USES AND IMPLICATIONS OF MODEL

The model represented by the diagrams is crude and qualitative. It does, however, provide a framework for collecting data on volume of flow in the various channels, on time requirements for processing operations, and on manpower, money, etc. These data are required to develop the quantitative model that would seem to be one prerequisite for intelligent decisions on any long-term policies that may affect the operation of the entire system. Even in its present form, the model has a number of uses. Among those we have explored tentatively and found to be promising are:

1) To identify critical operations and activities where limited capacity may disrupt the functioning of whole components or of the entire system. When these points are identified, action can be directed toward overcoming the bottlenecks. For example, an analysis of document retrieval operations in biomedical libraries apparently indicates that the capacity of this chain is inadequate to handle the demands that will be generated by the rapid improvement in reference retrieval services now taking place (6).

2) To specify the type of processor required for different services. Once the operations are analyzed by processes, it is easier to determine which jobs are essentially clerical (hence potentially amenable to automation) and which require a high degree of subject-matter knowledge or other special qualifications (such as education in library techniques). Activities that cannot be delegated by biomedical scientists to others can also be identified. The model shows that, regardless of automation, any increase in information processing services will require additional scientific manpower. The anticipated returns must, therefore, be weighed against competing demands for this limited resource.

3) To determine where innovations may be advantageous and to predict their effects on other parts of the system. The model helps to predict the probable gross effects of an innovation on preceding or subsequent operations in the given processing sequence, or on operations in parallel chains. For example, the model calls attention to a major difficulty that arises when some, but not all, of the operations in the reference retrieval chain are automated. Greatly increased capacity for preparing reference search tools, such as printed indexes, will not result in commensurate improvement in the service provided by the entire chain unless the capacity for document analysis is correspondingly increased (see Figs. D-3 and D-4). The first operation has proved to be much more readily automated than the latter. Subject analysis of documents will remain, at least for the near future, an intellectual operation—one for which the present acute shortage of qualified personnel is unlikely to be remedied quickly unless new approaches are adopted, e.g., author indexing.

4) To assess mechanisms for coordinating components, operations, and activities. The performance of the system depends upon effective coordination of its parts. Certain formal mechanisms at present insure some degree of horizontal coordination among different organizations performing the same basic operations (e.g., for publication, the Conference of Biological Editors; for abstracting-indexing, the National Federation of Science Abstracting and Indexing Services). Mechanisms to effect coordination among the major functional components of the biomedical information complex, e.g., between generation-use and document processing, are largely nonexistent. However, the efforts of the Office of Science Information Service of the National Science Foundation to promote this type of vertical coordination in the larger science information complex are seen as an important influence on the biomedical system.

5) To provide a holistic perspective for examining the problems of biomedical communication. Only within the framework of the total complex can the relative importance of these problems be judged and sound decisions in allocating resources be made. Not until the quantitative aspects of the model are better developed can some of the major questions about the relative importance of various channels and operations be answered definitively; but from what is now known, it appears that the problems of reference retrieval have received a disproportionate share of attention and of the money and effort devoted to communication research and development.

Another use of the model, which does not lend itself to specific illustrative examples but could prove of major

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[23] Considering the annual cost of conducting hundreds of biomedical research meetings, of publishing some 1000 U.S. biomedical journals and several hundred books, of running scores of abstracting-indexing services that process biomedical literature, and of maintaining over 500 biomedical libraries and various other types of document or information processing services, an estimate of \$50 million for the cost of the biomedical information complex (about 6% of total U.S. expenditures for biomedical research) is obviously conservative. The total may well be twice this figure. Either estimate represents only operating expenses and not the capital investment. If the operating cost per research worker has not increased in recent years, it is an exception to the general trend of research costs.

importance for future improvement of the system, is to demonstrate to biomedical scientists how the biomedical information complex and each of its components are integral parts of their research effort; how they, as scientists, are now involved in all of the system's major operations; and why technologic advances, expanding budgets for information services, and larger numbers of highly trained "information specialists," will increase rather than decrease the system's dependence upon their active, informed participation in all of its basic processes.

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Trends in oral communication among biomedical scientists: meetings and travel[1]

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ORR, RICHARD H., EDWIN B. COYL, AND ALICE A. LEEDS. *Trends in oral communication among biomedical scientists: meetings and travel.* Federation Proc. 23(5): 1146–1154, 1964.—This study was undertaken to provide factual bases for a broad consideration of communication problems in biomedical research and focused primarily on the formal type of oral communication, i.e., exchange of information at meetings. Data were collected on the growth in number and size of biomedical meetings, on services announcing forthcoming meetings, on international exchange of oral information, on scientists' travel, and on government support of biomedical meetings. In 1961, there were almost 500 U.S. biomedical societies, which held 1,500 regular meetings. The number of such regular meetings has trebled in the past three decades. Meetings that serve large segments of the biomedical research community have, since 1957, grown by 10–20% annually. In the past 10 years, the number of U.S. personnel working abroad in biomedical fields has increased 50%; but for other fields, the increase has been much larger. Of funds provided by the National Institutes of Health for direct support of all types of information activities, over 25% has gone to meetings. The importance of unanswered questions and the large amount of scientists' time devoted to oral communication merit more study than this mode of scientific communication has previously received and warrant increased efforts to improve both meetings and informal oral communication.

THOUGH perhaps not as frequently as complaints of "too many papers," cries of "too many meetings" are often heard today from scientists in all disciplines. Criticism of duplication among meetings and of other causes of inefficiency in oral communication are also common. Astute observers of the scientific scene view the trends in oral communication with emotions ranging from serious concern to enthusiasm. In a recent editorial, Abelson (1) remarked:

> The annual round of spring meetings reminds us that those great national gatherings are losing their effectiveness as media for scientific communication. At the recent Atlantic City meeting of the Federation of American Societies for Experimental Biology there were 3,138 papers presented and as many as 34 simultaneous sessions. There are comparable situations in other areas of science. Planning one's program of attendance on such occasions can be frustrating, for one notes numerous papers of interest but discovers that many of the attractive presentations are being given concurrently. All too often the harassed scientist cannot make up his mind and foregoes all of the choices. . . . We permit and even encourage scientists to deliver virtually the same lecture at meeting after meeting. It is annoying and wasteful to make a special effort to hear a paper only to find that the speaker is repeating, almost verbatim, material he has presented earlier.

Brookes (6), in looking at the scientific communication system, commented:

> Inevitably the scientist is beginning to find his way around the mountain of paper by organising more and more conferences at which he can meet personally those whose work most concerns him and thus re-establish direct contact, by-passing the formal channels of communication by creating informal channels that are more stimulating.

That provocative historian of science, de Solla Price (12), feels the trends he detects should be encouraged:

> The first noteworthy phenomenon of human engineering is that new groups of scientists emerge, groups composed of our maximal 100 colleagues. . . .
>
> The organization is not perfect; a few of the best men may not attend, a few of those who do attend might not qualify if we had perfect objective judgment. . . . But there is a limit to the useful size, and, if too many are invited, an unofficial subgroup of really knowledgeable members will be forced into being.
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> . . . Similar unofficial organizations exist in molecular biology, in computer theory, in radio astronomy, and doubtless in all sciences with tens of thousands of participants. By our theory they are inevitable, ... Conferences are just one symptom; it becomes insufficient to meet as a body every year, and there is a need for a more continuous means of close contact with the group of a hundred.
>
> And so these groups devise mechanisms for day-to-day communication. . . .
>
> . . . .
>
> Such groups constitute an invisible college, in the same sense as did those first unofficial pioneers who later banded together to found the Royal Society in 1660. . . . Such groups are to be encouraged, for they give status pay-off without increasing the papers that would otherwise be written to this end. . . .

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[2] This author's participation was supported by Public Health Service Grant GM 09166, from the National Institute of General Medical Sciences.

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Other thoughtful statements on oral communication could be cited, but these illustrate the main schools of thought.

Taken together, scientists' opinions on the changes that seem to be occurring suggest a number of hypotheses about oral communication, which are often conflicting. Some of the more significant of these are: *1*) that scientists are spending relatively more time in oral communication; *2*) that, for communication among contemporaries, the written record is being increasingly bypassed and relegated to serving primarily archival functions; and *3*) that meetings are becoming less effective and more wasteful of scientists' time, particularly that of senior scientists. These hypotheses merit careful, objective testing, since, if true, they have vital implications for those concerned with the rate of scientific progress and with improving communication among scientists.

Despite the importance of these implications and a growing recognition of the importance of oral communication to scientists, studies to learn more about this mode of scientific communication and projects aimed at developing improved means for oral communication have been few as compared with research and development efforts directed toward "the literature problem." Nor have important questions concerning the relation of oral communication to the literature of science been examined more than cursorily, e.g., How efficiently is orally reported information transformed into documents that become part of the scientific record? What are the relative advantages and disadvantages of oral and written communication for the various purposes to be served?

As a subject for study, oral communication poses one major difficulty not shared with other modes of scientific communication: it generally lacks concrete artifacts, such as documents, which facilitate quantitative analysis. Another major difficulty is one common to most research and development in scientific communication: there is no practical, widely accepted method for measuring directly, in terms of effect on research productivity, the value of any communication activity or service. This lack of suitable methodology rules out, for the present, any definitive test of the last of the hypotheses stated above. The validity of the first two hypotheses for the biomedical research community could be tested by known techniques, but to do this with acceptable rigor will require major projects.

In this study, our goal was limited in that we did not attempt a definitive test of these hypotheses. Rather, we collected and analyzed data on selected aspects of oral communication among biomedical scientists in an attempt to provide some factual bases for a broad consideration of communication problems in biomedical research. Our inquiry was confined largely to formal oral communication.[4] Data were collected from published materials and from unpublished records of professional societies and governmental agencies. The aim of this paper is to summarize our findings and to identify areas for future studies.

FINDINGS AND DISCUSSION

Regular Meetings of U.S. Biomedical Societies

The growth in the number of U.S. biomedical societies and their regular meetings[5] over the past three decades is shown in Fig. 1. A complete list of the U.S. biomedical societies existing in 1961, with the number of regular meetings held by each, is given in the appendix to this paper.[6] The total number of regular meetings trebled during the past 30 years. The rate of increase seems to have accelerated sometime in the late 1940's or early 1950's.[7] State and local societies typically hold more meetings than national and regional organizations—in 1961, an average of 4.2 per year per society vs. an average of 1.6 for national and regional organizations. Such societies accounted for about four-fifths of all regular meetings in 1961, a larger proportion than in 1948 or earlier; since the average meeting frequency for national and regional societies and for state and local societies has remained fairly constant, this change reflects the faster growth in the number of state and local societies. The over-all increase in meetings is secondary to the proliferation of societies.

Meeting Announcement Services

One of the ways in which scientists commonly learn of forthcoming meetings, other than those of their own societies, is through lists of meetings published in journals or lists compiled and distributed by special services set up specifically to perform this function. These two kinds of activities represent different types of meeting announcement services. Of the journal announcement services, *Science* and the *Journal of the American Medical Association* (*JAMA*) provide the most comprehensive listings of biomedical meetings. Of the special meeting announcement services, the most widely available and useful to the biomedical research community probably are: *Scientific Meetings*, Special Libraries Association, Science-Technology Division (first issue, 1957); *18-Month Calendar of National Meetings*, Office of the Surgeon

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[4] Oral communication can be classified as formal or informal, the formal type being all oral exchanges that are structured by the formalities of events planned for oral communication (e.g., lectures, symposia, and conferences) and the informal type constituting all other oral exchanges, face-to-face and by telephone.

[5] Events planned for oral communication fall into two categories: *1*) regular, i.e., meetings convened periodically on a continuing basis (e.g., annual meetings of societies), and *2*) ad hoc, i.e., meetings convened for a purpose that can be served by one event, or a short series of events.

[6] A copy of the appendix can be borrowed from the National Library of Medicine by initiating an interlibrary loan request for: *Appendix* to Orr, Richard H., Edwin B. Coyl, and Alice A. Leeds. Trends in oral communication among biomedical scientists: meeting and travel. *Federation Proc.* 23: 1146–1154, 1964.

[7] The regular alternation of plateaus with growth spurts suggested by the curves for both societies and meetings is probably artificial. One possible explanation is differences in the way successive editions of the source document were compiled.

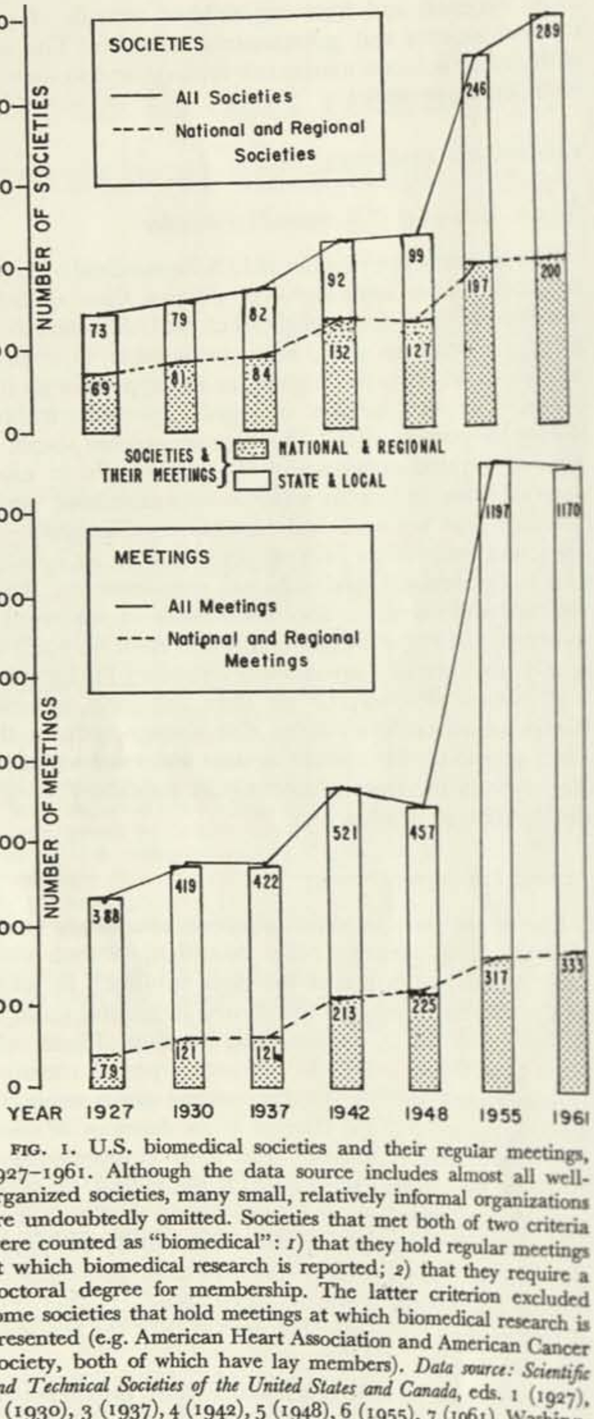

FIG. 1. U.S. biomedical societies and their regular meetings, 1927–1961. Although the data source includes almost all well-organized societies, many small, relatively informal organizations are undoubtedly omitted. Societies that met both of two criteria were counted as "biomedical": *1*) that they hold regular meetings at which biomedical research is reported; *2*) that they require a doctoral degree for membership. The latter criterion excluded some societies that hold meetings at which biomedical research is presented (e.g. American Heart Association and American Cancer Society, both of which have lay members). *Data source: Scientific and Technical Societies of the United States and Canada*, eds. 1 (1927), 2 (1930), 3 (1937), 4 (1942), 5 (1948), 6 (1955), 7 (1961). Washington, D.C.: National Academy of Sciences-National Research Council.

General, U.S.P.H.S. (first issue, 1958); and the *World List of Future International Meetings*, Part I. Science, Technology, Agriculture, Medicine, U.S. Library of Congress (first issue, 1959).

The journal services depend largely upon notices sent to editors by meeting organizers and societies. The special services rely chiefly upon scanning large numbers of journals for information on forthcoming meetings. The coverage achieved by either type of meeting announcement service, therefore, ultimately depends upon the initiative of meeting sponsors in sending out notices.

The numbers and types of biomedical meetings held in 1956 and in 1962, and announced by a combination of the major services, are shown in Fig. 2.[3] For 1956 meetings, only 7% of all biomedical meetings announced by the services studied were of the ad hoc type; for 1962 meetings, the corresponding ratio was 16%.

Completeness of combined coverage. A rough idea of the completeness of coverage provided by the combination of major services studied can be obtained by comparing the total number of 1962 meetings in the United States and Canada that were announced (408) with the total number of regular meetings held by U.S. biomedical societies in 1961 (1,500) (Fig. 1). The contrast between these two figures becomes more marked when one considers that the former figure includes some Canadian meetings and ad hoc meetings, which are not included in the latter figure. It is apparent that only one out of four regular meetings of U.S. biomedical societies are announced by these major services collectively.

A reasonable assumption is that most of the meetings announced by these services were those of national and regional societies, rather than of state and local organizations. Considering the extensive and lengthy planning and preparation that is usual for international meetings, it seems highly probable that at least one of the major announcement services learns about such meetings and, therefore, that coverage of international meetings, by the combination of services, has been consistently good. For ad hoc meetings, one would expect coverage to be less complete, because the distribution of notices is likely to be less systematic than for regular meetings and international meetings. Of all 1956 meetings, 80% were held in the United States and Canada, as compared to 52% in 1962. It can be seen that international meetings account for most meetings held "elsewhere," i.e., other than in the United States and Canada (see bars for "all meetings," Fig. 2). The remainder are largely meetings convened by foreign organizations that did not meet our criteria for international meetings. Coverage of the latter type of meeting by U.S. services is undoubtedly quite incomplete.

The number of "all meetings" announced by the combination of services increased by 48% in the 6-year period (1956–1961); whereas, announcements of ad hoc and international meetings increased during the same period by 206% and 117%, respectively. The fact that relatively more ad hoc and international meetings were announced does not necessarily mean that relatively more of these types of meetings were held. However, it seems likely that the striking increases in announcements do reflect actual changes in the frequency of these two types

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[3] The same meeting was very commonly listed by more than one service. The numbers used in Fig. 2 were obtained by counting a given meeting only once.

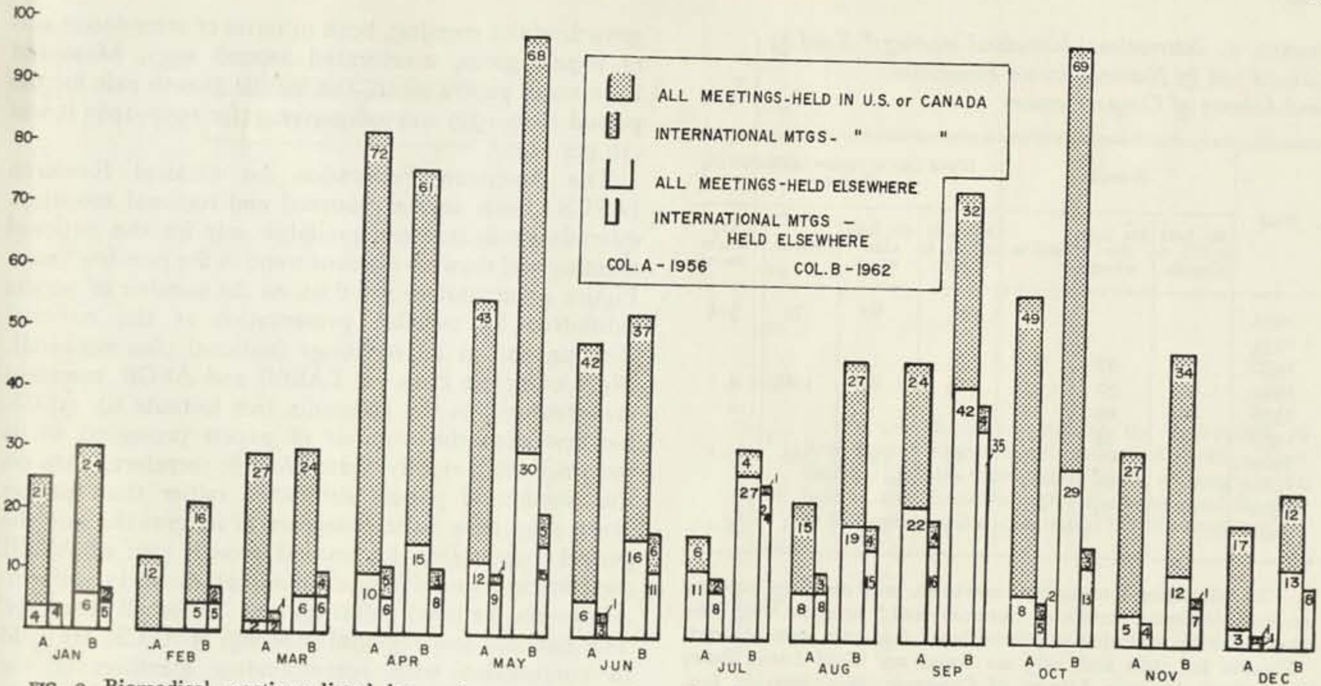

FIG. 2. Biomedical meetings listed by major announcement services for 1956 and 1962. International meetings are included in the totals for "all meetings." In tabulating international meetings, only meetings listed by an announcement service as "international," or those with titles that explicitly indicated an international character, were counted. *Data sources:* for 1956 meetings—*Science*, Dec. 2, 1955, thru Dec. 21, 1956; *JAMA*, Jan. 7, 14, 21, Feb. 25, Mar. 24, Apr. 28, May 26, June 30, July 28, Aug. 25, Sept. 29, Oct. 27, Nov. 24, and Dec. 8, 1956; *International Associations*, Jan. thru Dec. 1956; *List of International Conferences and Meetings*, Oct. 1 1955, Apr. 1, 1956, July 1, 1956, Oct. 1, 1956. For 1962 meetings—*Science*, Oct. 1961, thru Dec. 1962; *International Congress Calendar*, 1962 ed.; *World List of Future International Meetings*, Pt. 1, Oct. 1961, Jan., Mar., May, July, Sept., and Nov. 1962; *Scientific Meetings*, Science Technology Div., Special Lib. Assoc., Oct. 1961, Jan., Apr., and Oct. 1962; *JAMA*, Oct. 28, Nov. 25, 1961, Jan. 27, Feb. 24, Mar. 24, Apr. 28, May 26, June 23, July 28, Aug. 25, Sept. 29, and Oct. 27, 1962.

TABLE 1. *U.S. and Canadian biomedical meetings listed by selected services*

Year	*Science**		*JAMA*†		*USPHS Calendar*‡	
	No. meetings	Avg. length (days)	No. meetings	Avg. length (days)	No. meetings	Avg. length (days)
1951			200	2.6		
1956	80	4.1	212	3.2		
1957	94	3.5				
1958	72	3.6			94	3.7
1959	145	3.5			128	3.8
1960	165	3.7			95	3.4
1961	127	3.7	241	3.2	151	3.9

* Count includes all meetings of U.S. biomedical societies listed in the appendix to this paper (see footnote 6) and other meetings whose subject or sponsor indicated a likelihood that biomedical research was reported. † *Journal of the American Medical Association.* ‡ *18-Month Calendar of National Meetings*, Office of the Surgeon General, U.S.P.H.S.

of meetings, rather than simply more complete coverage by the services.

Coverage of individual services. The number of meetings announced by any given service depends upon how many it is informed about and its selectivity. Table 1 gives the total number of U.S. and Canadian biomedical meetings announced by each of the two most comprehensive journal services and by a widely available special service for biomedical meetings. In the period shown, the numbers of biomedical meetings announced by *Science* and by *JAMA* seem to have increased significantly. Of these three services, *JAMA* listed the largest number of 1961 meetings; but this number, which included both regular and ad hoc meetings, was only about one-sixth the number of regular meetings of U.S. biomedical societies alone (1,500).

Table 2 compares the number of international meetings announced by *Science* and by a special service for international meetings. Over the past decade, the figures for both services indicate a definite increase in the number of international meetings announced. *Science* shows the larger relative increase; but the number of 1962 meetings announced in the *World List of Future International Meetings* more closely approximates the total number announced by a combination of major services (86 in 1956 and 187 in 1962).

Length of Meetings

The relatively long average length of the U.S. and Canadian meetings announced (Table 1) probably reflects the fact that these were largely national and regional meetings, which tend to run longer than state and local meetings. International meetings are, on the average, significantly longer than other types (Tables

TABLE 3. *Growth of FASEB meetings vs. growth of U.S. biomedical research manpower*

Year	FASEB Meetings		U.S. Biomedical Research Manpower	
	Attendance	Papers	Total	Full-time equivalents
1954	6,453	1,539	19,200	14,000
1958	9,136	2,111	34,600	23,100
1960	11,015	2,654	39,700	27,285
Annual growth rate* (1954–1960)	.12	.12	.18	.16

* Annual growth rate = (b − a)/a·t, where b = value for last year of period, a = value for first year of period, and t = number of years in period. *Data sources:* FASEB records; for U.S. biomedical research manpower, ref. 14.

TABLE 4. *Per cent of NIH research grants expended for travel**

Year	Research Grants (millions)	% Domestic Travel	% Foreign Travel	Total % Travel
1947	$ 3.6			1.67
1949	13.6			1.83
1951	17.7			1.95
1956	39.6			2.54
1958	99.7	2.15	0.23	2.38
1960	202.9	2.15	0.38	2.53

* These figures exclude travel charged to training and fellowship grants, research contracts, or grants made expressly to support meetings. *Data source:* Office of the Assistant to the Director of NIH for Scientific and Technical Information, Aug. 1, 1963; based on samples of grant expenditure reports for the given years (for fiscal year 1960, the sample consisted of 1,008 grants).

scientific and technical personnel with grants to "work"[10] in foreign countries, and also corresponding data on foreign nationals working in this country.

The number of U.S. biomedical personnel working abroad increased some 50% between 1952 and 1962, while the corresponding increase for personnel in fields related to biomedicine (agriculture, anthropology, biology, chemistry, and psychology) was almost three times greater (140%). The increase in fields less closely related to biomedicine (e.g., physics and engineering) has been even more marked. As for foreign personnel working in the United States on grants, the increase in biomedical fields has been only about 30%, as compared to over 140% for workers in related fields. In the biomedical field, the ratio of the number of Americans working abroad to foreign nationals working in the United States has changed little (9/100 in 1952 and 11/100 in 1962). In 1952, 63% of the American personnel working abroad in biomedical and related fields were in Europe (including the British Isles); whereas, in 1962, the percentage had dropped to 52%. In 1952, 64% of the aliens with grants to work in the United States in these same fields came from Europe, but in 1962, this figure was only 32%.

For 1959–1961, the State Department has compiled data on all travel by scientific and technical personnel to and from the Soviet Union and Eastern Europe; these data are, however, not broken down by scientific field. During these years, about half again as many Americans visited "Iron Curtain" countries as citizens of these countries visited the United States. Poland, Hungary, and Romania, however, were exceptions, in that they sent more visitors than they received from the United States. The figures from year to year are characterized by marked variations probably explained, at least in part, by large international congresses and changes in the cold-war climate. A detailed breakdown of all data on international exchange is given in the appendix (see footnote 6).

Support of Meetings

Numerous federal agencies make grants or contracts specifically to support meetings at which biomedical research is reported. Of these, the Department of Health, Education, and Welfare (HEW) contributes the most support, largely through the National Institutes of Health (NIH). Table 5 indicates HEW and NIH expenditures for direct support of meetings. The basis on which federal agencies reported their expenditures for meetings has been changing; and the significance of the apparent decrease, both in terms of dollars and in percentage of total extramural research funds, cannot be assessed from the information presently available.[11] Table 5 also shows total expenditures for direct support of all types of information activities. For the same reason, the apparent changes cannot be evaluated. The data, however, do allow some comparisons. Over the 4-year period, NIH expenditures for extramural support of meetings accounted for over 25% of NIH expenditures for extramural support of all types of information activities; all direct support of information activities amounted to less than 2% of total research grants over the same period.

If the figures for indirect support (i.e., travel charged to NIH research grants, Table 4) are added to those for direct NIH support of meetings, the sum represents a gross approximation of all NIH extramural support for informal and formal oral communication activities. For 1960, this total came to around $6.5 million, or 3.2% of NIH research grant funds in that year.

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[10] As used here, "work" includes studying or teaching, attending meetings, and visiting laboratories. The State Department reports do not cover all foreign travel that is financed by institutional or personal funds, charges against research project funds, and special grants for international congresses.

[11] The difficulties are compounded when one attempts to compare data from different sources. For example, the source for data in Table 4 indicated that in fiscal year 1962, NIH awarded $840,000 for direct support of international meetings alone. If this amount is subtracted from the figure for NIH extramural expenditures in Table 5, the difference ($124,000) seems too small to represent all direct NIH support for domestic meetings.

TABLE 5. *Direct federal support for biomedical meetings*

Fiscal Year	Agency	Expenditures for Meetings (thousands)			Expenditures for All Types of Information Activities (thousands)		
		Intra-mural	Extra-mural*	Total	Intra-mural	Extra-mural*	Total
1960	HEW	$364	$1,638	$2,002	$5,008	$4,515	$ 9,523
	NIH	163	1,417 (.70%)	1,580	1,950	4,171 (2.1%)	6,121
1961	HEW	570	1,887	2,457	6,096	5,815	11,911
	NIH	348	1,679 (.57%)	2,027	2,297	5,419 (1.8%)	7,716
1962	HEW	657	1,341	1,998	7,165	7,134	14,299
	NIH	393	964 (.22%)	1,357	2,740	5,869 (1.4%)	8,609
1963†	HEW	762	1,038	1,800	8,128	6,928	15,056
	NIH	423	780 (.18%)	1,203	3,038	4,665 (1.0%)	7,703

Figures for NIH support are included in HEW figures. Figures on intramural expenditures for meetings include costs of "all efforts directed toward planning, scheduling, announcing, supporting, sponsoring, conducting, and attending symposia, conferences and meetings held primarily for the discussion, exchange and oral dissemination of scientific and technical information." Travel and subsistence costs of federal employees participating in such meetings are included. Figures on extramural expenditures for meetings are limited to grants or contracts with individuals and organizations outside the government which have as their primary purpose the support of a scientific meeting. Travel and subsistence paid by participants from regular research grants are, therefore, not included. "Expenditures for all types of information activities" include costs of publication and distribution, bibliographic and reference services, and research and development in scientific communication, as well as scientific meetings; as with meetings, the figures for extramural expenditures include only grants and contracts made primarily to support information activities. * Percentages in parentheses relate the given figure to total NIH research grant funds (excluding fellowships and training and construction grants) in that fiscal year. These totals were $203 million for 1960, $294 million for 1961, $434 million for 1962, and an estimated $450 million for 1963 (Office of Special Assistant to the Director for Scientific Communication of NIH). † All data for 1963 are based on budgetary estimates. Data sources: NSF-61-82, NSF 63-11.

Other Studies of Oral Communication

Although the limited goals of the present study precluded systematic investigation of the critical hypotheses and important questions posed in the introduction to this paper, we reviewed reports of other studies for methods that might be used to obtain definitive data on oral communication, and for suggestive data relating to the hypotheses. Probably the only accurate estimate of the time scientists spend in oral communication is that developed in Ackoff's study of chemists (7). He found that academic chemists devote 18.4% of their working time to oral communication of scientific information, as contrasted to 5.5% for reading. It seems unlikely that biomedical scientists are grossly different from chemists; but serial time-studies are required to assess the changes that are presumably occurring. Studies by Glass (9) and Menzel (10) on small samples of biological scientists have demonstrated qualitatively the importance of oral communication for acquiring needed information and for learning of work of major significance. Very recently, the Biological Sciences Communication Project reported some of the results of a study of informal modes of communication by personnel in selected biological and biomedical research laboratories (5). The complete results of this study may contribute materially to an understanding of the relative importance of oral and written communication. As part of an integrated series of studies being conducted by the American Psychological Association, Garvey and Griffith assessed the effectiveness of scientific meetings in serving some of the expressed needs of the psychologists who attend (2) and investigated how often and when oral reports become part of the written literature (3, 4). Their findings on the publication fate of oral reports agreed, in broad outline, with those of a study of biomedical scientists (11) and confirmed previous evidence that factors other than the quality of the work affect when and whether the results of research reach publication after having been given as an oral report.

CONCLUSIONS

1) The large increase, over the past few decades, in the number of meetings at which biomedical research is reported has not exceeded the increase in the number of scientists engaged in such research and is a direct consequence of this growth in manpower, as is the increase in the size of the larger research meetings.

2) None of the major journal or special services that announce forthcoming biomedical meetings, nor a combination of these services, approaches complete coverage of U.S. meetings, even if ad hoc and state and local meetings are excluded. Whether omissions in the meetings listed by a given service result primarily from selectivity aimed at tailoring the service for its clientele, or from lack of information, cannot be clearly determined from the present data; however, the latter explanation appears more likely.

3) The amount of information exchanged orally between U.S. biomedical scientists and foreign colleagues has probably increased as a result of more international meetings and travel; however, whether this absolute increase represents a relative improvement in international exchange is uncertain.

4) The typical biomedical scientist may be traveling more than he did several decades ago. Whether this increased travel speeds research progress or represents a substitute for other modes of communication that are more economical, in terms of funds and scientist-time, remains to be determined.

5) Federal expenditures for activities associated with oral communication account for a major fraction of total government support for biomedical information activities and services of all types. No criteria exist to judge whether this apportionment of funds is optimal.

6) The importance of oral communication as a means of information exchange, and as an activity that absorbs large amounts of scientists' time, warrants substantially more effort devoted to studying this mode of scientific communication and to improving the mechanisms for both formal and informal oral communication.

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Document retrieval: the national biomedical library system and interlibrary loans[1]

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Orr, Richard H., and Vern M. Pings. *Document retrieval: the national biomedical library system and interlibrary loans.* Federation Proc. 23(5): 1155–1163, 1964.—By 1965 improved reference retrieval services, such as those to be provided by the Medical Literature Analysis and Retrieval System (MEDLARS) of the National Library of Medicine (NLM), will enable biomedical scientists to obtain references to relevant documents more easily, and from a broader segment of the world's scientific literature, than at present. References to relevant material are, however, of no value to the scientist unless he can obtain the documents referred to (document retrieval). The aim of this study was to explore the likely impact of improved reference retrieval services upon the present "system" that supplies the biomedical scientist with the documents he requests, i.e., the biomedical library "system." By reviewing past studies, considering available evidence, and collecting such new data as time and resources permitted, the document retrieval operations of this system were analyzed. From their own collections, biomedical libraries supply varying percentages of the total documents requested by their respective local biomedical communities. They meet the remaining requests by calling on other libraries for interlibrary loans. The volume of these loans has been increasing by about 10% a year and presently exceeds 500,000 documents annually. The cost of maintaining this flow is over $2 million per year. Current signs of strain indicate that the system, as presently operated and financed, has reached its maximal capacity to meet the demand for interlibrary loans and is critically unstable. Present evidence indicates that this demand may reach one million documents annually by 1965. The capacity of the system must be increased rapidly if biomedical scientists are to benefit from the new and improved reference retrieval services that will soon be available. There are three major alternatives for a long-term program to meet this challenge: *1*) increase the capacity of NLM to furnish photocopies to libraries on request, *2*) establish regional loan centers, and *3*) develop the collections of local biomedical libraries to reduce the need for interlibrary loans. As an interim measure, subsidy of interlibrary loan operations is suggested.

The term "information retrieval" is currently applied loosely to any service, device, or means for performing one or more of the following functions: *1*) finding references to documents that may contain needed information; *2*) supplying documents, given references to them; *3*) providing the specific information required to answer a question. In the literal sense, only the last function represents true information retrieval. The first function is better called "reference retrieval," and the second should be termed "document retrieval."

Although reference retrieval is useful to a scientist only as a preliminary to document retrieval, the fact that these two functions must be closely coupled to satisfy his needs is often ignored in proposed solutions to his information problems. A machine or system that, within minutes, supplies him with a list of references represents little in the way of a practical advance if the documents referred to cannot be obtained with ease and speed. Despite the obvious interdependence of these two functions, current attention is focused largely on ways to provide new and improved reference retrieval services. The necessity for parallel improvements in document retrieval services is commonly overlooked, or present document retrieval services are assumed to be adequate to meet the new demands that will be imposed on them by improved reference retrieval.

The general aims of this study were: *1*) to determine how the improved reference retrieval services that can be expected within the next few years will increase and change the demand for delivery of biomedical documents, and *2*) to examine the adequacy of present means for meeting this demand. For this analysis, we assumed that by 1965 some of the current plans for major improvements in reference-type services for biomedical scientists will be realized and that these services will be utilized. For example, full operation of the MEDLARS[3] program (12) of the National Library of Medicine (NLM) was postulated.

APPROACH

In pursuing these general aims, our approach employed the following steps: *1*) to analyze the personal and institutionalized sources on which the biomedical scientist calls to obtain a document, once he has a reference to it; *2*) to assess the relative importance of

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[3] Medical Literature Analysis and Retrieval System.

these sources; *3*) to describe the major institutionalized sources (biomedical libraries) as a national system for delivering documents on request (document retrieval); *4*) to determine past trends in the total demand for document retrieval and estimate the capacity of the present biomedical library system for document retrieval; *5*) to predict the probable quantitative and qualitative changes in demand that will result from new reference retrieval services; and *6*) to compare the capacity of the present system with the probable demand in 1965.

Previous studies were reviewed; however, few provided data suited to our purpose. Some biomedical libraries publish annual reports, and these were useful when they provided data on document retrieval loads. To supplement the meager data available, and to test the assumptions made in estimating the volume of interlibrary loans, we conducted a modest survey, which is described later.

RESULTS AND DISCUSSION

Scientists' Sources of Documents

Faced with the need to obtain a document (an article, book, or report) that he can identify specifically (e.g., a document referred to in an article he has read), a scientist has six major sources to which he may turn:

1) He can sometimes find it in his personal collection of reprints, journals, and books.

2) He can ask a colleague who may have it, or he can write the author for a reprint.

3) He can request a copy from the publisher, or from various types of special services, e.g., book dealers, the Office of Technical Services of the Department of Commerce (for technical reports of government-supported research), or such services as the Excerpta Medica Foundation and the Institute for Scientific Information (for articles listed by their respective reference retrieval services, *Excerpta Medica* and *Current Contents*).

4) He can visit the library of his immediate working unit (department or laboratory), if such exists.

5) He can call on the resources of the main libraries of his institution.

6) He can use a local library outside his institution.

The first two possibilities constitute personal or informal sources. The last four represent services set up expressly to deliver documents on request, i.e., institutionalized or formal sources. A scientist's strategy for deciding in what order to try the different sources depends on many variables, including the nature and age of the document wanted, the urgency of his need, the relative effort and cost involved in using different sources, his knowledge of their respective holdings, and his previous experience in using them.

Little evidence is available that bears directly on the relative quantitative importance of various sources, i.e., what percentage of a biomedical scientist's needs for specific documents are filled by each of the different sources.[4] The relevant literature consists largely of more-or-less educated guesses. A reasonable hypothesis is that the typical academic biomedical scientist calls on his local services—the library of his working unit, and the other libraries of his institution—for 10–15% of the specific documents he needs; however, about all that can be said with certainty is that his local services are the formal sources he most frequently turns to for needs not satisfied by his informal sources.

The National Biomedical Library System

His local services are part of an informally organized system that has evolved to make the nation's total resources in biomedical documents available to any library. All libraries whose primary function is to serve local or regional communities can be considered to constitute, collectively, the local level of the system. The National Library of Medicine, whose primary mission is to serve the entire country, is the chief national-level component. Any local-level library may borrow documents from, or lend documents to, any other local-level component of the system. NLM satisfies the residual demands not met at the local level of the system. This view represents a considerable simplification of the system's operation,[5] but it is useful for the present analysis.

Table 1 summarizes the resources of the principal components of this system, i.e., the libraries that can be readily identified as biomedical.[6] The geographical distribution of these resources is shown in the appendix to this paper.[7] One-fourth of the biomedical libraries are in academic institutions; these libraries account for one-half of the total number of volumes in all biomedical libraries.

A biomedical scientist interacts directly with only the local level of the system, primarily with his own local services but occasionally with more distant libraries.[8] The remainder of the system is, for him, a "black box." How his request is filled does not concern him, only whether it is filled and how quickly. He requests a document from his local library, which first tries to fill this request from its own collection. If this is not possible, his library usually borrows the needed document from another local-level library (sometimes in

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[4] One study of eminent scientists in all disciplines indicated that the most common sources they used to obtain specific journal articles were authors, libraries, and publishers, in that order (3).

[5] For example, transactions with foreign libraries are ignored.

[6] That many other libraries deal, at least to some extent, with biomedical documents is indicated by the fact that in 1959 NLM loaned documents to 1,417 different libraries within the United States (6).

[7] A copy of the appendix can be borrowed from the National Library of Medicine by initiating an interlibrary loan request for: *Appendix* to Orr, Richard H., and Vern M. Pings. Document retrieval: the national biomedical library system and interlibrary loans. *Federation Proc.* 23: 1155–1163, 1964.

[8] The document retrieval services of NLM are available to him only through a local-level library, unless he visits NLM in person.

TABLE 1. *Principal resources of the national biomedical library system*

Type of Institution	1 No. Libraries	2 % of Total Libraries	3 No. Volumes Held	4 % of Total Volumes	5 Avg. No. Vol./ Library
Academic	143	26.8	6,129,400	50.0	43,000*
Federal (other than hospitals)	39†	7.3	2,012,900†	16.3	26,000‡
Professional	53	9.9	1,855,300	15.1	35,000
Hospital	241	45.0	1,558,100	12.7	6,500
Industrial	44	8.2	414,900	3.8	9,400
Public	7	1.3	197,600	1.6	28,000
Foundation	8	1.5	71,400	0.5	8,900
Totals	535	100.0	12,239,600	100.0	

Explanation of categories: *Academic*—Certain types of university libraries, e.g., biology and biochemistry department libraries, although they might be classified as biomedical, were excluded because consistent or complete information was not available. However, department libraries identifiable as medical, dental, or pharmaceutical were included. *Professional*—Libraries presently operated by a professional society, or originally established to serve the medical profession. *Hospital*—Private and governmental hospitals, including federal hospitals (e.g., Veterans Administration). *Public*—Libraries whose funds are derived from local taxes, or which have defined their primary function as serving the general public. * The collections of medical school libraries are larger, on the average, than other academic biomedical collections. For 75 U.S. medical schools in 1962–1963, the average collection contained 77,000 volumes (range 6,000–353,000 volumes) (5). Since these collections are growing about 5% annually, this average cannot be compared directly with the average given here for academic collections, which is based on data several years older. † Includes NLM, whose holdings exceeded one million volumes in 1962 (7). ‡ Excludes NLM. *Data sources* for columns 1 and 3: Ash, L. *Subject Collections*, 2nd ed. New York: Bowker & Co., 1961; and Medical Library Association *Directory*, 1959. Only libraries listed in these two sources were included in this tabulation.

other parts of the country) or calls on NLM. Occasionally, the document is ordered from the publisher.

The operations entailed in an interlibrary loan transaction are summarized in Fig. 1.[9] This transaction is much the same whether an original document or a photocopy is obtained, except that the former must be returned and the latter may require processing an invoice for charges to cover the lending library's costs for photocopying.

Figure 2 illustrates the complex interactions among libraries, using as an example, the relations of one academic library (Wayne State University Medical Library) with other local-level libraries and with NLM. In one year, this library borrowed 102 documents from 17 other local-level libraries, largely in the Midwest, and 67 documents from NLM. The total number of documents it borrowed (169) is small compared with the number (4,709) it loaned to 72 other local-level libraries. Details of Wayne State Medical Library's borrowing and lending transactions with other libraries are supplied in the appendix (see footnote 7). As might be expected, libraries with larger collections, in general, borrow relatively little and are primarily lenders; whereas the opposite is true of libraries with smaller collections. These data illustrate this phenomenon, which is important for understanding the problems of the system; the number of documents this medical school library (total holdings about 67,000 volumes) loaned to each of six smaller libraries exceeded the total of its own borrowing from all sources. Medical school libraries are, in general, primarily lenders; as a group they lend about two documents for every one they borrow (5).

Volume of Document Flow in the System

Table 2 gives the numbers of documents loaned by six local-level libraries for the years 1958–1961 and cites the corresponding figures for NLM. These libraries are not a representative sample of biomedical libraries; they were selected only because they had reported on their borrowing and lending over several years.[10] From the data for these six academic and professional libraries, it can be seen that the flow of documents originating at the local level of the system must be considerably greater than that from the national level (NLM loans). In 1961, the Library of the College of Physicians of Philadelphia alone provided almost one-sixth as many loans (16,035) as the National Library of Medicine made to all U.S. libraries (87,000).

If one knew either the number of documents loaned, or the number borrowed, by each of the local-level components of the system, it would be possible, since figures for NLM loans to U.S. libraries are known, to establish both the total flow of documents in the system (from lender to borrower),[11] and the load carried by local-level libraries collectively (total document flow minus NLM loans). Lacking these comprehensive statistics, the collective local-level contribution, i.e., the local-level flow, can be estimated from the figures for NLM loans to U.S. libraries (national-level flow), provided an approximate ratio of national-level to total flow can be established. In an attempt to establish such a ratio and to obtain a general idea of recent changes in the total volume of borrowing, we conducted a small questionnaire survey of biomedical libraries. The results are shown in Table 3.

If the respondents to this questionnaire are assumed to be representative of the local-level components in the national biomedical library system, then the total

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[9] A detailed analysis of intra- and interlibrary operations associated with loan transactions is available in *Medical Library Report No. 1*, Wayne State University, January 1964.

[10] A recent report gives these statistics for most U.S. and Canadian medical school libraries (5); however, the data are for only one year (1962–1963), and medical school libraries are only one type of biomedical library.

[11] The return of documents to the lending library is ignored here. The total number of documents borrowed within the system equals the total number loaned, and either quantity represents the total flow in the system.

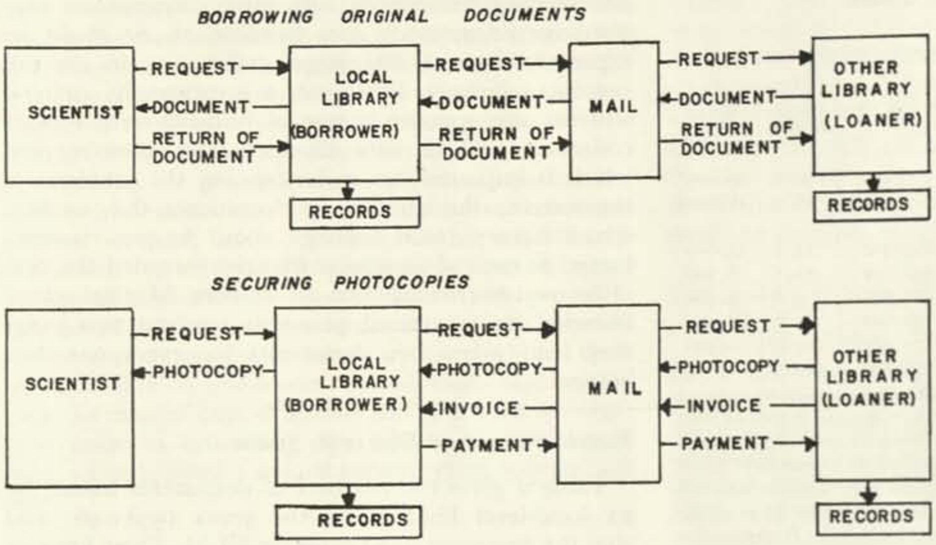

FIG. 1. The interlibrary "loan" transaction.

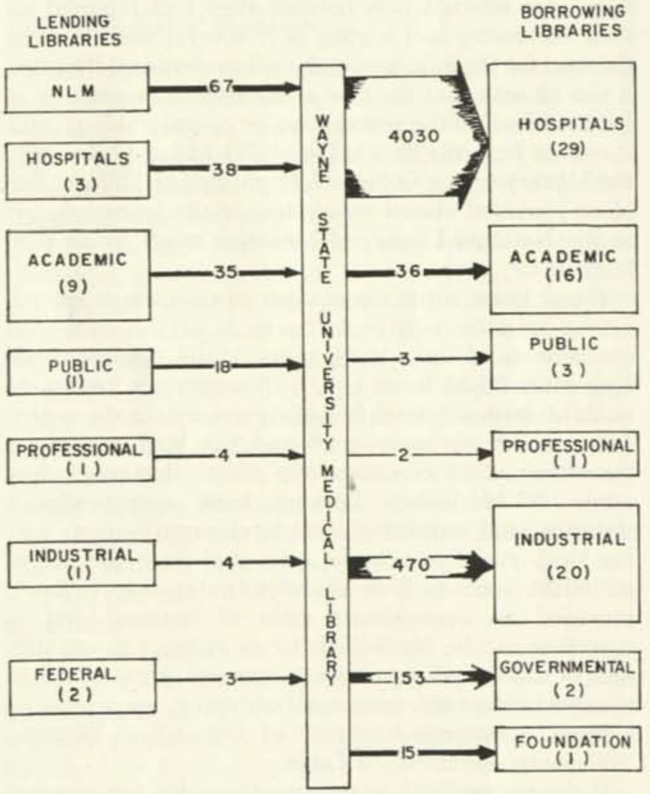

FIG. 2. Interlibrary transactions of Wayne State University' School of Medicine Library (June 1962–May 1963). The parenthetical figures inside boxes indicate the number of libraries in the given category. The arrows indicate direction and volume of flow (numbers of documents). Libraries are classified here in the same general way as in Table 1, except that the category "governmental" among borrowing libraries includes municipal as well as federal establishments, and that NLM is shown as a separate category of lending libraries, rather than being included under federal libraries.

amount of borrowing, hence the total document flow in the system, increased by about 10% per year from 1959 to 1962. This rate of increase is close to that for U.S. biomedical research manpower from 1958 to 1960, which was 9% per year in "full-time equivalents" (11). In this sample of libraries, about 15% of all borrowing during 1959 was from NLM. That this ratio of borrowing from NLM to all borrowing (i.e., the ratio of national-level to total flow) may be reasonably valid for the larger universe of all local-level libraries that handle biomedical documents is suggested by some preliminary findings of a study of libraries in the New York area. Of over 41,000 interlibrary requests initiated in 1963 by 153 libraries in this area, 20% were directed to NLM, and about 18% of the total number of documents these libraries borrowed came from NLM (L. Ash, personal communication).[12]

The total borrowing by the 50 libraries in our sample is plotted in Part B of Fig. 3 and compared with NLM loans to U.S. libraries and with loans by six academic and professional libraries (Table 2) during the same period. In Part A of Fig. 3, alternative estimates of the total flow of biomedical documents in the system are shown. Using 15% as the ratio of borrowing from NLM to all borrowing, the total flow in the system in 1959 can be estimated as 390,000 documents. Borrowing by the 50 libraries in the sample increased by about 10% annually; 10% annual increase projected from this estimate of total flow in 1959 would give a total flow of approximately 570,000 for 1963. On the other hand, if one assumes that the ratio of borrowing from NLM to all borrowing was the same in 1963 as it was in 1959 (15%), the total flow for 1963 would be estimated as around 720,000 documents.

While total borrowing by the sample libraries was increasing at 10% annually from 1959 to 1962, the number of NLM loans was increasing more rapidly (about 20% annually). This suggests that NLM was providing a greater proportion of all loans in 1962 than in 1959 when the ratio was 15%, and that the estimate of 1963 flow based on the 1959 ratio may be high.[13]

Relation of Interlibrary Document Flow to the Total Demand on System

The total interlibrary flow of documents represents only residual demand, i.e., the fraction of total user

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[12] During the same period, these libraries received over 43,000 interlibrary requests for documents.

[13] It is interesting, though probably accidental, that an estimate of total flow for 1963 based on the 18% ratio tentatively established for New York area libraries in 1963 would be about 600,000

TABLE 2. *Number of documents loaned to other libraries by six biomedical libraries during the years 1958–1961*

	No. Documents				% Increase 1958–1961
	1958	1959	1960	1961	
College of Physicians of Philadelphia Library	6,926	9,161	13,359	16,035	131
Texas Medical Center Library, Houston	1,683	1,973	1,746	2,374*	41
Louisiana State University School of Medicine Library	2,987	3,584	3,520	3,442	15
Harvard University, School of Medicine and Public Health Library	1,881	1,700	2,454	1,903	1
University of Alabama, Medical Center Library	490†	554	601	724	48
Wayne State University, School of Medicine Library	3,247	3,870	3,192	4,412	36
Totals	17,214	20,842	25,592	28,890	68
National Library of Medicine‡	59,946 (48,000)	72,728 (58,000)	95,595 (76,000)	109,258 (87,000)	82

* Interpolated from 1960 and 1962 reports. † Extrapolated from 1959–1961 reports. ‡ Figures represent total loans (U.S. and foreign) and are for fiscal years. That for 1958 is not strictly comparable to those for later years, as NLM adopted a new policy on interlibrary loans in September 1957. Figures in parentheses are estimates of NLM loans to U.S. libraries alone and are calculated as 80% of its total loans. This percentage is based on calendar year 1959, for which a complete breakdown of NLM loans is available (6). For other years, the annual reports of NLM give the domestic-foreign breakdown for photocopy "loans" but not for loans of original documents. If the domestic-foreign ratio for photocopies also holds for original documents (which actually account for only a small fraction of loans), between 77 and 82% of all loans in fiscal years 1958–1963 were to U.S. libraries. *Data sources:* Annual reports of the given libraries.

demand on local-level libraries that cannot be met from their own collections. Very few biomedical libraries have data on what proportion of all document requests they fill from their own collections. This proportion represents a "self-sufficiency" index. Esterquest (2) has proposed a hypothesis that relates the size of a biomedical collection to its self-sufficiency in serving research workers. This hypothesis is stated graphically in Fig. 4. There are few data to test this curve, particularly in the critical portion, where most biomedical libraries fall (95 % of biomedical libraries have less than 100,000 volumes).[14] In addition, factors other than mere number of volumes also determine a library's self-sufficiency, e.g., characteristics of the collection (the relative emphasis on journals vs. books, the proportion of old material to new, etc.) and the nature of the population served. It seems unlikely that the hypothesis is valid for other than university libraries; and even within this category of libraries, the curve probably does not apply to collections that have been established fairly recently and have concentrated on building a file of relatively recent (last 10–20 years) issues of the most frequently used biomedical journals. Such collections will undoubtedly meet a higher proportion of requests than those equal in size but containing larger amounts of older journal and monographic material.[15]

TABLE 3. *Borrowing by sample of U.S. biomedical libraries*

Type of Institution	No. in Sample	% of All Respondents	All Documents Borrowed			Documents Borrowed from NLM in 1959	
			1959	1962	% Increase	No.	% All documents borrowed
Academic	6	12	3,960	5,687	44	954	24
Federal (other than hospitals)	4	8	672	1,343	100	213	32
Professional	4	8	883	982	11	42	5
Hospital	21	42	8,123	10,487	29	1,208	15
Industrial	11	22	3,005	4,053	35	100	3
Foundation	2	4	634	644	2	112	18
Other	2	4	503	683	36	19	4
Totals	50	100	17,780	23,879	34	2,648	15

The classification used here is the same as in Tables 1 and 2. The number of documents borrowed from NLM by each of the libraries in the sample was determined from NLM records for 1959. *Sampling and survey methods:* After excluding foreign libraries, U.S. government libraries abroad, public libraries (unless exclusively biomedical), college and university libraries other than biomedical libraries, and elementary and secondary school libraries, every tenth library on the list of institutions to which NLM loaned documents in 1959 was sent a simple postal card questionnaire asking how many documents (originals or photocopies) it borrowed from all sources in 1959 and in 1962. Of the 104 questionnaires mailed, 78 were returned in time to be included in the analysis. Of these, 50 supplied usable information.

In the absence of data on how many documents biomedical scientists request of libraries, one can use the figures for a general academic community as a gross approximation. Quatman found that the average faculty member requested 134 items per year[16] from Purdue's libraries (9). If one assumed that the average biomedical research scientist uses his library as much as the average faculty member at Purdue, the 39,790 U.S. biomedical scientists estimated for 1960 (11) would have requested about 5,332,000 documents from their libraries in that

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documents—a figure close to the previous estimate (570,000 documents) based on a 10% annual increase projected from the 1959 level.

[14] Although medical school libraries average 77,000 volumes (compare with average for all biomedical libraries, Table 1), only 13 of 75 have collections exceeding 100,000 volumes (5).

[15] NLM receives five times more requests for journal material published after 1945 than for material published in 1945 or earlier, even though it has twice as much material of the latter age (7).

[16] This figure does not include the documents read in the library that did not entail addressing a specific request to the library's personnel.

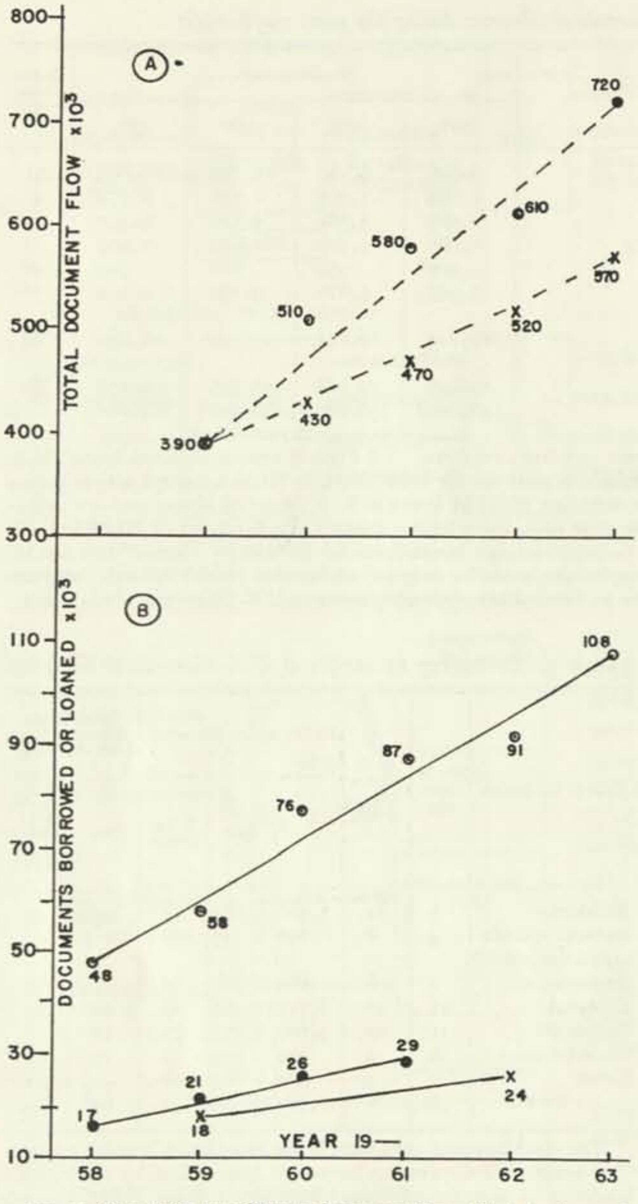

FIG. 3. Trends in interlibrary document flow. Part A: ⊙- - -⊙ estimate of total document flow based on fixed ratio (15%) of NLM loans to total borrowing by all libraries. ×- - -× estimate of total document flow based on 10% annual increment over 1959. Part B: •——• total loans by 6 academic and professional biomedical libraries. ×——× total borrowing by sample of biomedical libraries. ⊙——⊙ NLM loans to U.S. libraries (estimated at 80% of total NLM loans). *Data sources:* See Tables 2 and 3; total NLM loans (to U.S. and foreign libraries) for fiscal 1962 (113,485) and for fiscal 1963 (134,918) from NLM annual reports for those years.

year. If each of these scientists had available to him a library that could meet 90% of his requests from its own collection, the residual demand to be filled by interlibrary loans in 1960 would have been about 540,000 documents. Although the figure assumed for document requests from libraries may be somewhat high, and the assumption of 90% self-sufficiency for biomedical libraries is probably optimistic, this estimate is in the same range as those for the same years based on interlibrary loan data (430,000 and 480,000, Fig. 3).

The System's "Agreement" and Economics

It is an age-old library tradition that the scientific record should be freely available; and by general agreement, interlibrary loans have customarily been made according to the principle, "from each according to his ability, to each according to his need." "Courtesy" is the main motivation, except for those few institutions whose responsibilities have been defined legally or administratively to include lending to other libraries, e.g., NLM. That this courtesy has been strained by the demand in recent years is evidenced by the restrictions imposed on the traditional agreement by the "General Interlibrary Code of 1952" (4):

> The purpose of interlibrary loans is to make available for research and for serious study library materials not in a given library, *with due provisions made by the lending library for the rights of its clientele.*
>
> Interlibrary loan service is a *courtesy and a privilege*, not a right, and is dependent upon the cooperation of many libraries. . . . The interlibrary loan service should be restricted (especially when borrowing from large research libraries) to requests that *cannot* be filled by any other means.
>
> . . . .
>
> It is assumed that the borrowing library will carefully screen all applications for loans and that it will *reject* those which *do not* conform to the Code.

When libraries loan original documents to other libraries, the cost of processing (except postage) is assumed by the lending library. Today, however, many libraries "loan" only nonreturnable photocopies, for which they charge from 5 to 50 cents a page. This charge is intended to pay the direct expenses of photocopying, but the other costs of the service are not covered. The costs of billing and bookkeeping may, in themselves, exceed the revenue from photocopy charges. If each library borrowed as many documents as it loaned, the result could be described as a type of barter arrangement.

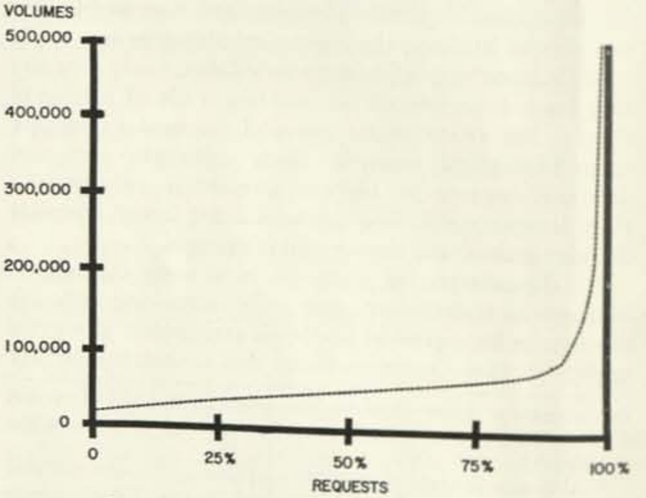

FIG. 4. Size of biomedical collections required to meet requests of research workers. The percentage represents the proportion of all requests that can be met from the library's own collection. Reproduced with permission from Esterquest (2).

However, as has been pointed out, big borrowers are not usually big lenders.

Both big lenders and big borrowers spend significant sums. The former bear the basic costs of making loans of either original documents or photocopies, and the latter pay a mounting bill for photocopies as the practice of loaning original documents declines, as it has in recent years. The borrowing library can, and does in some instances, pass photocopy charges on to the scientist when department or other research funds are available; but again, bookkeeping costs may exceed the revenue. The increasing financial burden on heavy borrowers probably explains, in part, the marked increase in demands on NLM (7); though a library can usually obtain loans faster from other local-level libraries in its vicinity, NLM does not charge for photocopies.

Cost of the System

Very few libraries have the type of cost accounting required to determine the true cost of borrowing or lending documents to other libraries; however, the consensus seems to be that it costs most local libraries about $2.00 to borrow a document and the same amount to lend one, making the cost of a complete interlibrary loan transaction $4.00.[17] On the basis of our estimates, the total cost of maintaining the flow of biomedical documents among libraries, therefore, exceeds $2 million annually at present.

The cost of interlibrary loans is, of course, only part of the total cost of operating the national biomedical library system and maintaining its varied services to the research community. Statistics on the cost of maintaining U.S. biomedical libraries are few and conflicting.[18] For college and university libraries in general, however, the annual cost per volume averages out at around $1.00 (10). Using this average, in the early 1960's when there were 12,240,000 volumes in the principal biomedical collections (Table 1), the annual cost of maintaining U.S. biomedical libraries can be estimated as over $12 million. This cost, of course, covers services other than document retrieval, and most of these libraries also serve populations other than the biomedical research community.

Performance

From the user's viewpoint, the performance of the system in retrieving documents can be assessed in simple terms: what proportion of his requests for documents can be filled, and how quickly? The resources of the entire system can meet practically all his requests for journal and book material. The time required to fill his request, however, varies with the resources and location of his local library, and with the nature and age of the document he desires. Any library's performance in document retrieval may be judged by what percentage of the requests of its clientele can be met: *a*) within minutes (own collection), *b*) in one to three days (loans from immediate vicinity), *c*) in three days to two weeks (loans from more distant libraries or NLM), *d*) longer than two weeks (items difficult to locate, e.g., theses, historical material, etc.), and *e*) never. Such objective performance figures, which facilitate comparisons, would seem to be essential for meaningful assessment of this library service and for establishing minimal standards. Unfortunately, to our knowledge, data of this type are not available for a single library.

The total time required to fill a scientist's request by interlibrary loan depends upon four variables: *a*) the time required by a scientist's local library to process the request, including locating a lender that is likely to have the document and sending out the request; *b*) the time required by the lender to process the request and send out the desired document; *c*) the transit times between the borrower and lender for both the request and the document; and *d*) the time required by the borrowing library to process the incoming document and to notify the scientist or deliver the document to him. For the Medical Library of Wayne State University (Detroit), the total time required to fill a scientist's request for documents (other than those difficult to borrow) breaks down as shown in Table 4.

Geography materially influences transit times. Libraries located in or near large metropolitan centers with many biomedical library resources (e.g., New York, Chicago, Boston, and Philadelphia) have a number of sources from which they can obtain loans quickly. Airmail is used infrequently for both requests and documents; hence libraries in the Western states are at a significant disadvantage, especially with regard to NLM loans. It can be seen that using telephone or teletype routinely to make requests would not, for the majority of libraries, reduce the total time for document delivery by more than two days (the transit time for mail request).

TABLE 4. *Time required for interlibrary loan transactions of Medical Library, Wayne State University School of Medicine*

	Avg. No. Days for Loans from Within City*	Avg. No. Days for Loans from Outside City
Processing request for loan	½	1
Lender processing	1	8
Transit times (to and from lender)	1	4
Processing incoming document and notifying scientist	½	1
Totals	3	14

* Informal arrangements with other libraries in Detroit and telephone calls speed processing operations within both the borrowing and lending libraries. Use of telephone and messengers for delivering requests and documents, rather than mail, reduces transit times.

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[17] Libraries that handle a large volume of transactions may have lower unit costs. Although the published budgets of NLM do not permit one to calculate directly the unit cost for its loan service, this appears to fall somewhere between $1.00 and $2.00 per loan.

[18] The annual budgets of 72 U.S. medical school libraries in 1962–1963 totaled more than $6 million (5). The average operating cost per volume for medical school libraries is somewhat higher than for academic libraries in general. Similar statistics, based on broad samples, are not available for other types of biomedical libraries.

Capacity of Present System

In the past decade the system has accommodated a large increase in traffic. If the ratio of borrowing from NLM to all borrowing has remained constant, the total flow of documents increased some 80% over the three-year period 1958–1961 (see increase in NLM loans, Table 2). During the same period, the increase in loans by the six local-level libraries on which we have statistics averaged 68%, with the largest lender (College of Physicians and Surgeons of Philadelphia Library) showing a 130% increase (Table 3). Signs of overload are, however, accumulating and indicate that the system's capacity is being strained.

As the volume of requests for loans increased, many libraries found that lending original documents (particularly bound journals) to other libraries affected their ability to meet the needs of their own clientele and restricted their loans to photocopies only. Of the 291 libraries old enough to be listed in both the 1943 edition of the *Union List of Serials* and the 1961 volume of *New Serial Titles*, almost half (135) no longer lend journals as original documents.[19] Borrowers try to avoid the expense of purchasing photocopies; and when one major lender restricts its loans in this way the load shifts to other lenders in the system, with the effect of accelerating the trend toward restricting loans to photocopies.

This trend, in turn, initiated another vicious cycle. Requests for photocopies mounted until the size of the photocopying operation jeopardized other services in some libraries, which then decided either to stop supplying even photocopies or to organize the operation and attempt to make it pay for itself by increasing charges for photocopies. The expense of billing and accounting, previously discussed, complicated the problem of making the charges adequate without being prohibitive.

On the borrowing end, mounting expenses for the purchase of photocopies strained already inadequate budgets and aggravated the chronic and serious financial plight of biomedical libraries.[20] Some libraries attempted to pass these costs on to the user; but, for the reasons mentioned earlier, the net benefit was generally disappointing. Others, faced with the prospect of curtailing purchases of journals and books in order to pay photocopy charges, concentrated on using the most economical sources for loans, even if this meant delays in filling users' requests because distant libraries had to be used, e.g., NLM.

The snowball effect of these actions by lenders and borrowers is obvious. Present evidence suggests the disturbing picture of a diminishing number of lenders, each providing a greater and greater proportion of a steadily increasing demand. Current signs of overload would seem to indicate that the system, as presently operated and financed, has about reached its maximum capacity for interlibrary loans.[21]

Probable Demands in 1965

Much of the increase in interlibrary document flow during the past decade has resulted from the growth of biomedical research manpower. This population has grown more rapidly than the others served by biomedical libraries (e.g., health-science practitioners and students) and also needs a greater number and variety of documents. The fact that reference retrieval services have improved significantly in recent years (8) has undoubtedly also increased the demand on the system. Scientists' requests for documents are influenced by how much they know about the existence of documents relevant to their work, i.e., by the effectiveness of the methods and services they use for reference retrieval.

When in full operation, the MEDLARS program will result in a change in biomedical reference retrieval services that may be likened to a quantum jump. Not only will the coverage of *Index Medicus* be increased from the present 2,200 journals to 3,500 in 1965 (12), but books will also be added to its coverage (5,000 annually by 1965). This general reference retrieval "tool" will be supplemented by many specialized tools and services, including monthly bibliographies tailored for special interest groups, and on-demand searches by computer of all articles and books indexed after January 1, 1963. If the need exists, copies of NLM's magnetic-tape files will be made available for use on other computers. In addition to the MEDLARS program, by 1965 other important new reference retrieval services, currently getting underway or being planned, will undoubtedly be fully available to the biomedical community, e.g., citation indexes.

An indication of the impact all these new and improved services can have on the system for delivering documents is provided by an unpublished study by one of the present authors. An experimental bibliographic tool listing all the journal articles indexed by NLM that were likely to be of interest to those working in cerebrovascular research was tested on a group of such research workers. This tool represented a prototype of the 50 monthly bibliographies MEDLARS can produce when it is in full operation. The test group consisted of leading investigators, who could be assumed to be knowledgeable, by present standards, about current work in their areas of special interest. Despite the fact that the articles listed in this bibliography during the test period were on the average at least six months old, the typical investigator found that over 80% were "new" to him.[22] When specialized reference retrieval tools similar to this experimental bibliography, but more current, become widely available, if scientists request from their local libraries any significant fraction of the articles that will be selected from 3,500 journals and called directly to their attention

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[19] NLM, in September 1957, restricted its loans of original documents for somewhat different reasons and instituted its present policy of furnishing photocopies to libraries without charge.

[20] The difficult problems of medical library support have been discussed recently by Adams (1).

[21] The implications of increasing dependence on the national-level component, NLM, which also has a limited capacity, are discussed later.

[22] This percentage relates to only those references that he judged, on the basis of their titles, to be relevant to his own work, but which had not previously come to his attention. Most of these "new" references represented articles in foreign languages.

(12), the demand on the national biomedical library system for document retrieval will increase sharply.

New and improved reference services will result not only in a marked increase in the demand for documents but also in qualitative changes in this demand. Many requests are likely to be for articles from the more obscure journals, those received by relatively few libraries. In 1962–1963, the average medical school library "held" 1,200 serials (5). Other than NLM, not more than three biomedical libraries currently receive as many as 2,200 journals. A large gap exists, therefore, between the 3,500 journals to be covered by the MEDLARS system and the resources of local biomedical libraries.

The effect of new and improved reference retrieval services, superimposed upon the already rapid growth of demand, could double the demand for interlibrary loans in the space of two or three years. A total load on the system of over one million transactions annually is a reasonable estimate for 1965. The capacity of the system, as presently operated and financed, is inadequate to handle such a load. Unless this capacity is increased rapidly, in the near future biomedical scientists may find themselves with the means to retrieve references to almost all the documents in the world literature pertinent to their work; but if they cannot readily obtain the documents referred to, they may well consider themselves worse off than before.

Possible Ways to Increase the Capacity of the System

In thinking about how the present system might be changed to accommodate the loads that can be expected in the next decade and, at the same time, to improve document delivery services for biomedical scientists, three major alternatives suggest themselves. First, NLM's capacity might be increased to the point where it could, if necessary, handle the entire demand for interlibrary loans. At the current rate of increase in requests to NLM for photocopy loans, the full capacity of its present equipment will be reached by the end of 1964 (7). NLM studies have indicated that major increases in capacity cannot be achieved without a major design and development program that would cost at least $3 million. Even with this outlay, solutions to the problems that have been identified cannot be guaranteed (7). If NLM becomes the source for most or all loans, the average time needed for scientists to obtain documents not held by their local libraries could increase significantly (see Table 4) unless the increase in transit times were offset. Consideration of this alternative should include the possibility that it may entail the development of an electronic network for transmitting both requests and documents. NLM recently concluded, at least tentatively: "The high-cost demand systems such as the present NLM interlibrary loan photocopy operation, operating as a single centralized national service, cannot supply the needs of all researchers and clinicians with promptness and efficiency. The real answer lies in expansion of local and regional resources" (7). A second alternative is that certain large libraries might be designated as regional interlibrary loan centers and subsidized to provide service for their respective regions. If the regions to be served by such a center were small enough to allow quick loans by mail, the collection of the largest existing library in some regions would have to be greatly enlarged before it could meet regional demands.[23] This alternative can be considered as equivalent to developing x number of smaller versions of NLM. Third, the collections of biomedical libraries might be developed to the point where they approach self-sufficiency and would have little need for interlibrary loans. A fourth possibility, of course, is an approach combining features of all three.

To evaluate the relative merits of these alternatives is beyond the scope of the present inquiry. Each of these possible courses of action would require expenditures that are large by present standards of support for library services, and each would require considerable time. Which of the alternatives would be most effective and efficient can be determined only by a systematic and detailed study. If such a study were begun at once, it is unlikely that the course of action selected could be fully implemented in less than three years. While long-term programs are being developed and implemented, in view of the inherent instability of the present system, the known limitations on NLM's capacity, and the probability of a rapid increase in demand within the next few years, it would seem prudent to provide short-term insurance against the possibility of a breakdown in the flow of documents among libraries. A modest program to subsidize the interlibrary loan services of biomedical libraries could serve this purpose.

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[23] Biomedical library resources are distributed unevenly on a geographical basis. This distribution is shown in the appendix (see footnote 7).

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Reference retrieval tools: biomedical abstracting and indexing services[1]

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ORR, RICHARD H., VERN M. PINGS, AND ALICE A. LEEDS. *Reference retrieval tools: biomedical abstracting and indexing services.* Federation Proc. 23(5): 1164–1176, 1964.—The primary objectives of this study were: *1*) to analyze the general functions of abstracting-indexing services; *2*) to describe quantitatively the operations, products, and performance of services useful to biomedical research workers; and *3*) to identify the problems associated with maintaining and improving the performance of U.S. services covering biomedical literature. Scientists use the bibliographic tools produced by these services for three general purposes: *1*) alerting, *2*) searching, and *3*) informing. The criteria by which a service's performance is judged differ for each of these use-functions, and compromises are necessary when a single tool must serve more than one purpose. In the past decade, mounting document loads, processing costs, and personnel shortages, coupled with demands for increased performance, have resulted in four major trends in U.S. services: increased mechanization, more single-purpose bibliographic tools, increasingly narrow specialization in subject scope, and more cooperation among services. Three hundred twenty-six foreign and 147 U.S. services process biomedical literature. Altogether these services process almost two million documents yearly; but all these documents are not biomedical, and this figure includes many biomedical documents processed by more than one service. In the past 10 years, the combined output of the larger U.S. services has increased much more rapidly than the biomedical literature has grown. The present study assessed the coverage by English-language services of a large sample of the documents currently being produced by U.S. biomedical research workers. Of the 891 journals in which the sample documents were published, all but 39 (96%) were "covered" by one or more of six major services: *Index Medicus* (*IM*), *Chemical Abstracts* (*CA*), *Biological Abstracts* (*BA*), *Excerpta Medica* (*EM*), *Bibliography of Agriculture*, and *Psychological Abstracts* (*PA*). Duplication of coverage was considerable; the sample journals were, on the average, covered by three of the six services. *IM* covered 66% of these journals and processed 87% of the sample documents; however, because of the selective policies of *CA*, *BA*, *EM*, and *PA*, it is likely that a significant percentage of the sample documents were not abstracted by any of these major services. Abstracting and indexing services useful to biomedical scientists have improved significantly in the past 10 years with regard to completeness of coverage; however, with rising unit costs and the demand for better performance, closer cooperation among the services and coordination of their efforts are imperative.

TWO TYPES OF FORMAL SERVICES have been organized to help a scientist identify the particular documents in the accumulated scientific record that are relevant to his work and interests, or that contain the answers to his questions. By using such services, he can find or "retrieve" references to those documents most likely to reward his effort in obtaining and reading them. The first type of reference retrieval service offers a personalized "product," tailored specifically for his own projects, interests, and questions—sometimes even for his personal habits, values, and preferences. Libraries and local information services of institutions engaged in research have always provided this kind of service to the extent allowed by personnel and budget limitations, e.g., by preparing subject bibliographies on request, or by automatically calling a scientist's attention to documents that relate specifically to his work and known interests. Recently there has been considerable interest in centralized versions of this type of service—national and international "information centers" specializing in narrow subject-matter areas and offering similarly personalized products to any scientist eligible for their services, regardless of his location. The second type of reference retrieval service concentrates on producing reference retrieval "tools" that can be used by the scientist himself[4] to find references to documents that will meet his varied needs. Multiple copies of these bibliographic tools are distributed periodically to the service's clientele. Libraries and local information services may provide this second type of service also, e.g., by distributing a list of the titles of new documents, or abstracts of

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[2] This author's participation was supported by Public Health Service Grant GM 09166, from the National Institute of General Medical Sciences.

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[4] And by information service personnel providing him with the first type of service.

these documents, to the scientific staff of an institution. Reference retrieval tools distributed on a national or international basis are the products of services that may be referred to generically as abstracting-indexing services. A substantial part of the total effort devoted to helping scientists with their "literature problems" has gone into the latter services.

The focus of the present study was abstracting-indexing services, specifically those covering biomedical literature. Our principal objectives were: *1*) to analyze the general functions of these services for the research community and for individual scientists; *2*) to describe quantitatively their operations, products, and performance; and *3*) to identify the problems of maintaining and improving their performance. This paper briefly reviews these functions, presents data on biomedical abstracting-indexing services, and suggests the nature and magnitude of some of the problems.

For the purpose of this study, we defined abstracting-indexing services broadly as any formal service issuing, for public use, i.e., available to the entire scientific community,[5] and on a continuing basis, bibliographic guides to the scientific literature consisting of one or more of the following: *1*) lists of titles of documents published elsewhere, *2*) abstracts or digests of these documents, and *3*) indexes to these documents. These tools may be distributed as: *1*) a serial publication, *2*) a set of cards or separate sheets, or *3*) a special section in a scientific periodical devoted primarily to other types of material (original articles, reviews, etc.). All abstracting-indexing services must, of course, include in their product the titles of documents (articles, books, patents, etc.); and simple or classified lists of document titles are the sole product of some, i.e., the "title-listing" services. Others provide abstracts of the documents, with or without a subject index. Still others produce indexes but not abstracts ("indexing-only" services). An abstracting-indexing service may concentrate on one particular form of literature, e.g., journals, books, technical reports, or patents. In this study we were concerned primarily with services that handle journal literature.

METHODS

As a first step, we reviewed published and unpublished studies and statements relating to the functions of abstracting-indexing services, the philosophies and policies of operating services, the performance of services, and coordination among services. Data on services processing documents considered to be biomedical by conventional definitions were extracted from the most recent and authoritative source on abstracting-indexing services for science and technology (12). Since we found no recent data on how well the major services used by U.S. scientists are covering the biomedical literature of special interest to research workers, we undertook to find out.

Some operational definition of what constitutes biomedical literature is required for any attempt to measure quantitatively how completely or inclusively a given service, or combination of services, covers this universe of documents. For our assessment of current coverage, we defined the biomedical literature as all documents generated by research similar to that supported by NIH. As a sample of this universe we used the documents cited in *NIH Research Grants Index, Fiscal Year 1962* as resulting from work supported by NIH grants.

These sample documents were published in several forms of literature, e.g., journals, monographs, proceedings volumes, etc.; but journals accounted for about 90% of the documents cited (16) and these documents were selected for analyzing abstracting-indexing coverage. The final sample consisted of 14,275 documents in 891 different journals. Only periodicals issued more often than once annually were considered as journals. The methods used for establishing frequency of publication and for reducing errors caused by treating variants of a given journal's name as separate journals are given in the appendix to this paper.[6] Since some of the documents cited in the *Grants Index* were abstracts of oral reports submitted for (or given at) meetings and printed in journals, we will use the general term "documents" rather than "articles" in referring to the sample items.

Each journal containing sample documents was then checked in a 1962 compilation of the journals covered by each of 12 major U.S. abstracting services (13) and also against 1962 or 1963 lists of the journals covered by the following individual services: *Index Medicus*, *Biological Abstracts*, *Excerpta Medica*, *Psychological Abstracts*, and *Chemical Abstracts*.[7] *Excerpta Medica* was included in this part of the study since it is the major foreign service in English that offers a broad coverage of the biomedical field.

GENERAL REVIEW OF FUNCTIONS, OPERATIONS, AND TRENDS

Functions of Abstracting-Indexing Services

The basic functions of abstracting-indexing services may be described in terms of the uses scientists make of the bibliographic tools produced by these services or from the viewpoint of the objectives the services set for themselves. In most respects, these alternative viewpoints

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[5] This definition excludes services available only to the staff of an institution or company, or to members of an organization.

[6] A copy of the appendix can be borrowed from the National Library of Medicine by initiating an interlibrary loan request for: *Appendix* to Orr, Richard H., Vern M. Pings, and Alice A. Leeds. Reference retrieval tools: biomedical abstracting and indexing services. *Federation Proc.* 23: 1164–1176, 1964.

[7] Biological Abstracts 1963 List of Serials, *Biological Abstracts* 43: 3, July 1963; *Chemical Abstracts List of Periodicals with Key to Library Files 1961*, Washington, D.C.: American Chemical Society, 1962; and *1962 Supplement to the 1961 Chemical Abstracts List of Periodicals*, Washington, D.C.: American Chemical Society, 1963; List of Journals Indexed in Index Medicus, *Index Medicus* 4 (1, Pt. 1): LJI 39, Jan. 1963; Psychological Abstracts List of Journals, *Psychological Abstracts* 36(6): 859, Dec. 1962.

merely depict opposite sides of the same coin; however, there are subtle but important differences.

For obtaining references to documents of interest, scientists employ these tools for two major purposes: to alert themselves to the existence of all new documents relevant to their work, and to identify those documents in the accumulated scientific record that relate to a specific subject or contain answers to their questions about specific information or data. Services that provide abstracts are used in a third way: to obtain needed information without consulting the original document when *a*) the original is inaccessible or is in an unfamiliar language, *b*) the subject is of peripheral interest and the abstract suffices for keeping broadly informed, and *c*) the abstract itself contains the specific information or data sought. When used as in (*c*) abstracts are not serving for reference retrieval but, rather, as condensed, convenient substitutes that can be read and consulted as sources of information in lieu of the original documents. These three major use-functions may be called *1*) alerting, *2*) searching, and *3*) informing.

These uses are often combined. For example, when a chemist wants a quick reference to a method for synthesizing a compound, he may use *Chemical Abstracts* first for searching and then consult the abstract for the necessary details. As part of a scientist's efforts to keep abreast of scientific progress, he may use an abstracting service for alerting himself to new documents he will obtain and read later, and simultaneously for informing himself on subjects of peripheral interest. The latter activity is sometimes called "browsing."

The aim of all abstracting-indexing services is to produce bibliographic tools to serve one or more of these three uses, but their specific objectives are better described in terms of the functions they perform for the scientific community: *1*) *announcement*, i.e., making known the existence or availability of new documents; *2*) *control*, organizing the scientific record so that it will be possible to find a desired document or group of related documents; and *3*) *condensation*, digesting original documents and extracting useful information.

User Studies

There have been many arguments about the relative importance of the three functions of abstracting-indexing services and of criteria for judging performance. More studies have probably been devoted to establishing scientists' habits, preferences, and needs with regard to these bibliographic tools than to any other aspect of scientific communication except scientists' use of journals. All these studies, however, have not settled such continuing arguments as whether indicative or informative abstracts are "better,"[8] and whether abstracts or indexes are "more important."

To answer these and similar questions requires that they be phrased meaningfully by specifying *a*) for what function or use, *b*) for what types of information, and *c*) for which scientists. Although many such studies are of limited value because these requirements were not met, or because they were biased by parochial interests, a few provide quantitative information that is generalizable, if interpreted cautiously. One reason for caution is that information-service personnel, and others who help scientists meet their informational needs, are infrequently included in otherwise excellent studies. Even academic scientists often have some help from librarians, secretaries, graduate students, and technicians, hence, when only the direct uses of these services by scientists are assessed, one may get a false impression of how often and for what purposes they are employed. It is doubtful that available data on frequency of use give a reliable indication of total direct and indirect use. Studies that attempted to assess scientists' satisfaction with a given service are difficult to evaluate since they rarely include a "control" service for comparison; they commonly come up with the same result regardless of which service and scientist population is studied, namely, that about 80% of the users are "reasonably well" satisfied.

Despite these numerous qualifications, the collective findings have led to some understanding of the uses of abstracting-indexing services. A detailed review of user studies is beyond the scope of this paper; however, two studies of biomedical populations should be mentioned specifically because they emphasize aspects that are often forgotten: Herner's, which demonstrated that U.S. biomedical scientists are considerably more dependent upon abstracting-indexing tools for learning of foreign literature than for domestic literature (9) and the survey by Glass, which should have settled the still continuing argument as to whether scientists use abstracts as substitutes for the original documents (7).[9]

Performance Criteria

The quality and utility of abstracting-indexing services depends upon how well they fulfill certain criteria. The general findings of user studies regarding major criteria on which the performance of these services may be judged are summarized in Table 1, according to the function to be served, and roughly in order of importance for the given function. Each of these criteria provide a basis for objective measurement and for comparing services.

The criteria listed for alerting and for informing are obvious; with the possible exception of "novelty," which has not commonly been recognized as important in determining the value of an alerting tool, though it

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[8] To serve alerting or searching functions, an abstract need only describe the original document well enough to allow the user to judge whether it will be worth his effort to obtain and read it. Such an abstract has been called "indicative." For the informing function, a mere description of the document will not suffice; an "informative" abstract is required.

[9] This study of *Biological Abstracts* found that "perhaps 20–25% of the total use of abstracts is in substitution for the original articles, which presumably are those difficult to obtain."

TABLE 1. *Performance criteria for abstracting-indexing services*

For announcement-alerting:
- *Currency*—speed in processing new documents
- *Convenience*—size, arrangement, periodicity, etc., suited to user
- *Novelty*—proportion of contents unlikely to have come to users' attention by other means
- *Inclusiveness or exclusiveness*—either inclusion of all documents related to designated subject, or exclusion of documents not meeting some quality criterion
- *Specialization*—subject scope matches that of users' interests

For control-searching:
- *Continuity*—unbroken coverage of old as well as new literature, stability
- *Inclusiveness*
- *Breadth of subject scope*
- *Richness and depth of indexing*—indexing from multiple points of view and at multiple levels of specificity
- *Consistency*—uniformity of quality and form of abstracts or index entries
- *Currency*

For condensation-informing:
- *Understandability*—without recourse to original document or familiarity with jargon
- *Informativeness*—presenting the most useful information contained in the original document
- *Readability*—clear expository style, format, and typography

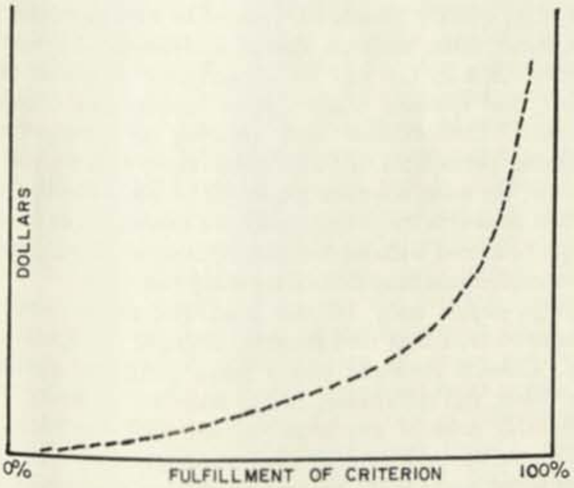

FIG. 1. Economics of abstracting-indexing.

should be obvious that calling scientists' attention to documents about which they already know serves little purpose. Some of the criteria for searching may require explanation. If a scientist (or someone assisting him) desires to find all useful documents on a given subject, the coverage of the service should extend back into time far enough that he can be reasonably certain any earlier documents would not be useful. Inclusiveness not only increases the probability of finding all relevant references but also the likelihood that a search disclosing no references means no relevant documents exist. Even when the purpose is not to make an exhaustive search, but merely to obtain a complete citation for a specific document known to exist, inclusiveness is important. Other things being equal, the broader the subject scope of a service, the less need there is for using additional tools in making a search. Each user approaches a bibliographic tool with his own terminology and viewpoint; when the service provides rich and deep indexes he is much more likely to find what he is seeking and to miss fewer pertinent references.

Services that attempt to perform more than one function are often forced to compromise when criteria conflict. For example, a service producing a bibliographic tool intended both for alerting and for searching the literature faces serious problems. The extensive processing needed to meet certain of the requirements for the searching function (inclusiveness, richness and depth of indexing, and consistency) tends to reduce promptness of announcement, hence to decrease the tool's value for alerting scientists to new documents. If a service attempts both announcement and condensation, all of the criteria for the latter conflict with currency. Different criteria may conflict, even when only one function is to be served. Some examples of such inherently competitive requirements are: convenience of use vs. inclusiveness, currency vs. inclusiveness or exclusiveness, and breadth of coverage vs. inclusiveness. All of these conflicts call for compromises in addition to those necessitated by economics and availability of qualified personnel.

Economics

The unit cost of processing a document varies widely from one abstracting-indexing service to another and depends on many factors, including the proportion of volunteer to paid personnel, currency, inclusiveness, depth and richness of indexing, quality standards, and form of dissemination. A general economic law for such services seems to be that cost rises exponentially as efforts are made to fulfill more completely any of the performance criteria. Figure 1 illustrates this principle, which is a special case of the "law of diminishing returns." With finite limitations on funds and manpower available to a service, it is apparent that compromises and "trade-offs" are inevitable.

A general average of $10 per document processed (either abstracted or indexed or both) seems to be a reasonable estimate of unit costs, at least for the major U.S. services.[10] Some of the smaller, specialized services are known to have costs as high as $30 to $50 per document. Unit processing costs have doubled in the past 12 years (8).

Sponsors and Support

The traditional sponsors of abstracting-indexing services are scientific societies. Organizations representing the classic, broad disciplinary groupings, e.g., chemistry, physics, biology, etc., are responsible for the largest U.S. abstracting services. Organizations of applied scientists, e.g., engineers and medical practitioners, also

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[10] Eighteen U.S. services, with budgets totaling $7 million accounted for one-third of the two million documents processed in 1961 by 288 U.S. services in all scientific fields (8), making the average cost about $10 per document.

maintain major abstracting and indexing services. In the past, most U.S. abstracting services were supported entirely by subscriptions and society membership dues; however, some of the major services have been forced to increase their subscription rates progressively, and recently signs have appeared that further increases are not likely to produce additional revenue (9). The present trend is toward increasing federal support, direct and indirect, of the major private, nonprofit services.

Commercial interests supply a number of important services that are financed by subscriptions or advertising. e.g., the *Agricultural Index* and *Current Contents of Chemical, Pharmaco-Medical and Life Sciences*. National governments maintain some of the broadest services, e.g., the all-embracing services of the U.S.S.R., and in this country, *Index Medicus* and the *Bibliography of Agriculture*. More recently, increasing numbers of private and governmental agencies that support research programs have established specialized abstracting-indexing services intended to further their specific missions, e.g., the American Heart Association (abstract section of the journal *Circulation*), Atomic Energy Commission (*Nuclear Science Abstracts*), and the National Institute of Mental Health (*Psychopharmacology Abstracts*).

Approaches

Sponsoring organizations' approaches to their services may be characterized along two major axes—"orientation" and abstracting "philosophy." With regard to orientation, services have been classified as discipline- or profession-oriented vs. mission- or problem-oriented. The broad, discipline-oriented services (e.g., *Chemical Abstracts* and *Biological Abstracts*) have generally tended to emphasize the long-term responsibility of establishing and maintaining bibliographic control of the scientific record for future as well as present scientists. They generally give priority to the performance criteria associated with this aspect of the control function. Mission-oriented services, and many of the specialized profession-oriented services, such as the abstract sections in journals devoted to medical specialties and *Psychopharmacology Abstracts*, more commonly stress the function of announcement and the short-term responsibility of controling current scientific literature to facilitate its contemporary use.

With regard to abstracting philosophy, the contrasting approaches favor either the "slanted" abstract or the "balanced" abstract. Most services claim their product is slanted or specially tailored for a specific population of users, i.e., the abstracts are written employing a special viewpoint and language, or are designed to extract selectively certain types of information from the document. Services advocating the balanced abstract attempt to produce an abstract useful to the broadest possible audience by condensing the document while maintaining its general balance. The success of the major disciplinary services in slanting their abstracts is not notable in practice (10, 18); however, some services for applied scientists have demonstrated the feasibility of producing abstracts that are distinctly and consistently slanted, e.g., *Modern Medicine*.

Trends

In the past decade, mounting document loads, processing costs, and shortages of qualified personnel, coupled with demands by scientists and research sponsors for increased performance by all criteria, have resulted in many changes in the traditional methods and products of abstracting-indexing services. This ferment has been accelerated by the availability of federal funds and of a new technology ready for exploitation. Four major trends are apparent.

Mechanization. Data processing equipment is being used increasingly, particularly by services handling large loads of documents, for the clerical operations entailed in preparing the published products, e.g., the use of a computer for filing, sorting, error correction, and page-layout operations in the production of *Index Medicus* (23). Not only has data processing equipment affected the conventional products of these services, but it also has made possible some new products that supplement the old, e.g., quickly prepared, index-like arrangements of document titles, such as *Biological Abstracts' Subjects In Context* (*B.A.S.I.C.*) (4) to supplement *Biological Abstracts*, and *Chemical Titles* (3) to supplement *Chemical Abstracts*. Composition and printing of abstracting-indexing periodicals are also being progressively mechanized; the most advanced example of such mechanization at present is the printing of *Index Medicus* from filmed pages produced without human intervention by a photocomposition machine driven by computer (23).

Single-purpose tools. In the past, the major services produced tools that had to serve multiple use-functions, e.g., *Chemical Abstracts* was a major tool for alerting, searching, and informing, as was *Biological Abstracts*. The inevitable price of any multipurpose tool was compromising on the performance of any one function. The current trend seems to be toward producing single-purpose tools requiring fewer compromises, particularly for alerting, where currency is vital. One example of such a tool is *Current Contents of Chemical, Pharmaco-Medical and Life Sciences*, a title-listing service that reproduces the tables of contents of journals directly from page proofs and thereby approaches maximal currency. Another is *Chemical Titles*, a product designed almost exclusively for alerting, whereas, *Chemical Abstracts* better serves searching and informing functions.

Specialization. The subject scope covered by many of the newer services is specialized to match the interests common to relatively small groups of scientists (in some cases a few hundred) who are working in narrow research fields, e.g., *Cancer Immunology Abstracts*. Some of the large services (e.g., *Biological Abstracts* and *Chemical Abstracts*) are offering the option of subscribing to only one (or a few) of the multiple sections of their major product. The Medical Literature Analysis and Retrieval

System (MEDLARS) of the National Library of Medicine (NLM) will carry this trend further by supplying periodically to numerous groups[11] of biomedical workers printed indexes of documents relevant to each group's interests that have been selected from all the documents processed for *Index Medicus*. Progressively narrower specialization for smaller and smaller groups on the basis of their research problems, however, tends to be self-defeating in that the interests of individuals in the group are seldom confined completely to those common to the group. This means that the more specialized the tool is, the smaller the fraction of the individual's total subject interests it covers. For the individual there comes a point when the necessity for using increasing numbers of specialized tools to serve his needs outweighs their advantage over broader tools.

A different approach to specialization of bibliographic tools is being tried in at least one pharmaceutical company (6), as well as in other industrial research settings. Here the total output of major services is sifted by computer, and a personalized bibliographic tool is provided to each individual at frequent intervals. The selection of documents is based on a profile of his particular interests and preferences, which is modified continuously according to his expressed wishes and to his reactions to the references previously provided by the personalized service. This type of tool can be produced from the output of the major services with minimal need for the highly qualified information service personnel previously required for personalized service and is economically feasible because it lends itself to optimal use of computer capacity. This approach, which certainly better accommodates the individual scientist, may prove more economical in the long run than the problem-oriented approach to specialization of bibliographic tools for groups of scientists. NLM plans to make available multiple copies of the master magnetic tapes produced for *Index Medicus* (19). In the hands of institutional libraries and other local information services, these could be used to prepare regularly a personalized bibliographic tool for each biomedical scientist on the staff.

Cooperation among services. Recent years have seen the beginning of national and international cooperation among abstracting-indexing services that may result in substantial work sharing. The savings that might be realized by work sharing was one of the major reasons for the formation in 1958 of the National Federation of Science Abstracting and Indexing Services (NFSAIS) (8), which now includes some 20 major nonprofit services, private and governmental; the 1960 agreement between *Biological Abstracts* and *Chemical Abstracts* to exchange up to 5,000 abstracts annually (1) is one tangible result.

In the past the demand for specialized tools that cut across the coverages of several of the discipline-oriented services has often resulted in the creation of a new service processing over again the same documents already being processed one or more times by existing services. If the performance desired for the specialized tool is greatly different from that of existing services already processing the relevant documents, establishing a new, independent service may be justified. However, in many cases the specialized tool might have been produced at considerably lower cost by "repackaging" relevant portions of the output of existing services, if any mechanism for drawing upon the pooled output of established services existed. Other potential advantages of repackaging rather than recreating includes reducing competition for the short supply of trained information service personnel and providing additional revenue for the cooperating services, thus speeding their general improvement. In 1963, a study sponsored by NFSAIS, recommended the establishment of such a mechanism and suggested one form it might take (9).

Progress toward work sharing and pooling output, however, has been slow. One of the general conclusions of the report cited above states: "There is much duplication of effort among many services in their production operations. An orderly plan for increasing joint action is greatly needed. There is too little cooperation at present, and few plans are being made in this direction."

DATA AND DISCUSSION

Number of "Biomedical" Services

At present there are more than 1,800 abstracting-indexing services for science and technology (12). About 470 of these process literature that is, at least in part, biomedical by conventional definitions; 326 are published in foreign countries. Table 2 summarizes the foreign biomedical services by country. A considerable number of these services are in English. U.S. services of interest to the biomedical community number 147. The appendix to this paper (see footnote 6) contains lists of these foreign and U.S. services and the form and volume of their outputs.

Total Output

The combined annual output of the world's biomedical services exceeds 1,200,000 abstracts. In addition, almost 700,000 documents are processed annually by services that list the titles of documents or index them, but do not provide abstracts. Foreign services account for roughly two-thirds of the total output of abstracts and one-third of the documents processed by title-listing or indexing-only services. The total of almost two million documents processed is misleading as an indication of the annual volume of new biomedical documents, since some of the largest services process great numbers of documents that fall outside the conventional definitions

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[11] MEDLARS is designed to produce up to 50 recurrent specialized bibliographic listings updated at intervals of from one week to six months (23).

TABLE 2. *Output of foreign biomedical abstracting and indexing services by country*

Country	No. Services	No. Printed as Section of Journal	Output (No. of documents processed/year)	
			Abstracted	Listed or indexed*
Argentina	6	4	1,210	4,000
Austria	7	6	2,850	3,000
Belgium	3	3	1,100	
Brazil	4	3	900	1,000
Bulgaria	2		9,400	
Canada	1	1	500	
China	5	1	15,500	
Czechoslovakia	13	6	16,140	59,000
Denmark	4	1	1,700	1,500
England	27	9	62,850	17,300
Finland	2	1	800	100
France	38	30	134,220	7,600
Germany	60	37	165,100	11,850
Hungary	3	1	1,000	16,900
India	3	3	1,400	
Italy	42	37	14,450	62,800
Japan	15	8	38,170	18,400
Netherlands	27	3	82,400	
Poland	10	10	4,120	
Portugal	1	1	1,000	
Romania	8	3	9,340	
Scotland	3	2	6,000	4,400
Spain	5	3	1,300	5,500
Sweden	2	2	400	2,000
Switzerland	6	4	2,300	12,000
USSR	21	5	222,120	15,000
Yugoslavia	8	6	7,070	
Totals	326	190	803,340	242,350

* The number of documents processed by title listing or indexing but not abstracted. *Data source:* ref. 12.

of biomedical, and many of the documents are processed by more than one service.

U.S. services. The majority of U.S. services (also of foreign services) are small[12] and are oriented toward particular diseases, problems, or professional specialties. Over half are published as a section in a journal devoted mainly to other types of documents (original articles, reviews, etc.). These smaller services serve primarily alerting and informing functions. U.S. services that process more than 10,000 documents per year and provide abstracts or indexes are shown in Table 3. The combined output of the four larger abstracting services (only 5% of the total number of U.S. abstracting services) constitutes three-quarters of all abstracts (approximately 400,000 in 1962) produced in the United States by services covering biomedical literature. The predominance of the larger indexing services is even more marked; in 1962, these seven services accounted for over 90% of the roughly 450,000 documents processed by title listing or indexing only.

TABLE 3. *U.S. abstracting-indexing services covering biomedical journal literature and processing more than 10,000 documents annually*

	Approx. No. Documents Processed/Yr.		
	1952	1962	% Increase
Provide Abstracts			
Chemical Abstracts	55,000	165,000	200
Biological Abstracts	37,400	100,000	170
Nuclear Science Abstracts	6,800	33,000	390
Psychological Abstracts	7,300	10,000	37
Totals	106,500	308,000	190
Provide Indexes Only			
Index Medicus	96,000	145,000	51
Bibliography of Agriculture	96,000	100,000	4
Index Chemicus	*	†	
Chemical Titles	*	75,000	
Agricultural Index	†	40,000	
Biochemical Title Index	*	24,000	
Hospital Literature Index	‡	18,000	

Title-listing services, i.e., those that do not provide abstracts or subject indexes, are not included here. A document processed is one that is abstracted or indexed. All figures are rounded to the nearest thousand. * These services did not exist in 1952. † This service provides graphic "abstracts" of the synthesis of about 100,000 new chemical compounds annually and indexes these compounds; the number of documents processed is less than the number of compounds listed. ‡ Data not obtained for this year.

Data sources for 1952 figures—Chemical Abstracts: read from graph in Crane, E. J. *Proceedings of the Chemical Society*, Dec. 1957, p. 335; *Biological Abstracts:* personal communication from Phyllis V. Parkinson, Staff of *Biological Abstracts*, Oct. 14, 1963; *Nuclear Science Abstracts:* the abstracts in the 1952 issues were counted; *Psychological Abstracts:* personal communication from Mrs. Betty Galloway, Editorial Office, American Psychological Association, Oct. 10, 1963; *Index Medicus:* estimated from count of every 10th page of *Current List of Medical Literature* (predecessor of *Index Medicus*); *Bibliography of Agriculture:* personal communication from Mr. L. Lulitch, Division of Indexing and Documentation, National Agricultural Library. *Data source for 1962 figures*—ref. 12. The figures given in this source were the latest available to the compilers during the latter part of 1962.

Total Cost of U.S. Services

After making a rough allowance for the numbers of nonbiomedical documents processed by such services as *Chemical Abstracts*, *Nuclear Science Abstracts*, and *Bibliography of Agriculture*, one is left with about 200,000 abstracts and 200,000 documents processed by indexing only as the current processing load of U.S. services. At an average unit cost of $10, the total cost of processing biomedical documents can be conservatively estimated as $4 million annually. This estimate does not include the costs of the extensive intramural services of some pharmaceutical companies. If the annual output of biomedical literature grows at the same rate as it did in the past 10 years, i.e., about 20% in 10 years (16), the annual cost of abstracting and indexing this literature in 1972 may be expected to approach $8 million.[13]

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[12] The average U.S. service processes approximately 6,000 documents annually; for foreign services this average is about 3,200. If the larger U.S. services, which are shown in Table 3, are excluded, the average for the remaining services is only 1,300.

[13] This estimate assumes that the cost of document processing

Inclusiveness of Major Services in English

Present assessment. The growth of some of the larger services over the past 10 years (Table 3) is impressive. The combined output of the larger abstracting services alone has increased more rapidly in the past 10 years (190%) than even the commonly quoted, but seldom supported, estimates of the increase in the volume of all scientific literature or of biomedical literature.[14] The number of documents processed by indexing services has increased even more sharply. In addition, of all present U.S. services, large and small, about 40% were started since 1952. Unless the amount of overlapping coverage among the services has increased greatly, these facts indicate that U.S. services are now covering a greater proportion of all biomedical literature than they did a decade ago. For *Index Medicus*, one can be more specific. In 1957, its predecessor (*Current List of Medical Literature*) indexed about one-half of the 220,000 substantive biomedical articles produced in the world that year (2). If the most recent estimate is reliable, the annual volume of biomedical articles increased about 20% during the period 1950–1960 (16); whereas, the number of articles processed by *Index Medicus* rose 51% in the same period. This represents a substantial gain in the inclusiveness of this key bibliographic tool.

For establishing the way in which the literature generated by, and of special interest to, biomedical scientists is currently being handled by the major English-language abstracting-indexing services, our procedure and sample (see "Methods" section) have limitations that affect the conclusions that can be drawn from the data we obtained.

First, using lists of the journals "covered" by the services to assess what proportion of the sample documents were processed by each service and by the services collectively introduces a large element of uncertainty. Of the 13 services included in the present assessment, only *Index Medicus* processes all the substantive articles in any journal it covers.[15] The other services cover selectively some or all of the journals in which sample documents were published, i.e., they process (abstract or index) only those articles falling within their respective spheres of interest. For example, *Biological Abstracts* covers clinically oriented journals selectively and processes only the articles considered to be of interest to "basic" scientists, while *Nuclear Science Abstracts* selects those articles relating to radioisotopes, nuclear energy, etc. For the selective services, therefore, the proportion of the sample documents processed can be given only as a theoretical upper limit set by the number of sample documents in the journals they cover. One can only estimate what fraction of this number they actually processed. The magnitude of the difference between the theoretical and actual figures was noted by the Welch Medical Library study (11). For this reason, and the one that follows, we will not report the coverage of the sample in terms of percentage of sample documents except in those cases where the uncertainty is relatively small.

Second, a significant number of the sample documents (about 20%) were not journal articles, but rather abstracts of oral reports given at meetings.[16] The major services do not ordinarily process the abstracts of oral reports printed in journals they cover.[17]

Third, restricting the sample to documents in journals results in some overestimation of the inclusiveness of abstracting-indexing services, since the other forms of literature generated by biomedical scientists, e.g., proceedings volumes, are known to be less well covered than journals. However, as about 90% of all documents cited in the sample source appeared in journals, this overestimation cannot exceed 10%.

Fourth, although NIH grantees as a group quite frequently publish in journals of countries other than the United States,[18] foreign journals are underrepresented in the sample as compared to a random sample of the document output of all biomedical scientists.[19] Since U.S. abstracting-indexing services undoubtedly cover U.S. literature more completely than foreign, this sample bias also leads to some overestimation of the inclusiveness of these services if one attempts to generalize the findings to all the world's literature.

Table 4 shows how 13 major abstracting-indexing services processed the sample of biomedical journal literature used in this study. These services are ranked by the number of sample journals they cover. If these data are interpreted with an appreciation of their limitations, they provide a useful general picture of the relative contributions by each of the larger U.S. services and by *Excerpta Medica*. Since the sample documents were distributed unevenly among the sample journals,[20] and some services could be expected to process a higher proportion of the sample documents in the journals

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will not increase more rapidly than in the recent past. No allowance has been made for any improvement in the performance of existing services nor for any new services.

[14] Estimates of a doubling every 10 years (100% increase) are most frequently heard.

[15] This statement has a few exceptions that are not important for this study, e.g., *Index Medicus* covers only the biomedical articles in such general journals as *Science* and *Nature*. Certain other journals, largely in peripheral fields are covered selectively in that only those articles selected for the *Bibliography of Medical Reviews* are listed in *Index Medicus;* however, in the present study, these journals were counted as not covered.

[16] The composition of the sample is given elsewhere (16).

[17] For particular meetings, there are exceptions to this general rule, e.g., *Biological Abstracts* and *Chemical Abstracts* process at least some of the abstracts of oral reports published in *Federation Proceedings*.

[18] Of all the sample documents, 18.5% appeared in foreign journals. This surprisingly high percentage is explained, in part, by NIH grants to workers abroad and by the fact that foreign investigators working in the United States under NIH grants sometimes publish in the journals of their native countries.

[19] In 1957, about one-quarter of all biomedical journal articles were in U.S. journals (2).

[20] *Federation Proceedings* contained 1,064 sample documents; 286 journals contained only one sample document each.

they covered than others, the rank order shown would be somewhat different if it were based on actual counts of the sample documents processed by each of the services. *Index Medicus* would rank first on this basis.

Journals covered by *Index Medicus* (*IM*) contained 87% of the documents in the sample. Because of *IM*'s coverage policy, one can be reasonably certain that this service actually processed close to this percentage of the journal articles in the sample.

The sample journals not processed by *IM* can be broadly categorized as follows: biological sciences, 28%; chemistry, 16%; psychology or social sciences, 12%; dentistry, 7%;[21] paramedical specialties, 5%; medicine, 7%; and the remaining 27% were primarily engineering, technologic, or general science journals. The chemical journals contained the largest number of sample documents (659). Less than one-half of these journals (containing 8% of the sample documents) were listed in *Biomedical Serials, 1950–1960*, and can therefore be considered to be biomedical by the conventional definition.

All but 39 of the journals not covered by *IM* were covered by *Chemical Abstracts* (*CA*), *Biological Abstracts* (*BA*), *Excerpta Medica* (*EM*), *Bibliography of Agriculture* (*BAg*), or *Psychological Abstracts* (*PA*). A rough analysis indicates that most probably at least two-thirds of the sample articles in journals not covered by *IM* were processed by one or more of these services. When these articles are added to those processed by *IM*, one can reasonably conclude that a minimum of 96% of all journal articles in the sample were covered by at least one of these six services. The remaining seven services shown in Table 4 did not add much to the inclusiveness achieved by the combination of *IM*, *CA*, *BA*, *EM*, *BAg*, and *PA;* they covered only four journals that were not covered by any of the latter services, and these journals contained only one sample document each.

Although the relative contributions of the listed services toward inclusive coverage are not strictly proportional to the percentage of the sample journals they covered, the first six services qualify to be considered the major contributors. One of these, *BAg*, is not usually thought of as a major service for biomedical research workers. How these six major contributors processed the sample journals is summarized in Table 5. The 112 journals covered by only one of the six services contained 3% of the documents in the sample; whereas the 33 journals covered by all six services contained 19%. Sample journals not covered by any of the six services contained less than 1% of the sample documents; but, for the reasons given before, the percentage of sample articles actually processed cannot be said to exceed 96% with reasonable certainty.

Table 6 summarizes the coverage afforded by the four of these six services that provide abstracts. Although 78 journals not covered by any of the four abstracting services contained 308 (2%) of the sample documents, because of the selective policies of these services, one cannot safely conclude that close to 98% of all sample articles were abstracted by at least one of them. The

TABLE 4. *Coverage by major abstracting-indexing services of sample of document output of U.S. biomedical research*

Services	No. Sample Journals Covered	% All Journals in Sample
Chemical Abstracts	624 (23)	70
Index Medicus	589 (34)	66
Biological Abstracts	550 (13)	62
Excerpta Medica	524 (7)	59
Bibliography of Agriculture	270 (5)	30
Psychological Abstracts	176 (12)	20
Nuclear Science Abstracts	68 (0)	8
Mathematical Reviews	34 (0)	4
Review of Metal Literature	32 (0)	4
Applied Mechanics Reviews	31 (0)	3
Engineering Index	29 (1)	3
Meteorological and Geoastrophysical Abstracts	23 (0)	3
International Aerospace Abstracts	12 (0)	1
Covered by above services collectively	856	96
Covered by none of above services	35	4
Totals	891	100

Sample consists of 14,275 documents cited in *NIH Research Grants Index, Fiscal Year 1962*. These documents were published in 891 different journals. "Covered" is a term used by abstracting-indexing services to mean that they process (i.e., abstract, index, or list by title) at least some of the documents in a given journal. Title-listing services are not included here. The figures in parentheses represent the number of journals processed by only this 1 of the 13 services listed, i.e., the "unique" coverage of sample journals by the given service.

TABLE 5. *Overlapping coverage of sample of document output of U.S. biomedical research by six major abstracting-indexing services*

No. Services Covering Sample Journal	No. Sample Journals So Covered	% All Sample Journals
All 6 services	33	4
Some 5 of the 6 services	122	14
Some 4 of the 6 services	214	24
Some 3 of the 6 services	215	24
Some 2 of the 6 services	156	17
Only 1 of the 6 services	112	13
None of the 6 services	39	4
Totals	891	100

Sample consists of 14,275 documents cited in *NIH Research Grants Index, Fiscal Year 1962*. These documents were published in 891 different journals. The six abstracting-indexing services are: *Index Medicus, Chemical Abstracts, Biological Abstracts, Excerpta Medica, Bibliography of Agriculture*, and *Psychological Abstracts*. In number of sample journals covered, these services ranked highest among the abstracting-indexing services studied. "Covered" is a term used by abstracting-indexing services to mean that they process (i.e., abstract, index, or list by title) at least some of the documents in a given journal. How various combinations of specific services covered the sample is indicated in the appendix (see footnote 6).

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[21] These 21 dental journals were, as a group, relatively poorly covered by the services shown in Table 4; however, all but one are covered by the *Index to Dental Literature* (lists of journals covered supplied by American Dental Association, Dec. 30, 1963).

TABLE 6. *Overlapping coverage of sample of document output of U.S. biomedical research by four major abstracting services*

No. Services Covering Sample Journal	No. Sample Journals So Covered	% All Sample Journals
All 4 services	76	9
Some 3 of the 4 services	292	33
Some 2 of the 4 services	249	28
Only 1 of the 4 services	196	22
None of the 4 services	78	9
Totals	891	100

Sample consists of 14,275 documents cited in *NIH Research Grants Index, Fiscal Year 1962*. These documents were published in 891 different journals. The four abstracting services are: *Chemical Abstracts*, *Biological Abstracts*, *Excerpta Medica*, and *Psychological Abstracts*. These services ranked highest in number of sample journals covered. "Covered" is a term used by abstracting-indexing services to mean that they process (i.e., abstract, index, or list by title) at least some of the documents in a given journal.

true figure is undoubtedly considerably lower. From the present data alone, no meaningful lower limit can be placed on the percentage of sample articles that were actually abstracted by these abstracting services.

If the sample had included all documents cited in the *Grants Index*, rather than only those identified as appearing in journals, the figure of 96% previously given as the best estimate of the inclusiveness of combined coverage by the 13 services most likely would be reduced by perhaps 6 or 7%.[22]

The appendix to this paper (see footnote 6) contains separate lists of the journals *a*) not covered by any of the 13 abstracting-indexing services shown in Table 4, *b*) not covered by *IM*, *c*) not covered by any of the six services analyzed in Table 5, and *d*) not covered by any of four abstracting services included in Table 6; in addition, the frequencies with which combinations of services processed the same journal are given.

Comparison with other studies. A 1961 study (15) of the coverage of cardiovascular, endocrine, and psychopharmacologic literature, in which each abstracting-indexing service was searched for every paper in the sample of literature studied,[23] found that the best coverage of the sample papers by any one abstracting service was 43% (*EM*), and that *BA*, *CA*, *EM*, and *PA*, collectively, had abstracted only about 70% of the sample papers that were 1–4 years old. The inclusiveness of the *Current List of Medical Literature* (the predecessor of *IM*), however, was found to be about the same (87% of the sample papers) as in the present study. The authors concluded: "A worker in the problem-oriented fields of medical research studied will probably find that none of the standard abstracting services adequately covers his field and, although a combination of three or four of these services will give him satisfactory coverage, it is hardly practical, lacking completely current subject indexes to these services, for a researcher to scan them all to alert him to relevant work. At present, the *Index Medicus* is probably one of the better tools for this purpose."

It is probable that the actual coverage by abstracting services of journal articles in the sample used for the present assessment was somewhat greater than the 70% established by this earlier study, but it was most likely closer to 70% than to 98%.[24]

Duplicate Processing

Present assessment. The sample journals covered by any of the six services in Table 5 were covered, on the average, by 3.2 different services. When only the four abstracting services are considered (Table 6), the corresponding figure on duplicate coverage is 2.3 services processing each journal. Another indication of the high frequency with which these journals were processed by more than one of the services studied is given by the figures in Table 4 for unique coverage.

From the present data no reliable estimate can be made concerning total duplication of processing on a document basis.

Comparison with other studies. The Welch Medical Library study in the early 1950's also showed marked overlapping of coverage and concluded:

"As has been pointed out for the five major services [*BA*, *CA*, *EM*, *PA*, and the *Current List of Medical Literature*] there is a great amount of overlapping and duplication among them. This is even more accentuated when we take into account all the services, and beyond these, the great number of other journals that publish abstracts as a regular feature. A tremendous amount of time and effort is being expended on keeping up with the literature. It would seem that a great deal of it is wasteful. There is certainly a great need for more coordination of effort and publication and particularly among the major services."

The 1961 study previously cited found that, of all abstracts of sample papers produced by *BA*, *CA*, *EM*, and *PA*, 40% were for papers abstracted by more than one of the four services. Figure 2, which is reproduced from the cited study, depicts graphically the extent of duplicate processing of articles.

A recent study (8) concludes that the world's scientific journals are being covered, on the average, nearly four times by U.S. abstracting and indexing services.

Significance of duplicate processing. Processing of a given journal or a given article by more than one service does not necessarily constitute wasteful duplication since

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[22] Although 10% of the documents cited in this source were not in journals, about one-half of these nonjournal documents were in proceeding volumes, some of which were covered by these services.

[23] The sample consisted of 240 published papers resulting from oral reports at selected, major U.S. meetings for research workers in these fields.

[24] Two reasons dictate this conclusion. First, the earlier study included papers published in proceedings volumes, a form of publication not as well covered as journals. Second, the coverage of at least some of the services has undoubtedly improved since the earlier study.

services have different users and may be designed for different functions. However, it does represent an opportunity to save time, cost, and manpower by cooperative arrangements to minimize unnecessary duplication of processing operations.

Currency

No attempt was made in the present study to determine the interval between the time the sample documents were published and when they appeared in the various services. Data from the previously cited 1961 study (15) are given in Fig. 3. The processing times shown here are based on papers published between 1957 and 1960, almost all of which were in U.S. publications. U.S. abstracting and indexing services are expected to be slower in processing articles in foreign languages; however, a 1963 study of mental health literature, which carefully sampled the world's literature,[25] found the following median figures for time lag between journal publication and abstracting-indexing coverage: *IM*, 4 months; *EM*, 12; *BA*, 8; and *PA*, 15 (unpublished study performed for the National Institute of Mental Health). With the reservation that one study used averages and the other medians, some comparisons may be made between these two studies of literature samples that differed in age by 2–4 years. The intervals for *EM* and *PA* in 1963 are remarkably similar to those shown for psychopharmacologic papers in Fig. 3. The decrease in *BA*'s processing time may indicate an improvement in the last few years, and the decrease in the figure for *IM* as compared to that for *Current List of Medical Literature* in Fig. 3 may also be significant.

Whereas a processing time of 3–4 months is a reasonable goal for the large services, and one that is currently being approximated by *IM* and *CA*, services that process smaller numbers of articles can achieve greater currency, e.g., 8 weeks for the *Hospital Literature Index* (previously cited unpublished study of mental health literature).

Coordination of Effort

Horizontal coordination. The trend toward more cooperation among abstracting-indexing services was discussed earlier. From the viewpoint of the scientific community, however, something more is needed than simple bilateral or multilateral arrangements among services if gaps in the coverage of the world's scientific literature are to be filled, increasing document loads handled, and the level of performance materially improved in all fields of science. With complete laissez faire it appears highly unlikely that these goals can be achieved in a reasonable time with an acceptable expenditure of resources. More than money is involved, since some of the processing operations of these services require a high level of scientific training;[26] and any duplication of effort that represents unnecessary use of scientific manpower cannot be justified. The choice seems to be between some mechanism to assure coordination of the efforts of the present independent services or a centralized service for all of science similar to that established by the U.S.S.R. (25).

The question of centralization vs. pluralism has been decided, at least for the moment, in favor of the latter; but it is not dead (22, 24). The National Science Foundation has been charged with exercising "leadership" to see that the necessary coordination of both federal and private efforts is achieved (Title IX of the National

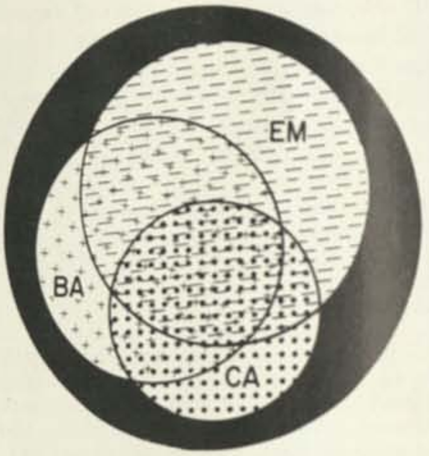

FIG. 2. Coverage of research papers by abstracting publication. Reproduced from ref. 15.

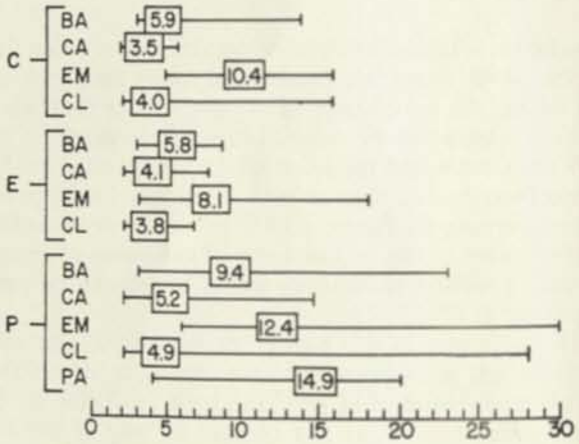

FIG. 3. Interval between publication and appearance in abstracting-indexing service. Reproduced from ref. 15. *C* = cardiovascular papers; *E* = endocrine papers; *P* = psychopharmacology papers. The average time lag (months) is given in the boxes. The horizontal bars give the range of variation.

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[25] About 70% of the sample documents were in English.

[26] All abstracting and indexing is not performed by individuals trained to the level usually implied by the term "scientist," but abstracting services (e.g., *BA* and *CA*) depend largely on abstractors with graduate training in science, and the current effort to improve the quality of indexes is resulting in a steady increase in the level of scientific competence required of indexers. In view of present and anticipated processing loads, the aggregate use of scientific manpower assumes significant proportions, particularly that required for abstracting. There is general agreement that preparing a good abstract usually requires one-half hour or more.

Defense Education Act of 1958 as applied by Executive Order 10807, dated March 13, 1959). Two reports sponsored by the Office of Science and Technology (17, 20) have recommended a number of actions intended to improve coordination of services controlled directly and indirectly by federal agencies.

In addition to the coordination that may be achieved by carrying out systematic plans for filling gaps and minimizing duplicate processing of marginal utility, mechanisms to facilitate serial rather than parallel processing of the same documents by different reference retrieval services can make important contributions toward improved performance. The plans for MEDLARS provide for a mechanism of this type. NLM could perform the initial processing of the world's biomedical literature and refer to the appropriate specialized services for further processing all documents relating to their respective subject coverages (19). If this kind of serial coordination can be realized in practice, the large, broad services could act as "wholesalers" supplying more specialized "retail" services.

Vertical coordination. Some progress has also been made toward a basically different type of coordination that may be called "vertical" to distinguish it from the horizontal coordination of reference retrieval services as a group. Vertical coordination between the activities publishing scientific literature and the services engaged in producing bibliographic tools has potential advantages that have only begun to be exploited in the biomedical field. For more than 10 years, various national and international assemblages and organizations[27] have been urging that at least part of the intellectual work required to maintain abstracting services should be performed when documents are published, and that "source" abstracts, prepared by authors and carefully edited, be made available to abstracting-indexing services, preferably by publishing these abstracts as part of the original documents.

For technical report literature, this type of vertical coordination is being effected by specifying in research and development contracts that author abstracts be furnished (21). For journal literature, progress, although slow, has been encouraging in all major fields except the biological sciences.[28] In the United States at least, the lag of the biological sciences in adopting the practice of source or author abstracting may be attributable to the fact that publication in biology and the biomedical disciplines is not as centralized as in chemistry and physics, where single organizations (American Institute of Physics and American Chemical Society) publish many of the "core" research journals and are in a strong position to influence publication practices.

More recently, the next logical step in decentralizing some of the work of abstracting-indexing has begun. The Engineers Joint Council has decided that journals of its member societies (which include most U.S. engineering societies) would publish with each article, in addition to an abstract, appropriate indexing terms selected by authors and editors (5). In the biomedical field, the *American Journal of Physiology* instituted a similar policy in 1963.

Requirements for Cooperation and Coordination

In addition to the numerous economic and political problems inherent to the kind of division of labor required for close cooperation and effective coordination of effort, many practical details must be worked out to insure exchangeability of the respective products of abstracting-indexing services, e.g., standardized methods of abbreviating journal titles, compatible indexing terminology, etc. If the full potential of modern technology is to be realized, even such seeming minutiae as the punctuation in citations need to be standardized. Resolving these problems and details entails changes in long-established practices that will require painful compromises and the giving up of some cherished ideas. It is unrealistic to expect that these compromises can be effected unless the motivations are of overriding strength. To the present, motivations of such potency seem to be lacking. Perhaps the main reason is that neither a common goal nor an over-all action plan has been formulated by joint deliberations of the three interested parties—the services, the scientific community, and research sponsors. Only when a clear and specific consensus has been reached will it be possible to develop systematic policies to provide the practical incentives required to override, when necessary, the established practices and the parochial interests of each of the parties to the agreement.

CONCLUSIONS

1) In the last 10 years the services processing biomedical literature, as it is conventionally defined, have materially improved the inclusiveness of their collective coverage; however, important gaps probably remain in abstracting coverage.

2) The literature generated and used by scientists engaged in health-related research includes significant amounts of material falling outside the conventional definition of biomedical literature; this development means that a larger number of basic bibliographic tools must be available to, and used by, this research population.

3) The demand for new mission-oriented bibliographic services cutting across the coverages of the large discipline-oriented services provides unrealized oppor-

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[27] For example, the Royal Society Scientific Information Conference in 1948, the UNESCO Information Conference on Science Abstracting of 1949, and continuing bodies, such as the International Council of Scientific Unions Abstracting Board, the Fédération Internationale de Documentation, and the Conference of Biological Editors (United States).

[28] In 1959, 59% of U.S. "basic-science" journals in chemistry carried author abstracts for some or all articles; whereas, for biological journals, the corresponding figure was 35% (14).

tunities for strengthening the latter type of service, upon which long-term bibliographic control of the scientific record depends, and for achieving important savings in money and scientific manpower.

4) The trends toward mechanization and specialized bibliographic tools will probably culminate in personalized services tailored to meet an individual scientist's needs for learning about the existence of new documents relevant to his work.

5) Author abstracting and indexing offers great promise for alleviating some of the current problems, but biomedical journals have been inordinately slow in adopting this practice.

6) If the advantages of our present pluralistic system are to be preserved while its over-all performance is being improved materially, better coordination of effort among abstracting-indexing services and between these services and the generators of new documents is required; the available resources will be inadequate to meet the challenge unless the present duplication of effort is reduced systematically.

7) A clear goal, specific plans for action, and strengthened incentives are required before such horizontal and vertical coordination can be achieved; these prerequisites can be developed only by joint decisions of the abstracting-indexing services, the scientific community, and the sponsors of research.

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ERRATA

On page 1307, in footnote 21, the first word on the second line, three-quarters should be one-half.

In the abstract, page 1310, the date in line 14 should be 1951, rather than 1950. On page 1312, the date in the last line of text in the right-hand column should be 1950, rather than 1951. The b/ footnote to Table 1 (page 1313) should read like the two sentences enclosed in the following brackets: [Derived by us by examining the founding date given for each serial listed in the source, and counting only the serials existing in 1951. For 115 serials, the founding date was given as "19--," and for 72 as "195-"; these serials are not included in the figure for 1951 but are included in the 1960 figure if the serial was alive then.] The first line of text in the right-hand column, page 1313, should read as indicated within the following brackets: [The period 1951-60 was at most 7.3%.10/ Although, in the]. The number in the fourth line of the right-hand column, page 1313, should be 43, rather than 38. The second and third lines of footnote 10 on the same page should read as indicated within the following brackets: [founding dates (a total of 187), were founded in 1950 or earlier, the percentage increase for the period would be only 3.8%.] In the last line of the legend to Fig. 4, page 1328, the first date should be 1951, rather than 1950.

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Generation of information: published output of U.S. biomedical research[1]

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ORR, RICHARD H., GREGORY ABDIAN, AND ALICE A. LEEDS. *Generation of information: published output of U.S. biomedical research.* Federation Proc. 23: 1297–1309, 1964.—The aim of this study was to determine quantitative relations between the magnitude of the U.S. biomedical research effort and the volume of published documents it generates. Statistics on the funds, manpower, and organization of this research effort over the past two decades were compared with data on the number of documents that could be attributed directly to work supported by the major sources of research funds. The document output of U.S. research was also assessed indirectly by collecting and analyzing data on the publication habits of biomedical scientists. During the period 1957 to 1961, the ratio of the number of papers generated each year by the extramural program of the National Institutes of Health to the number of research grants active two years earlier was relatively constant. In contrast, the ratio of research expenditures to document output in this and other major programs increased steadily. Serial data on the publication habits of biomedical scientists in specific institutions show that, as individuals, they are writing neither more nor less papers now than previously; but a steady, general trend toward multiple authorship suggests tentatively that the over-all ratio of the number of papers published annually by these populations to the number of scientists may be decreasing. The total document output of U.S. biomedical research in 1960 is estimated at 26,000 papers, or about half the total number of U.S. biomedical papers published in that year. Over the past decade, document output has increased at roughly the same rate as research manpower and approximately one-half as rapidly as total research expenditures. These findings have implications for the users of biomedical literature, for the information services that must handle the document output of biomedical research, and for those concerned with the development of the national research effort.

INFORMATION is both a major nutrient and a primary end-product of research and development. The information utilized by biomedical scientists can be considered as "input" to the research effort, and that resulting from their work as "output." Although development projects may have other kinds of output—a new or improved product, process, or service, e.g., a better drug or improved diagnostic equipment—new information is the only immediate result of basic research.

Presumably, the most significant information resulting from the biomedical research effort is published. This portion of the total information output constitutes a sample that lends itself to objective measurement. For a definitive assessment of the research effort based on such a sample of its output, quality as well as quantity must be measured. Pending development of practical and generally accepted techniques for measuring the over-all quality of the published information generated by biomedical research, however, simple quantitative measures have some interest. By comparing data on published output with statistics on the magnitude of the biomedical research effort, the gross relations between effort and result may be studied.

Knowledge of these quantitative relations can also help in understanding and meeting current and future problems associated with the communication of scientific information within the biomedical community. The mounting volume of new biomedical literature is frequently blamed for most of the difficulties biomedical scientists experience in obtaining the information input they need to work effectively and efficiently. Undoubtedly this volume is a major cause of the problems faced by "middlemen" in the flow of documents from generators to users—publishers, editors, abstractors, librarians, etc. Despite the acknowledged importance of volume, however, little is known about the factors determining the rate at which new documents are produced.

This study was undertaken to explore the quantitative relations between the biomedical research effort and its document output. Our approach was: *1*) to describe the past, present, and projected effort in terms

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of manpower, funds, and organization; *2)* to identify the output of published documents directly attributable to this effort; *3)* to establish general relations between past effort and output; and *4)* to look for any serial trends in these relations. This approach could be applied only to research communities for which suitable statistics on manpower and expenditures were available and for which document outputs could be readily recognized and counted. Therefore, the study was limited to the U.S. research effort. This paper summarizes our findings, estimates the total U.S. output, and suggests questions that warrant further study.

METHODS AND SOURCES

Statistics on the U.S. research effort have improved greatly in recent years. Nevertheless, no single source, nor any combination of sources, provides the kinds of serial measures we wanted for the past two decades, during which major changes in both the size and the organization of the U.S. biomedical research effort have occurred. The major deficiencies are lack of statistics on biomedical research manpower prior to 1954 and on research supported by nonfederal sources. In addition to the gaps that exist, there are troublesome differences in the definitions and methods used for different statistical compilations and for different periods; these differences often make available figures unsuitable for establishing serial trends.

Statistics on federal expenditures for biomedical research are best developed, but even these present numerous problems when comparable serial data are desired. The most recent and accurate figures on federal support for biomedical research during the period 1947–1964 (24) are not directly comparable with either the statistics on total governmental and private support or with those on research manpower, which were compiled earlier (see footnote 10 for a discussion of the newer figures on federal support). Therefore, we used the older statistics on funds when serial changes were of primary interest.

After collecting and comparing statistics on funds, manpower, projects, and performing organizations from numerous sources, figures suitable for our purpose were selected on the basis of comparability and probable reliability. As these selected statistics are presented in this paper, the sources are identified.

Reliable statistics on the document output of U.S. biomedical research are few; with few exceptions, the published estimates are unsystematic guesses. Much of our time, therefore, was devoted to obtaining and analyzing new data on the document output that could be clearly attributed to research programs for which the manpower and funds were known, and on the publication habits of biomedical scientists. These new data, and the usable data we could glean from previous studies, are presented here in reduced form. The methods we used for data collection and analysis are described briefly; detailed methodology and primary data are given in the appendix to this paper.[5]

DATA

U.S. Biomedical Research Effort

Funds and manpower. Figure 1 summarizes key statistics on funds and manpower[6] devoted to U.S. biomedical research. These are tabulated in the appendix (see footnote 5). The logarithmic plot (Part A) shows that growth of the research effort, as measured by these statistics, has not been truly exponential except over relatively short periods. In both plots, all the curves representing funds break upward rather sharply at 1956. Table 1 compares the distribution of manpower in 1954, 1958, and 1960 among the major types of organizations performing research and gives the average expenditure per professional worker. These years are the only ones for which comprehensive manpower statistics are available. During the period 1954–1960, the average expenditure per worker increased at a compound rate of 7.5% per year, or 5.3% when corrected for inflation (23).

Research projects. For publication purposes, a project commonly serves as a unit of research. Serial statistics on projects are presented in Table 2. Over the past 10 years, an increasing proportion of all U.S. biomedical research projects has been registered with the Science Information Exchange (SIE); however, the figures in columns 4 and 5, even for the most recent years, do not represent complete national totals (25). Several years ago, a study estimated these totals from the total expenditures for U.S. biomedical research by assuming that the average annual support per project was the same for all U.S. research as for NIH extramural research (9); these estimates were not used in the present study since the information now available on nonfederally supported projects registered with SIE (column 6) makes this assumption questionable.

Another factor that could influence the document output of biomedical research is the duration of projects, which has been changing, at least for the projects supported by NIH. Between 1950 and 1955, the proportion of 1-year grants by NIH decreased from 50% to 10%, while 3- to 5-year grants increased from 20 to 50% (19); in 1960, the average duration was 2.86 years (22).

The average number of scientists associated with a research project could also affect document output. Our analysis of grantees named in the *NIH Research Grants Index, Fiscal Year 1962* shows that a total of 17,109 different scientists served as principal or co-principal

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[5] A copy of the appendix can be borrowed from the National Library of Medicine by initiating an interlibrary loan request for: *Appendix* to Orr, Richard H., Gregory Abdian, and Alice A. Leeds. Generation of information: published output of U.S. biomedical research. *Federation Proc.* 23: 1297–1309, 1964.

[6] Manpower is given by the statistical source (23) in terms of "professional" workers, defined as individuals with doctoral degrees (or with less than doctoral training) "who functioned as principal investigators and collaborators." These criteria generally excluded individuals functioning as research assistants, technicians, and supporting personnel, regardless of their degrees. The source notes, however, that "Federal and State personnel classification systems and industrial employment practices are keyed more closely to position descriptions than to the more rigorous standards applied in the extramural [academic] sector."

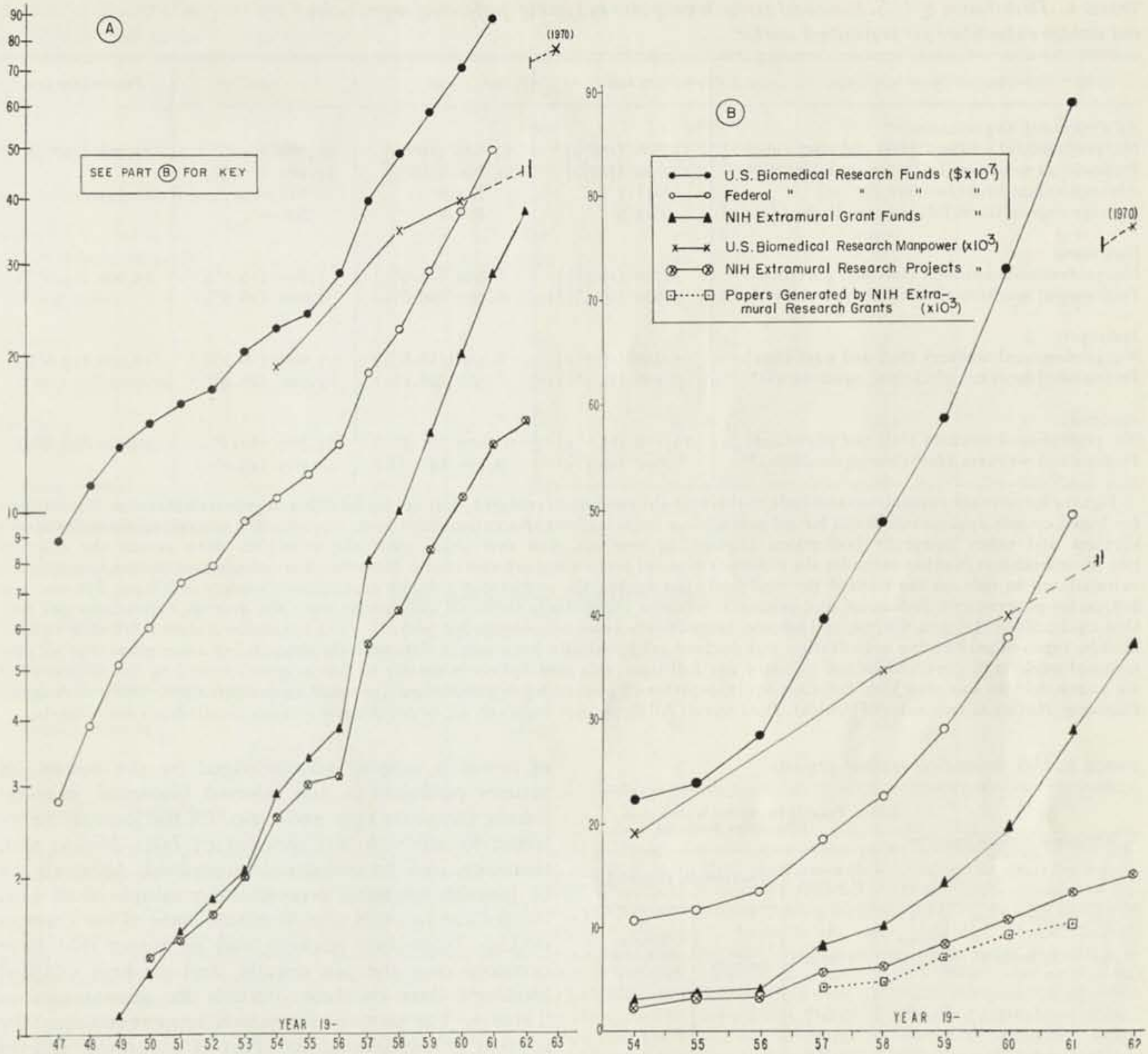

FIG. 1. Key statistics on the U.S. biomedical research effort. The funds shown are for the conduct of research and exclude expenditures for construction and research training. In Part A, dollars, manpower, and projects are plotted on a log scale; in Part B, the same figures are plotted on a linear scale for the period during which manpower data are available. Broken lines represent projections to estimated manpower in 1970. Data on the number of papers generated by NIH extramural research grants are included in Part B to facilitate comparisons when the relations between effort and output are discussed. *Data sources:* For U. S. biomedical research funds, ref. 23, except 1947 figure, which is from ref. 19, and 1948 and 1949 figures, which are from ref. 22; for federal research funds, derived from figures for U. S. funds by subtracting totals for "nonfederal support of medical research" given in ref. 23, except for 1947 figure, which is from ref. 19; for NIH extramural grant funds, ref. 9, except 1962 figure from ref. 13; for manpower, ref. 23; for projects, ref. 9, except 1961 and 1962 figures from refs. 12 and 13, respectively; for papers generated by NIH extramural research grants, see Table 4.

investigators on projects active in fiscal 1962[7] (not all members of research teams are named); each of these scientists had an average of 1.3 NIH projects. For the average project, 1.5 investigators were named.

Information Output of U.S. Biomedical Scientists

Output identified in biomedical journals. Numerous studies have been made of the rate at which new biomedical literature is being generated. The findings of these studies, however, are generally not suitable for our purpose, since all the biomedical documents being produced cannot be attributed directly to the U.S. research effort

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[7] If the manpower statistics in Table 1 are extrapolated to the period corresponding with fiscal year 1962, it can be seen that NIH grantees constituted about 40% of all U. S. research manpower.

TABLE 1. *Distribution of U.S. biomedical research manpower by types of performing organization and average expenditure per professional worker*

	1954	1958	1960	Projected for 1970
All Performing Organizations				
No. professional workers (full and part-time)	19,200 (100%)	34,600 (100%)	39,700 (100%)	77,000 (100%)
Professional workers (full-time equivalents)	14,000 (100%)	23,000 (100%)	27,285 (100%)	
Average expenditure/worker (X 10³)	$11.7	$14.2	$18.0	$39.0
Average expenditure/full-time equivalent (X 10³)	$14.9	$21.2	$26.0	
Government				
No. professional workers (full and part-time)	3,700 (19.3%)	6,900 (19.9%)	7,800 (19.7%)	12,000 (15.6%)
Professional workers (full-time equivalents)*	3,700 (26.4%)	6,900 (29.8%)	7,800 (28.6%)	
Industry				
No. professional workers (full and part-time)	3,400 (17.7%)	6,500 (18.8%)	7,200 (18.1%)	12,000 (15.6%)
Professional workers (full-time equivalents)*	3,400 (24.3%)	6,500 (28.1%)	7,200 (26.4%)	
Academic				
No. professional workers (full and part-time)	12,100 (63.0%)	21,200 (61.3%)	24,700 (62.2%)	53,000 (68.8%)
Professional workers (full-time equivalents)*	6,900 (49.3%)	9,700 (42.0%)	12,285 (45.0%)	

Figures for average expenditures include outlays for the conduct of research, but not for facilities or research training. Percentages are based on the appropriate totals for all performing organizations. As categorized here, "academic" organizations include universities and other nonprofit institutions performing research. For one year, 1961, the available data permit the calculation of expenditure/worker ratios for the different types of performing organizations. If the numbers of workers in each category are extrapolated to 1961 on the basis of the 1958 and 1960 figures, the calculated average expenditure/worker is $18,400, $32,700, and $18,500 for government, industrial, and academic workers, respectively (over-all average $21,000); the average expenditure per full-time equivalent is $18,400, $32,700, and $36,000, respectively (over-all average $30,300). *The breakdown of total full-time equivalents by types of performing organization was derived arithmetically from source data with the simplifying assumption that all professional workers in government and industry are full-time; this assumption is similar to that originally used by the compilers of the source data to calculate total full-time equivalents for all performing organizations (personal communication, Office of Program Planning, National Institutes of Health). *Data source*: All figures are from ref. 23, or are derived arithmetically from data therein.

TABLE 2. *U.S. biomedical research projects*

Extramural Projects Supported by NIH			Projects Registered with Science Information Exchange		
			All sources of support	Nonfederally supported	
1 Year	2 No. projects	3 Average annual support/project	4 No. projects	5 No. projects	6 Average annual support/project
1950	1,400	$9,360	3,317		
1951	1,500	10,400	3,216		
1952	1,700	10,700	4,269		
1953	2,000	10,150	4,933		
1954	2,600	11,120	6,015		
1955	3,000	11,300	6,693		
1956	3,100	12,450	7,967		
1957	5,700	14,140	10,849		
1958	6,500	15,390	12,410		
1959	8,500	16,550	15,080		
1960	10,700	18,620	30,012	4,283	$12,644
1961	13,500	21,250		4,876	11,457
1962	15,000	24,800		4,600	11,975

Data sources: Column 2, 1950–1960, ref. 9; 1961 and 1962, refs. 12 and 13, respectively; all figures rounded to nearest hundred. Column 3 derived arithmetically from column 2 and data on NIH extramural grant funds (see legend for Fig. 1). Column 4, ref. 25. Columns 5 and 6 supplied by Science Information Exchange, June 6, 1963.

as this effort is defined by the available statistics on funds, manpower, and projects.

One exception is a study by Shilling (20) of the sources of research support acknowledged by the authors of articles published in 100 selected biological journals[8] during the years 1950 and 1960. Of the journals he selected for study, 61 are indexed by *Index Medicus* and, therefore, may be considered biomedical. Although the 61 journals are not a representative sample of all U.S. biomedical journals, they illustrate some of the changes in U.S. biomedical research and its output that have occurred over the past decade, and we have adapted Shilling's data on these journals for presentation in Table 3. The pattern of research support indicated by support acknowledgements (Part A) sensitively reflects the general pattern of U.S. support for biomedical research.[9] For example, in the journal sample, of all articles acknowledging "outside" support in 1950, 38% identified federal sources and 18% acknowledged Department of Health, Education, and Welfare (HEW) support; whereas, in 1948, federal and HEW support accounted for 41% and 18% of all U.S. biomedical research expenditures, respectively. In 1960, for the journal sample, the corresponding percentages are 53% and 33%, as compared to 50% and 34% for the respec-

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[8] The selection criteria are described as follows: "The list was furnished by the National Science Foundation (NSF) as being representative of the broad scope of biology and having been used for other research in documentation. Regional, house organ, and other special purpose journals were generally excluded. Some changes had to be made in the NSF list in order to replace those not published in 1950" (20).

[9] For U.S. scientific journals and research support in general, the same phenomenon has been noted by Milton and Johnson (10).

TABLE 3. *Sources of support and types of organization performing research reported in 61 biomedical journals, 1950 and 1960*

	1950 (Total no. articles published = 7,195)		1960 (Total no. articles published = 9,321)	
	No. articles	% articles*	No. articles	% articles
A. Sources of Support Acknowledged by Authors				
Sources outside author's institution	4,798	66 (100)	8,751	94 (100)
HEW	836	12 (18)	2,900	31 (33)
Other federal agencies	994	14 (21)	1,783	19 (20)
Total federal	1,830	25 (38)	4,683	50 (53)
State	149	2 (3)	530	6 (6)
Total government	1,979	28 (41)	5,213	56 (60)
Industry	627	9 (13)	540	6 (6)
Other private sources	737	10 (15)	1,142	12 (13)
Total private	1,364	19 (28)	1,682	18 (19)
Unclassifiable sources	1,455	20 (30)	1,856	20 (21)
No outside sources acknowledged	2,397	33	570	6
B. Institutional Affiliation of Authors				
Government	723	10	1,209	13
Universities	3,895	54	5,090	55
Other non-profit institutions	1,754	24	1,620	17
Total academic	5,649	78	6,710	72
Industry	265	4	343	4
Unclassifiable institutions	558	8	1,059	11

The titles of the 61 journals are listed in the appendix (see footnote 5). *Part A*. Sources of outside support acknowledged in the articles (or identified by authors in response to a questionnaire) were classified in the data source as follows: under "support by federal grant or contract"—"AEC" (Atomic Energy Commission), "NSF" (National Science Foundation), "DOD" (Department of Defense), "HEW" (Department of Health, Education, and Welfare), and "other"; under "non-federal support"—"foreign work with U.S. support," "foreign work with non-U.S. support," "fellowship," "industry," "state funds," and "private." Two of the categories under "non-federal support" ("foreign work with U.S. support" and "fellowship") could represent government, industrial, or private funds. These two categories, and "foreign work with non-U.S. support," are not adaptable to the classification used in this table and are combined here as "unclassifiable sources." Articles for which no outside sources were acknowledged presumably represent work supported solely by the performing organizations' (or the scientists') own funds. *Part B*. Performing organizations, i.e., the authors' institutions, were classified in the data source as follows: "federal lab," "state university," "non-state university," "private lab or hospital," "foreign work with U.S. support," and "foreign work with non-U.S. support." The last two categories are not adaptable to the classification used in this table and are combined here under "unclassifiable institutions." The data source category "private lab or hospital," which has been converted to "other non-profit institutions" in the present classification of performing organizations, may have included a few commercial organizations; however, we have assumed all institutions so categorized to be nonprofit and have lumped this category with "universities" under "academic." This assumption was made to allow comparisons with statistics on funds and manpower. *The parenthetical figures are calculated on the basis of all articles that acknowledged support from sources outside the authors' institutions, rather than of the total number of articles published. *Data source:* Adapted from ref. 20.

tive ratios of federal and HEW support to total U.S. research funds in 1958.[10]

Output identified by source of support. A more direct way to obtain data on the document output of research is to count all the documents generated by specific research programs. Table 4 shows the annual output of papers that can be attributed directly to NIH extramural and

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[10] Data on documents published in 1950 and 1960 are compared with funding statistics for 1948 and 1958 because of the time lag between funding and publication. This lag is discussed on page 1304. The sources of the statistics on research funds shown in Fig. 1 do not give data on HEW funds. The percentages of total U. S. biomedical research funds used here for comparisons with the journal sample are based on data given in another source (24). This recent compilation gives figures for federal expenditures during the years 1947 to 1961 that average about 20% higher than those in earlier compilations; however, estimates of total support from all sources during the corresponding years have not been revised. For these comparisons we calculated revised figures for total U. S. funds by adding the difference between the old and new figures on federal expenditures in 1948 and 1958 to the old figures for total U. S. support shown in Fig. 1.

TABLE 4. *Papers generated by NIH-supported research*

1 Year	2 Extramural Research (No. papers)	3 Intramural Research (No. papers)	4 Total (2 + 3)
1957	4,070	1,160	5,230
1958	4,795	1,100	5,895
1959	7,035	1,329	8,364
1960	9,400*	1,616	11,016
1961	10,400*	1,627	12,027
1962		1,849	

The term "papers," as used here and throughout this report, means published documents other than abstracts of oral reports given at meetings. Detailed methodology and primary data are given in the appendix (see footnote 5). * These figures are calculated from the primary data on grantee publications (which included published abstracts of oral reports) so as to be comparable to figures for earlier years; they have been rounded off to the nearest hundred. *Data sources:* Column 2—data for 1957–1960, Dr. Errett C. Albritton, Chief of Research Accomplishments, Division of Research Grants, NIH; figure for 1961 obtained by analyzing the grantee publications cited in *NIH Research Grants Indexes* for fiscal years 1961 and 1962, and adding the papers associated with terminated projects and omitted from 1962 *Index* (data on terminated projects supplied by Mrs. Lynda McGee, Chief, Research Documentation Section, NIH); a figure for 1962 is not given since, although some 1962 papers are cited in *NIH Research Grants Index, Fiscal Year 1962*, a complete count for the calendar year 1962 cannot be made until *NIH Research Grants, Fiscal Year 1963* has been analyzed. Column 3—the annual bibliographies of NIH intramural staff for given years, ref. 14.

intramural programs during the years 1957 to 1961.[11] In analyzing the *NIH Research Grants Index, Fiscal Year 1962* for the number of documents cited by grantees as resulting from their NIH-supported projects, we found that an average of 1.2 papers were listed for grants that had run two or more years.

Output rates of biomedical scientists. The quantitative output of biomedical research can also be assessed by studying the output rates of scientist populations engaged in the U.S. research effort.

About the only data suitable for our purpose, and relating to a systematically derived national sample of a broad biomedical research population, were reported by Gerard in his impressive study of physiologists (8). In this study, one of the questions answered by 4,751 U.S. and Canadian research physiologists[12] was how many papers they had published (as "senior" author or coauthor) in a 3-year period (roughly 1950–1952, inclusive). Gerard noted that, as a measure of the document output of physiologists, the average derived from their answers (1.7 papers per year) was misleading, since, if one multiplied the number of respondents by this average, the product obviously exceeded the known output of physiology papers; and he commented that multiple authorship of papers "may well cut the number to a half or a third."

We searched for published and unpublished statistics that could be analyzed for possible changes in the document output of U.S. biomedical scientists over the past decade, but found no reports that provided serial data on national populations, and only one report on an institutional population. The Publications Section of the Mayo Clinic, which handles all publications emanating from that institution, reported (unpublished internal document) the total number of manuscript pages it processed each year from 1950 to 1962 and related this figure to the total number of Mayo Staff Members in the given year. The ratio of total manuscript pages to all Staff Members (including those who had no publications in the given year) averaged 66 for the years 1950–1962. The maximal yearly variation from this average was ±12 %, with no apparent trend toward an increase or decrease. The original data, supplemented by counts we made of the total number of papers published by Mayo Staff Members, are given in the appendix (see footnote 5). The ratio of the annual total of published papers to the total number of Staff Members averaged 1.8 for the years 1950–1954 inclusive, 1.4 for 1955–1959, 1.4 for 1960–1962, and 1.6 for the entire 13-year period.

The ratio used to describe the document output of Mayo Staff Members is not equivalent to the one used to express Gerard's data on physiologists. The difference is analogous to that between the birth rate for a population and the average number of times individuals in the population become parents.[13] To prevent confusion, and to facilitate comparisons of data from different sources, we will use the term "average authorship rate" for the average number of papers "authored" per year by members of the given population, and the term "publication rate" for the ratio of the total number of papers produced annually by a population to the total number of scientists in the population. Gerard's statistic is, in our terminology, an average authorship rate; whereas, the statistics for the Mayo Clinic are publication rates.

To obtain more data bearing on possible serial changes in publication habits, we attempted to find comprehensive bibliographies for the staffs of research institutions that had been compiled on a uniform basis annually for at least five years and were otherwise suitable for analyzing authorship and publication rates. Although others undoubtedly exist, the only suitable series found to date are the annual bibliographies of NIH intramural staff and those of Medical College of Virginia faculty. Analyses of these two serial bibliographies for authorship and publication rates are summarized in Table 5 and are compared with the rates for physiologists and for Mayo Staff. Also included here are corresponding sta-

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[11] Lindsay and Allen reported counts on the total output of NIH-supported research (extramural and intramural) for the years 1957 through 1960 (9). Our figures for these years differ from theirs only for 1960, and then by only 16 papers.

[12] These respondents represented almost 80% of the estimated total number of U. S. and Canadian physiologists at the time of the study. Canadians accounted for only 5% of the respondents.

[13] The analogy is imperfect in that papers can have one, two, or more "parents"; therefore, the relation between the two types of document output ratios may vary with time and from one scientist population to another.

TABLE 5. *True and apparent average authorship and publication rates for U.S. biomedical research populations and for the world biomedical community*

	Average Authorship Rates				Publication Rates				
Year	Physiologists	Med. College of Virginia faculty	NIH staff	*Index Medicus* authors	Physiologists	Med. College of Virginia faculty	Mayo Clinic Staff Members	NIH staff	*Index Medicus* authors
1942				(1.3)					(1.0)
1943			(2.4)					(1.5)	
...									
1950							2.4		
1951							2.0		
1952	1.7 (1.9*)			(1.4)	0.74 (0.83)†		1.4		(.95)
1953							1.7		
1954			(2.6)				1.8	(1.4)	
1955							1.5		
1956							1.5		
1957		0.79‡ (2.2)				0.51‡ (1.4)	1.8		
1958		(2.0)				(1.5)	1.4		
1959		(2.2)				(1.5)	1.1		
1960		(2.2)				(1.3)	1.8		
1961		(2.1)				(1.3)	1.1		
1962			1.4 (2.2)§	(1.9)			1.4	0.62 (1.0)§	(1.0)

Average authorship rate = average number of papers published annually by members of the given population; the dimensions are "authorships" per scientist per year. Publication rate = the ratio of total number of different documents produced annually by the given population to the number of individuals in that population. The figures not enclosed by parentheses are "true" rates, calculated on the basis of all scientist members of the population i.e., all potential authors; whereas, the parenthetical numbers are "apparent" rates, based on only those members of the population who wrote at least one paper in the given year (active authors). Where true rates are not given, data on the total number of scientists in the population were not available. Authorship rates for Mayo Clinic staff are not given since the number of authors named on their papers was not counted. * Calculated on the basis of all physiologists who wrote at least one paper during the 3-year period covered by the data source. † Both true and apparent publication rates calculated from source data with the assumption that papers published in the *American Journal of Physiology* were typical of U.S. physiology literature during the period of Gerard's study; in 1950 papers in this journal carried an average of 2.3 authors' names. ‡ Calculated on basis of all full-time and part-time faculty (662); this statistic is given by the data source only for 1957. § After the analyses of NIH staff bibliographies had been completed, we realized that the author population represented in these bibliographies does not correspond exactly with NIH intramural staff since individuals not employed by NIH are included in the author indexes of these bibliographies when they have collaborated with NIH staff in writing papers. Other papers written by these nonstaff authors are not included in the NIH bibliography; therefore, the rates shown here are not strictly comparable with the rates given for the other U.S. populations, which are based on all papers produced by members of the given population. When the original analysis for 1962 was refined by eliminating nonstaff authors, the true and apparent authorship rates for this year were 1.3 (3.1), respectively, and the publication rates 0.89 (2.2). If these rates are further refined by correcting for administrative NIH professional staff, who account for about 20% of the total (11), the true authorship rate becomes 1.6 for all NIH professional staff actively engaged in research; and the true publication rate becomes 1.0. We do not have the information required to make the latter refinement of the rates for the other U.S. populations, which also include some scientists who are not active in research.

Data sources: For *Index Medicus* authors, analyses of 5 or 10% samples of all articles listed by *Index Medicus* (or by its predecessors, *Quarterly Cumulative Index Medicus* and *Current List of Medical Literature*) in 1942, 1952, and 1962; for physiologists, derived arithmetically from ref. 8; for faculty of Medical College of Virginia, analyses of annual bibliographies published in *Bulletin Medical College of Virginia*, Annual Report Issues 1957–1958, 1958–1959, 1959–1960, 1960–1961, 1961–1962; for Mayo Clinic staff, unpublished report supplied by Dr. Carl M. Gambill of the Publications Section of the Mayo Clinic, supplemented by our counts of all papers published by Mayo Staff in the *Proceedings of the Mayo Clinic* or listed therein as published elsewhere; for intramural NIH staff, analyses of all citations in the annual bibliographies for 1943, 1954, and 1962, ref. 14.

tistics on papers listed in *Index Medicus*, which represents a selective bibliography of the world's biomedical population. The primary data and analytic methods are presented in the appendix (see footnote 5).

Increase in multiple authorship. Changes in the number of authors named on NIH staff papers and on papers in *Index Medicus* are shown in Fig. 2. The corresponding data for papers published by the faculty of the Medical College of Virginia (average number of authors per paper = 1.8, 1.8, 2.0, 2.0, and 1.8 for the years 1957 to 1961, respectively) fall between the figures for *Index Medicus* and for the NIH staff bibliography.

The average number of authors named on papers produced by a population governs the relation of the authorship rate for that population to its publication rate.[14] For both NIH staff and *Index Medicus* papers, this average has increased steadily in the past 20 years. We

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[14] If the average number of authors named on papers is known for a given population, the average authorship rate can be calculated from the population's publication rate, and vice versa. (Average authorship rate ÷ average number of authors per paper = publication rate.) The figures in Table 5, however, were obtained by direct counts, with the exception of the publication rates for physiologists. For the figures in Table 5, where the relation of authorship to publication rates is not exactly the same as would be calculated from the data on multiple authorship in Fig. 2, the minor discrepancies are attributable to the fact that a few papers listed in the bibliographies were not included in the determination of both authorship and publication rates (e.g., anonymous papers, committee reports without specific authors, etc.).

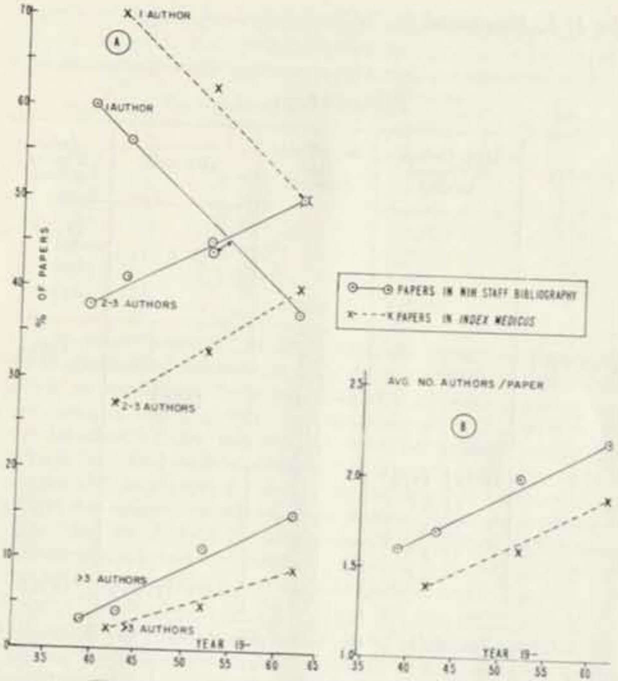

FIG. 2. Trends in multiple authorship. Primary data and methods of analysis are given in the appendix (see footnote 5). *Data sources:* For papers in NIH staff bibliography, analyses of all citations in annual bibliographies for the years 1939, 1943, 1952, and 1962, ref. 14; for papers in *Index Medicus*, analyses of samples of documents listed by *Index Medicus* (or its predecessors, *Current List of Medical Literature* and *Quarterly Cumulative Index Medicus*) for the years 1942, 1952, and 1962.

could find no comparable serial data on other broad biomedical populations.[15]

DISCUSSION

Growth of Research Effort

The growth of the U.S. biomedical research effort has been characterized by irregularities, which make comparisons of the various growth rates manifested by effort and output statistics misleading for any but the short periods during which growth was reasonably steady. The longest of these periods was 1957–1961, during which all the log plots (Fig. 1, Part A), except that for manpower, approximate straight lines and therefore represent steady exponential growth. During this 6-year period, the slopes of the three plots representing funds are quite similar, indicating that the relative contributions of the major sources of research support did not change grossly. The slope of the curve for NIH projects is appreciably less than for NIH extramural grant funds, reflecting the steady increase in the cost of research. Apparently, Price's hypothesis of a "Fechner law situation" between stimulus and effect for scientific research in general (18) holds for biomedical research as well. The acknowledged shortage of scientific manpower (23) may explain why manpower did not grow as steadily as funds and projects during the period 1957–1961. Whether manpower growth can be maintained at a somewhat higher rate than that from 1958–1960, as will be required to meet the 1970 projection, can be judged only when additional serial data are available.

Relation of Effort to Document Output

The irregularities in the growth of the research effort and the complex relations among effort statistics complicate attempts to establish quantitative relations between effort and document output. An additional complication is that, if an increase in funds or manpower resulted in an increase in output, one would expect this effect to be delayed; a minimum lag of two years between cause and effect is reasonable considering the nature of project research and the known delay in publication (16).

Growth of effort vs. growth of output. Table 6 shows some of the trials we made in attempting to relate growth of effort and growth of output using the available statistics on effort and data on document output. In each comparison the effect of an increase in effort, as reflected by a given statistic, was sought in document output two years later. A requirement was that the document output compared should be expected, *a priori*, to be closely "coupled" to the segment of the research effort described by the effort statistic, or that the output should be expressly identified as resulting from this segment. For the comparisons with the output data derived from the sample of 61 biomedical journals (Part A), despite the previously demonstrated sensitivity of this sample to national patterns of research funding, the correlations between the growth rates of funds (E) and growth of corresponding document outputs (O) are low. Output increased about one-third to one-fourth as rapidly as funds. Similar comparisons of total NIH funds and of NIH extramural grant funds with the appropriate total outputs of NIH programs (Part B) show higher correlations; output grew about one-half as fast as expenditures. The closest similarity, however, is between the growth in the number of extramural NIH projects and that of papers generated by the extramural program. In Fig. 1, Part B, this close agreement is manifested by the similar slopes of the curves for NIH extramural research projects and for the corresponding output. The break in the output curve around 1958 probably represents a delayed effect of the sharp increase in NIH projects that occurred in 1956.

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[15] Clarke recently demonstrated that the number of authors named on the oral reports given at annual meetings of the Federation of American Societies for Experimental Biology has not changed significantly since 1947 (5). There are two possible explanations for the difference between his findings and ours: first, that the author populations differed, and second, that authorship practices for oral reports differ from those for regular papers. He has since apparently ruled out the first possibility by analyzing separately the oral reports given at these same meetings by NIH staff members and showing that these documents do not manifest the trend toward multiple authorship we find for the regular papers published by NIH staff (personal communication of unpublished data).

TABLE 6. *Correlation between measures of the growth of biomedical research effort and document output*

A. For Articles in Selected Journals	Effort (Funds × 10^6 or no. of projects)			Output (No. of articles or papers)			Correlation of Growth Rates (O/E)
	1948	1958	Annual growth rate (E)	1950	1960	Annual growth rate (O)	
U.S. biomedical research funds	$113	$490	0.33	7,195 (4,798)[a]	9,321 (8,751)[a]	0.030 (0.083)*	0.091 (0.25)*
Federal biomedical research funds	$39	$226	0.48	1,830[b]	4,683[b]	0.16	0.33
HEW research funds	$22	$183	0.73	836[c]	2,900[c]	0.25	0.34
B. For Papers Generated by NIH-Supported Research	1956	1959	Annual growth rate (E)	1958	1961	Annual growth rate (O)	Correlation of growth rates (O/E)
NIH research funds							
Total	$71	$210	0.65	5,895[d]	12,027[d]	0.35	0.54
Intramural	$32	$69	0.39 (0.22)†	1,100[e]	1,627[e]	0.15	0.38 (0.68)†
Extramural grants	$39	$141	0.87	4,795[f]	10,400[f]	0.39	0.45
NIH extramural research projects	3,100	8,500	0.58	4,795[f]	10,400[f]	0.39	0.67

Annual growth rate = $V-V_0/V_0 \cdot T$, where V = value for last year of period, V_0 = value for first year of period, and T = number of years in period. [a] The first figures are the total numbers of articles published by the 61 journals; the parenthetical figures are the total numbers of articles acknowledging "outside" support (both from Table 5). [b] Numbers of journal articles acknowledging support by any federal agency (from Table 5). [c] Number of journal articles acknowledging HEW support (from Table 5). [d] Number of papers generated by all NIH-supported research, both extramural and intramural (from column 3 of Table 4). [e] Number of publications generated by intramural NIH research (from column 2 of Table 4). [f] Number of publications generated by extramural NIH research (from column 1 of Table 4). * The parenthetical figures are based on the corresponding figures in the columns to the left. † The figures shown for intramural research funds in 1948 and 1958 include expenditures for administration of the extramural grant program as well as for the conduct of intramural research; another data source (11), which breaks down NIH intramural funds, indicates that expenditures solely for "direct research" were $28 million in 1956, and $46 million in 1959; the parenthetical ratios are based on the latter figures, which are more comparable to those for extramural funds. *Data sources:* For U.S. and federal research funds, see legend for Fig. 1; for HEW funds, ref. 24; for NIH funds (total, intramural, and extramural grants) and for NIH extramural projects, ref. 9.

It is apparent that the journal-derived sample does not accurately reflect the total output resulting from the given effort. Two explanations can be offered. First, over the interval between the two years which the journal sample represents (1950 and 1960), funds were not increasing at a steady rate (see Fig. 1). Second and more importantly, the journal sample, which was a nonrandom selection of older periodicals (see footnote 8 for selection criteria), did not contain as large a proportion of all U.S. research papers in 1960 as it did in 1950; journals founded since 1950 took part of the output in 1960.

One might expect manpower statistics to be intimately related to output. Unfortunately, this hypothesis could not be tested directly with the present data on the NIH extramural program. Even if we knew the total number of professional workers engaged in NIH-supported projects during the years 1955–1959, since these individuals had other sources of support, the number of papers generated by the NIH extramural program in 1957–1961 would not represent their total output; nor could this number be assumed to represent a constant fraction of their total output since the pattern of support was changing during this period. The number of NIH projects, however, appears to be roughly proportional to U.S. biomedical research manpower; the average annual support per NIH project in 1954, 1958, and 1960 (Table 2) was reasonably close to the average annual expenditure per full-time and part-time professional worker in the corresponding years (Table 1).

Output per unit effort. For the reasons discussed, the data on the journal sample are not suitable for establishing quantitative relations between effort and output. The following analyses, therefore, employ only data on the total document output generated by NIH programs. To eliminate one possible source of error, attention is confined to output data corresponding to the effort statistics for 1956 to 1959, a period during which funds and projects were increasing at a relatively constant exponential rate.

The ratio of papers generated by the NIH extramural program (Table 4, column 2) to extramural projects funded by NIH two years earlier (Table 2, column 2) is remarkably stable; for papers published during the years 1958, 1959, 1960, and 1961, the ratio is 1.5, 1.2, 1.4, and 1.2, respectively. These values are very similar to the ratio of 1.2 paper per project we established independently for 1961–1962 output by determining the average number of papers cited in the *NIH Research Grants Index, Fiscal Year 1962* for projects two or more years old.

In contrast to the stable output to project ratio, the ratio of expenditures to papers has been increasing for both the extramural and intramural NIH programs, as shown in Table 7. For the extramural program, the year-to-year variation makes it difficult to judge the

TABLE 7. *Relation of NIH research expenditures to document output (average expenditure per paper published two years later)*

Year of Output	Extramural	Intramural
1958	$8,000	$25,000
1959	11,000	26,000
1960	11,000	24,000
1961	13,000	28,000
4-year average	11,000	25,000

All averages are rounded off to two significant figures. *Data sources:* Calculations are based on annual totals for NIH extramural grants in 1956, 1957, 1958, and 1959, from ref. 9; annual totals for NIH intramural expenditures solely for "direct research" in the same years, from ref. 11; and annual document output of the extramural and the intramural programs in the years 1958 to 1961, from Table 4.

true rate of increase in expenditures per paper; however, this increase appears greater than could be explained wholly by the general national increase in expenditures per professional worker, which averaged 9% (simple rate) annually over the period 1954–1960 (see Table 1). Part of the increase in expenditures per paper is probably explained by the increasingly common practice of charging faculty time to research grants (23). In contrast, the increase in expenditures per paper for the intramural program is roughly the same as the general rise in biomedical research costs. The marked difference between the average expenditures per paper in the two programs can be attributed largely to the fact that the statistics on intramural program expenditures include the full costs of the research reported in NIH staff papers, whereas, extramural grants cover only part of the costs of many projects reported in NIH grantees' papers that are also supported, in part, by funds from the grantees' institutions and other sources.

These figures for NIH programs are substantially lower than the average expenditure per paper published by scientists engaged in "basic research" and employed by chemical and pharmaceutical companies. For 1954 papers, the latter ratio has been estimated as $26,000 (7), and for 1959 papers as $59,000 (15); both of these values are based on the total expenditures for basic research reported by the companies for the year prior to the papers' publication dates. Since different methods were used to determine output, these estimates for different years cannot be used to establish trends in industrial research. Although much of the research supported by NIH can be considered "basic," the inherent subjectivity of this classification makes it difficult to judge how comparable these expenditures per paper ratios for industrial research are to those for NIH programs.

Changes in Publication Habits of Biomedical Scientists

"Big Science" and multiple authorship. The trends toward multiple authorship among NIH staff and *Index Medicus* authors are remarkably similar when one considers how different the two author populations are. For all statistics shown in Fig. 2, the rates of change for these two populations match well; however, in any given year the average number of authors per *Index Medicus* paper is about the same as that for NIH staff papers 10 years earlier. Since an increase in multiple authorship has been described as characteristic of "Big Science" (18), and since three-quarters of the papers in *Index Medicus* are from foreign periodicals (3), the observed time difference may indicate that the Big Science syndrome is more fully developed in the United States than abroad. The publication habits of NIH staff are probably not representative of the U.S. biomedical community as a whole; but the fact that, for a given year, the average number of authors named on papers by the faculty of the Medical College of Virginia falls closer to the NIH curve than to the *Index Medicus* data supports the hypothesis that the observed difference reflects national differences. A definitive test of this hypothesis will require a separate analysis of U.S. papers listed in *Index Medicus.*

The phenomenon of increasing multiple authorship is also seen in other fields of science. Both *Chemical Abstracts* and *Physics Abstracts* are comparable to *Index Medicus* in that they cover most of the world's serial literature in their respective fields. The average number of authors named on papers covered by *Chemical Abstracts* has increased steadily; in 1960 this average was about the same for chemistry papers[16] as for papers in *Index Medicus.* No similar average could be found for physics papers; however, only 50% of the papers covered by *Physics Abstracts* in 1961 had a single author (1), a figure very similar to that for *Index Medicus* papers in 1962 (Fig. 2). Unfortunately, as in the biomedical field, there seem to be no data on chemistry or physics papers to test our hypothesis concerning the difference between U.S. and world scientific populations.

Trends in authorship and publication rates. Authorship rates are influenced by, or correlated with, many factors relating to scientists' personal characteristics, their training, and the nature and setting of their work. Some of these factors have been studied formally,[17] e.g., age (2, 6, 8), ability (4, 18), and institutional setting (8, 21). The distribution of authorship rates within scientific populations has also received some attention (4, 8, 18). Among the general findings of such studies, two are particularly relevant to the present inquiry in that they affect the inferences to be drawn from our findings. First, there is a definite correlation between the number of a scientist's publications and most other quantitative and qualitative measures of his ability or performance as a research worker. Second, the distribution of authorship

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[16] Calculated from graphic data in ref. 18, which were difficult to read accurately; however, the error introduced should not affect the general validity of the conclusion drawn.

[17] The references cited in this paragraph represent selected studies that relate directly to biomedical populations or are examples of systematic studies of other broad scientific populations. Despite considerable interest in the publication habits of scientists and frequently expressed concern that these habits have been deteriorating, we could find no published reports of systematic studies that assessed any serial changes in a given population, other than multiple authorship.

rates in any sizable research population is highly skewed; the number of scientists producing more than one paper a year seems to fall off roughly as an exponential function of authorship rate (18).[18] At the level of data interpretation, these facts dictate caution in estimating average authorship rates and publication rates for the entire U.S. biomedical research community or its major performing sections from data on nonrandom samples and local populations, such as institutional staffs. One is rarely justified in assuming that authorship and publication rates for such groups approximate those of national populations defined by institutional environment, e.g., all professional workers in academic institutions.[19] For this reason, we consider the present data on institutional staffs and other possibly nonrepresentative groups useful primarily for suggesting possible trends, which should be assessed in future studies.

In the only two U.S. populations for which we have serial data on either true or apparent average authorship rates (see Table 5), there is no convincing trend toward either higher or lower rates.[20] The serial data on publication rates in two U.S. populations do suggest a downward trend; but this evidence is not adequate in itself to support a conclusion that publication rates are probably declining in these institutions or in the U.S. biomedical community as a whole. However, if the incidence of multiple authorship is increasing generally and average authorship rates are indeed stabilized, as they seem to be, the possibility of a generally declining publication rate should be seriously considered.

Among the possible causes of a decreased publication rate in a research population, local or national, some would be considered by most scientists as desirable, e.g., greater self-discipline of authors, reduced pressure to publish as a result of longer-term grants, more emphasis on quality than quantity, and increasing reliance on multiple authorship to discharge publication obligations. Other possible causes would represent developments justifying careful evaluation, if not serious concern, e.g., growing reliance on oral presentations as definitive reports of research, or a declining general level of ability as the given population grows. On grounds other than data on publication rates, several eminent scientists have suggested that the latter changes are occurring. These hypotheses have been advanced most directly and provocatively by Price (18). The implications that any material changes in publication rates could have for scientific progress, and the importance of these rates in determining the load on biomedical information services, warrant a substantial effort to collect serial data on representative samples of biomedical research workers.

Total Document Output of Research Effort

Method of estimation. Given appropriate quantitative expressions of how document output is related to the magnitude of the research effort, as described by the available statistics on manpower and funds, a simple model can be used to estimate the total output of the formal U.S. biomedical research effort for any period covered by these statistics and to predict future output from statistical projections. For two large research programs (the extramural and intramural programs of NIH), we have determined directly some quantitative relations; but one cannot assume that these relations hold generally for all research conducted in any of the three major types of performing organizations, governmental, industrial, or academic. The NIH intramural program is not typical of research programs in government installations, federal, state, or local. Although the NIH extramural program now provides most of the funds for the "academic" (nonprofit) sector of biomedical research, the output to effort ratios we have established for this program are not appropriate for application to all U.S. academic research.[21] Rather than generalizing from data on these programs, or from publication rates for other populations that cannot be assumed to represent the populations defined by the available manpower statistics, we have developed the estimates offered here

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[18] For NIH staff, *Index Medicus* authors, and faculty of the Medical College of Virginia, the distribution of authorship rates conforms to this general rule. These data are included in the appendix (see footnote 5).

[19] This point is emphasized by Shilling's recent report of significant quantitative differences in document output among 14 microbiology laboratories in U. S. academic institutions (21). These differences were strongly correlated with independent assessments of the respective laboratories as "strong" or "weak." The 64 laboratories included in his study were not selected to constitute a representative sample of all U. S. biological research facilities, and the document output of laboratories rather than individuals was reported; however, his data can be used to calculate approximate average authorship rates for 84 academic scientists working in biochemistry and 82 in microbiology as 2.5 and 2.2 papers per year, respectively, over the period 1958–1963. If these are true authorship rates, i.e., valid for all the biochemists and microbiologists in the laboratories he studied, they are higher than the true rates for NIH intramural staff, the only population in Table 5 that consists solely of scientists attached to an organizational unit devoted primarily to research. Other instances of high average authorship rates for selected populations could be cited; in the biomedical field a striking example is provided by the senior (first named) authors of papers in the *Proceedings of the Society for Experimental Biology and Medicine*. We found that these scientists published an average of 2.8 papers per year in the serials covered by *Index Medicus*. A complete count of their publications would undoubtedly materially raise this average.

[20] Although the data on *Index Medicus* papers seem to indicate a definite world-wide increase in authorship rates, other factors that might account for this apparent trend, e.g., the increasingly comprehensive coverage of *Index Medicus* during the past 10 years, have not been assessed.

[21] From data in ref. 23, it can be calculated that in 1961 over three-quarters of the total research funds of academic and other nonprofit organizations came from NIH; however, for the reasons previously discussed, the ratios of expenditures to papers for the NIH extramural program cannot be used to calculate the total academic output even for the years when the total research expenditures of the academic sector are known. The papers to project ratio for NIH is also unusable since the total number of academic projects is unknown. Our data on grantees' publications do not permit calculation of their true publication rate; and since grantees are a selected group, this rate could not be used for the entire academic population even if it were known.

from a general hypothesis about the publication habits of biomedical research workers. This hypothesis evolved by postulating true publication rates for the governmental, industrial, and academic sectors of the biomedical research effort that seemed, from the available evidence, to be reasonable first approximations and by testing these approximations in the model.

Data from a previously cited report (15) indicate a true publication rate for scientists engaged in "basic" research in chemical and pharmaceutical companies of 0.34 papers per scientist per year. In considering whether this value, which is based on a nonrandom sample, might serve as a reasonable first approximation for industry-based professional workers in biomedical research, we noted that only 38% of the industrial population described by the 1960 statistics on biomedical research manpower had doctoral degrees; whereas, the corresponding percentage for government scientists was 54%, and 91% for academic workers (23). The similar values of the two ratios for industrial scientists (0.34 and 0.38), the observed true publication rates in Table 5, and commonly heard opinions about general differences in the number of papers published by industrial, governmental, and academic scientists,[22] suggested the hypothesis that, for the national populations described by the manpower statistics, true publication rates are roughly equal to the percentage of doctoral-level workers in the given population.[23] Since the distribution of authorship rates would be expected to be highly skewed, even when populations consist solely of doctoral-level scientists, one would not expect a close agreement between the rate predicted for an institutional population by this hypothesis and the observed rate unless the institution happened to be representative and all of its staff members were functioning as principal or co-principal investigators (see footnote 6 for definition of professional workers used for the manpower statistics). When these conditions are considered, it is surprising how well the true publication rates in Table 5 agree with rates predicted by the hypothesis.[24] In view of this general consistency with the limited data on publication rates, the hypothesis was accepted as providing useful approximations pending further tests.

Estimated document output in 1960. Using the manpower statistics for 1958 in Table 1, and the true publication rates predicted by the hypothesis for each of the three major populations, in 1960 government scientists would have produced approximately 3,700 papers, industrial scientists 2,500, and academic workers 19,300, for a total output of roughly 26,000.[25] The relative contributions of the governmental, industrial, and academic populations to the total output would be about 14%, 10%, and 74%, respectively. This pattern agrees reasonably well with that for authors' institutional affiliations in the 61 U.S. biomedical journals in Table 3 (see "government," "industry," and "total academic," in Part B). By the other crude tests we have devised using our data and the available effort statistics,[26] estimates of total output based on this hypothesis are reasonably consistent with all present evidence; and we believe that, for the period covered by manpower statistics, such estimates are sufficiently reliable to be useful until more adequate data on publication rates are collected.

To the extent that the manpower statistics do not cover all professional-level workers, we have underestimated the total document output of the formal U.S. biomedical research effort; but it seems unlikely that errors from this source would exceed 10%. The other major source of errors is the hypothesis concerning publication rates; here overestimation is more likely. The true publication rates predicted seem, in general, a little high. For example, the over-all rate for the entire U.S. population of professional workers (0.74 per man per year), roughly half of whom devote only part of their time to research (23), means that each member of this population must write, on the average, more than one paper a year.[27] By most standards, this would be considered an impressive level of literary productivity. Price's data indicate that the average scientist in his lifetime produces only 3.54 papers (18).

Predicted document output for 1970. Any prediction of the document output in 1970 is considerably less reliable.

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[22] Opinions on this point seem to be more uniform than are the findings of studies; however, in few, if any, of the studies were the subjects selected in such a way as to insure the generalizability of the findings.

[23] The true publication rates predicted by this hypothesis would be 0.38, 0.54, and 0.91 papers per scientist per year for industrial, government, and academic biomedical scientists, respectively. The previously cited study of U. S. biological laboratories (21) lends some support to this hypothesis; Shilling found a high correlation between the document output of a laboratory and the proportion of its staff with doctoral degrees.

[24] Of all professional staff employed by NIH, about 80% have doctoral degrees; there were 1,464 doctoral-level staff in 1962 (11), as compared to the 1,846 "professional" staff listed in the annual directory for fiscal year 1963 (14). If only NIH staff directly engaged in research are considered, the percentage of doctoral-level personnel undoubtedly equals or exceeds that for the academic sector; and the predicted true publication rate would be 0.91 or higher (see footnote to Table 5 for refined rates for NIH staff). The proportion of doctoral-level individuals among the Staff Members of the Mayo Clinic and the faculty of the Medical College of Virginia can be assumed to approach 100%; however, the relatively low true publication rate observed for the latter population can be explained by the fact that all its members are not directly engaged in research. It is also interesting to compare the observed true publication rate of physiologists with that predicted from the knowledge that "over 90%" of the respondents had a doctoral degree and "nearly 90%" did "some research" (8).

[25] The level of training of these populations is assumed to be the same as previously given for 1960. Total output can also be calculated from the over-all percentage of doctoral-level workers in the U. S. biomedical research population, which was 74% in 1960 (23).

[26] A description of these tests is included in the appendix (see footnote 5).

[27] This estimation of the average authorship rate makes a generous allowance for co-authors who do not qualify as "professional workers." The typical 1960 paper carried the names of two or more authors. If all authors were professional-level workers, then the average professional worker would have to write three papers every two years to account for the predicted publication rate.

If the assumptions underlying the projected total of 77,000 professional workers in 1970 (23) hold, and if present publication rates continue, the total document output in 1970 will be about twice that estimated for 1960.[28]

Relation of Research Output to U.S. Biomedical Literature

In addition to scientists engaged in the formal research effort, a population of several hundred thousand other individuals contributes to U.S. biomedical literature. Large numbers of papers are written by authors who would not be considered professional research workers by the criteria used for manpower statistics, e.g., health science practitioners recounting clinical observations and experience, teachers not directly engaged in research, professional medical writers, etc. To obtain a general idea of the major sources of U.S. biomedical literature, our estimate of the 1960 output of the formal research effort may be compared with the total volume of biomedical literature produced in the United States that year. Brodman and Taine estimated that there were 54,000 papers in U.S. biomedical serials in 1957 (3). Another study (17) concluded that the total annual production of U.S. biomedical papers is increasing 2% annually; at this rate of increase over the 1957 figure, the total production in 1960 was approximately 57,000 papers. Even if a 10% allowance is made for research workers not included in our estimate, the document output for 1960 that we can associate directly with the formal research effort accounts for only about one-half of all U.S. biomedical papers published in 1960.

Since, in 1960, 94% of the articles in the selected sample of 61 biomedical journals carried acknowledgements of research support (Table 3), the question arises as to where the other half of the literature is published. The answer seems to be that the document output of research is concentrated in a relatively small number of journals that are "research-oriented"; these are journals of the types represented in the selected sample. The other half of the literature is closely associated with clinical practice and is published largely in other types of journals (e.g., regional and local journals) that are "practice-oriented." This conclusion is supported by the fact that less than 100 journals publish more than half of all the papers generated by the NIH extramural program (17).

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[28] Based on interpolated 1968 figures for manpower in the three performing sectors, the total output in 1970 would be about 53,000 papers.

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Biomedical literature: volume, growth, and other characteristics

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ORR, RICHARD H., AND ALICE A. LEEDS. *Biomedical literature: volume, growth, and other characteristics.* Federation Proc. 23: 1310–1331. 1964–This study's aim was to gather and analyze reliable data on the quantifiable characteristics of the biomedical literature that affect communication problems within the research community. Previous studies and standard bibliographic compilations were critically reviewed, particularly for data that could be used to determine changes with time. In addition, all publications generated during 1961–1962 by the extramural and intramural research programs of the National Institutes of Health (NIH) were analyzed as samples of the current document output of U.S. research. The world's substantive biomedical serials numbered about 5,700 in 1960, an increase of less than 7.5% since 1950; and during this decade, the best available evidence indicates that the total number of papers published annually in these serials increased by around 20%. This rate of growth means a doubling of the serial literature in 38 years. The proportion of the world's biomedical serials published in the U.S. remained constant (about one fifth) from 1950 to 1960, and gross language patterns were relatively stable for the literature as a whole. Approximately 500 technical books in biomedicine are currently being produced each year in the U.S., and the total accumulation of biomedical monographs is doubling about every 32 years. Roughly 2,000 U.S. technical reports on biomedical subjects are being issued annually; only a few are security-classified, but many of the remainder are, for practical purposes, inaccessible to scientists who are not eligible for the special services that have been set up by governmental agencies. Of 15,979 documents generated in 1961–1962 by grantees of NIH, 90% were published in journals; some 100 "core" journals contained two-thirds of all grantee publications and 10 accounted for over one-quarter of all the publications in journals. Analyses of the distribution of sample documents among different journals and books show that the biomedical literature is more scattered than that of chemistry or physics, but the degree of scattering varies widely from one subfield to another. The findings concerning languages and scatter have important implications for biomedical research workers and for information services, such as libraries and abstracting-indexing services. Concern over the "literature explosion," the statistics of which seem to have been based on inappropriate data, has led to an overemphasis on volume as a factor in the communication problems of biomedical scientists and in the difficulties of information services attempting to serve their needs.

THE "COMMUNICATION PROBLEMS" of scientists are often equated with "literature problems" in that the primary source of difficulty is assumed, explicitly or implicitly, to be changes in the characteristics of the scientific literature—its volume, growth, form, content, or quality. In discussions of these problems, phrases connoting an acute threat, such as, "the publication explosion" or "the paper flood," are commonly employed; and assertions that scientific publication is deteriorating are frequent. Quantitative data, however, are seldom introduced into these discussions except with regard to the volume and growth of the literature; and when such statistics are given, they rarely meet minimal standards for scientific data. Often the data sources are not identified; and operational definitions of what was measured, adequate descriptions of methodology, and statements of data limitations are usually lacking.

In an effort to provide a better factual basis for any considerations of the communication problems of biomedical research workers, we undertook to gather reliable data and information on some of the characteristics of the literature that may affect these problems and to determine how these characteristics have changed in the last few decades. The quality of the literature, i.e., its value to the scientists who use it, does not lend itself to objective measurements that would make possible valid comparisons of the current biomedical literature with that of the past. For this reason, we confined the present study to literature characteristics that are quantifiable or, at least, can be described in objective terms, e.g., volume, growth, dispersion, publication form, language, and geographic origin. In addition to studying the major literature forms familiar to the biomedical community, we attempted to assess similarly the technical report, a form relatively new to most biomedical scientists, and to compare the way technical reports are published, distributed, re-

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trieved, and used with the handling of the traditional forms of biomedical literature. This paper summarizes our findings in the hope that they will be useful to the biomedical research community in evaluating proposed approaches and "solutions" to scientists' communication problems.

DEFINITIONS AND APPROACH

The scientific literature may be defined as all "formal" documents generated by the scientific community, i.e., those intended for general distribution, as contrasted to "informal" documents meant only for personal, intramural, or administrative distribution. If asked to classify this literature by form, a scientist usually names two major categories, "journals" and "books." He generally thinks of journals as periodicals that contain original or review articles and are issued more than once a year. Books are not characterized as precisely; the concept is commonly one of bound volumes, usually with hard covers, issued alone or in series. If his field is the physical sciences, a scientist will probably identify a third category, "technical reports," and define these as reports of research or development that are submitted to the financial sponsor of the work and are distributed by the sponsoring organization as separate documents. Other forms of literature (theses, pamphlets, etc.) are usually lumped together in a "miscellaneous" category. Librarians make somewhat different and more precise distinctions. For example, they apply the term "serial" to all publications that are intended to continue indefinitely and are issued recurrently in parts under a common title. Journals, as defined by scientists, are serials; but the latter term is more inclusive, since it covers annual and less frequent periodicals, as well as nonperiodic series. Thus many publications that scientists think of as books are described by librarians as serials.

In this study, when possible, we followed the scientist's classification scheme and definitions of literature forms. For some of the characteristics we were interested in, however, the only available statistics were in terms of serials. Of the four broad categories of literature, we concentrated on journals and technical reports. Books received less attention; and the miscellaneous category, which we refer to as "other forms," was treated very cursorily.

The adjective "biomedical" as applied to literature is difficult to define satisfactorily for a quantitative study such as this. Basically the choice is between defining biomedical literature in terms of the subject matter of documents, or on the basis of the scientists that use or generate the documents. Conventional definitions of the biomedical literature in general, or of the literatures of biomedical disciplines and subfields (e.g., physiology and infectious diseases), are subject-based, i.e., dependent on some explicit or implicit scheme of classifying knowledge. As conventionally defined, the biomedical literature includes all documents classified as relating to clinical medicine and to the preclinical sciences taught in medical schools. In addition, documents pertaining to any or all of the following may be included, depending upon the definer: pharmacy, dentistry, nursing, homeopathy, osteopathy, hospital administration, and veterinary medicine. Such subject-based definitions are useful for some purposes, but the aim of this study was to collect data directly relevant to the literature problems of biomedical research workers and of the information services that attempt to fill these scientists' needs. Ideally, we wanted to analyze quantitatively the universe of documents useful to the biomedical research community—the large and varied scientific population currently engaged in "health-related" research, i.e., research similar to that supported by the National Institutes of Health (NIH).[4] Even if the members of this community could be classified neatly by subject or discipline, the scientific documents they find useful cannot. The biomedical literature as conventionally defined constitutes a part, but not all, of a larger document universe useful to this population.

Although it is possible to study, by direct means, the entire body of literature useful to the biomedical research community,[5] this ideal approach was not feasible for the present investigation; practical constraints dictated that the direct approach be postponed for future efforts with larger resources. Instead, we elected an indirect approach that explored two major parts of the total document universe in which we were interested. To assess some of the gross changes that have occurred with time, we used available sources of data on biomedical literature as conventionally defined. To assay the composition of current additions to this universe, we analyzed the documents being generated by U.S. biomedical scientists. These two basically different types of data are presented in separate sections of this paper.

METHODS AND DATA SOURCES

Specific data sources are identified as the data are introduced; and methods of collection and analysis, when these are not obvious, are usually summarized at the same time. Where further details are required to specify the methodology adequately, these are included in the appendix to this paper.[6] It seems desirable, however, to describe here the selection of data sources and the general procedures used for analyzing technical report literature

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[4] For our purpose, this definition of biomedical research has two major advantages. First, it dynamically reflects changing research patterns. Second, the bulk of the scientist population engaged in such research can be readily identified, in this country at least; and considerable data are available on the characteristics of this U.S. research community.

[5] The documents actually used by this population can be identified by analyses of citations, diaries of reading habits, interviews, questionnaires, etc. Potentially useful documents could be identified by giving biomedical scientists unfamiliar documents and asking them which they found useful for their research. Every scientific document is, of course, potentially useful to some biomedical scientist, and any practical measure of potential utility must be relative.

[6] A copy of the appendix can be borrowed from the National Library of Medicine by initiating an interlibrary loan request for: *Appendix* to Orr, Richard H., and Alice A. Leeds. Biomedical literature: volume, growth, and other characteristics. *Federation Proc.* 23: 1310–1331, 1964.

and for sampling and categorizing the documents generated by U.S. scientists.

Collection of Data on Biomedical Literature Defined by Subject Classification

The number of studies meeting our criteria for data sources was small. Most of the considerable number of published and unpublished reports on characteristics of biomedical and related literature consist either of estimates based on data that were not available for evaluation, or of observations for which the methods of sampling and analysis were inadequately described. Of the few reliable data sources we found, still fewer were suitable for assessing changes with time; because of varying definitions and methods, we could rarely be reasonably certain that data from different sources, or even from the same source but relating to different times, were comparable. To supplement the sparse supply of "ready-made" data, we analyzed comprehensive bibliographies for several biomedical subfields and also the most complete of the available lists of periodicals classified as biomedical.

For technical reports, in addition to reviewing previous studies, expressions of scientists' opinions, and the policies and practices of governmental agencies, we collected and analyzed data on those reports that might be classified as biomedical. All 1962 issues of the following periodicals, which list or "announce" technical reports as they are made available, were examined: *Technical Abstract Bulletin* (issued by the Defense Documentation Center of the Department of Defense, formerly the Armed Services Technical Information Agency); *Nuclear Science Abstracts* (Atomic Energy Commission); *Technical Publications Announcements* (National Aeronautics and Space Administration); and *U.S. Government Research Reports* (Office of Technical Services of the Department of Commerce). Each of these announcement periodicals arranges the titles of technical reports (with or without abstracts) under subject headings. All reports listed under certain headings were considered to be biomedical. The headings used for analyzing each periodical are given in the appendix (see footnote 6). Documents other than technical reports that were listed in these periodicals (e.g., theses, journal articles, reports of foreign work, and government publications other than reports of research) were excluded from the count. In the *Technical Abstract Bulletin*, which is the only one of these periodicals that lists security-classified as well as nonclassified reports, any stated restrictions on the distribution of individual reports were also noted. In one issue of *U.S. Government Research Reports* (January 1962, Vol. 37, No. 1), the purchase price and number of pages for each biomedical report were recorded.

Collection of Data on Biomedical Literature Defined by Generators

For samples of the documents currently being generated by biomedical scientists, we used all the documents listed in the annual bibliography of NIH staff for 1961 (24) and in the *NIH Research Grants Index, Fiscal Year 1962* (23). The samples established by these two lists represent the equivalent of a full year's document output for the NIH intramural and extramural research programs, respectively. Each document listed in these author bibliographies was tabulated by the title of the publication in which it appeared. These publication titles were then checked in standard bibliographic references and categorized as journals, books, technical reports, or "other forms" by the definitions adopted for this study.

FINDINGS RELATING TO BIOMEDICAL LITERATURE AS CONVENTIONALLY DEFINED

Serial Literature

Total number of biomedical serials. Table 1 compares the figures for the world total of "substantive"[7] biomedical serials given by (or derived from) all the comprehensive studies and compilations since 1950 that meet the criteria of employing a roughly comparable definition of the biomedical literature and of making a systematic effort to ascertain whether each serial counted was "alive," i.e., still being published. For any reliable data on the number of serials extant at a given time, the latter criterion is critical, since the turnover in biomedical serials was rapid during the decade, 1950–1960.[8] The preface to the third edition (1961) of *World Medical Periodicals* states that 130 serials listed in its second edition (1957) were dropped from the new edition and that 1,130 new ones were added, all of which did not live until 1961 (45). Our analysis of the publications listed in *Biomedical Serials, 1950–1960* (28) indicates that, of all serials alive in 1950, more than one-third had died by 1961; and during the same period, roughly the same proportion of the serials born after 1951 also died.[9]

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[7] Brodman and Taine define a substantive serial as one that is "indexable" and characterize "nonsubstantive" serials as those containing "merely news items, abstracts, statistics, and other nonsubstantive miscellany" (6). The footnotes to Table 1 indicate that the use of this term varies somewhat from one bibliographer to another.

[8] A serial "dies" when it either ceases publication or is absorbed into a pre-existing serial. In 1879, Billings gave the total number of "medical journals and transactions" then alive as 850 (3). For the first half of the 20th century, however, data meeting our criteria are lacking. A recent study (9) gives figures on the number of U. S. medical serials existing at various times in the last two centuries, but the data are not comparable with those in Table 1. They were obtained by tabulating the founding dates of all medical serials in an authoritative compilation that listed only those U. S. serials alive sometime during the period 1950–1953 (personal communication from author). The many U. S. journals that had been born and had died before 1950 could not be included in the tabulation of founding dates; therefore, for years prior to 1950, the resulting figures do not represent all the serials that were alive in the given year. The data are unsuitable for determining either the growth in the number of living U. S. biomedical serials or the rate at which serials were born in the past.

[9] More refined analyses of death rates seem to show that mortality rates of newly founded serials are higher than those of older ones. Calculations of birth and death rates, and examples of foreign and U. S. serials that were born or died during this period, are given in the appendix to this paper (see footnote 6).

TABLE 1. *Number of substantive biomedical serials extant in given years during past decade*

Data Source	1950–1951	1953	1957	1960–1961
Welch Medical Library Project (17)	4,454*			
Brodman and Taine Study (6)			3,879†	
World Medical Periodicals (45)		3,498‡	4,360§	5,803[a]
Biomedical Serials, 1950–1960 (28)	5,323[b]			5,711[c]

All figures shown are either given explicitly by the specified data source as the number of substantive biomedical serials "alive" at the time of compilation, or have been derived from source information on individual serials by checking all the serials listed and eliminating any titles that had ceased publication or had merged with a pre-existing serial prior to the given time. Although the term "substantive" is usually applied only to serials containing "indexable" material, these figures (with the exception of that established for 1957 by the Brodman and Taine study) include abstracting and indexing periodicals, which number in the hundreds.

* This project ran from 1948–1953, but it is reasonable to assume that its report generally reflected the status in 1950–1951. This figure includes 289 congress proceedings (a class of serials excluded by the other studies and compilations) and 301 abstracting and indexing periodicals, 86 of which were noted to publish some original or review papers. The authors of this report stated that the first edition (1953) of *World Medical Periodicals* (*WMP*) listed about 1,300 substantive serials that they had not identified in their project; however, they had identified over 2,000 serials that were not listed in *WMP*. They also found that only 2,211 serials were common to both their list and the first edition of *WMP*, and that the combined lists included 5,726 different serials. † Brodman and Taine, whose study was based on the collection of the National Library of Medicine (NLM), stated that the difference between this figure (which was established by their own study), and the one they derived (see footnote §) by analyzing the second edition (1957) of *WMP*, could be largely explained by the relatively poor representation of Latin American and Japanese serials in the NLM collection at the time, and that "the Welch Medical Library figures are higher on account of differences in definition of current substantive periodicals." ‡ We derived this figure by analyzing the first edition (1953) of *WMP*. § Given by Brodman and Taine as the number of "current" serials listed in the second edition (1957) of *WMP* and presumably derived by them, since the figure is not found in the source. [a] Derived by us from data in the third edition (1961) of this publication. [b] Derived by us by examining the founding date given for each serial listed in the source, and counting only the serials existing in 1950. For 113 serials, the founding date was given as "195?," and for 72 as "19??"; these serials are not included in the figure for 1950 but are included in the 1960 figure if the serial was alive then. [c] In this compilation are listed 8,939 titles, for which NLM had received at least one issue since 1950; of these, 3,228 were presumed to be dead at the time the compilation was edited.

Although each of the studies and compilations cited in this table represents a major effort to include all appropriate serials and to identify all those that had died, the resulting data are conflicting. There are marked discrepancies between figures for a given year; and if each data source were considered equally reliable, it would be difficult to determine how rapidly biomedical serials increased during the 1950's. The inherent vagaries of any subject classification by different individuals, or even by the same individual at different times, explains some of the discrepancies. Since "nonsubstantive" biomedical serials number in the thousands (6, 17), slight differences in the interpretation of the term "substantive" can account for material variations. Finally, any such effort is biased by the library collections and the earlier bibliographic compilations used. The important effect of guidance by prior compilations is suggested by the decreasing differences between figures from different sources. In 1950, no recent compilations of biomedical serials were available and the difference is greatest; whereas, for the two 1960–1961 efforts, which agree closely, four earlier compilations could be utilized.

For these reasons, only the figures for 1950–51 and 1960–61 that are derived from a single source, *Biomedical Serials, 1950–1960*, are reliable for assessing change. This compilation had the benefit of all previous efforts, and we can be certain that the critical interpretations of "biomedical" and "substantive" for serials extant in 1950 and in 1960 were made by the same individuals at the same time. From these two figures, it can be seen that the increase in the number of biomedical serials during the last decade was at most 7.3%.[10] Although, in the average year, several hundred new serials were started, births were largely offset by the demise of existing publications; and the average net gain was less than 38 serials a year.

TABLE 2. *Changes in thickness of one year's issues of a sample of well-established biomedical serials*

Year	Total Thickness All 110 Serials in Sample (cm)	Average Thickness (cm)	% Increase in Decade	
1941	432.0	3.9		
1946	444.6	4.0	1941–1951	16
1951	502.2	4.6		
1956	527.5	4.8	1951–1961	11
1961	555.0	5.0		

These data were supplied through the cooperation of Dr. Vern M. Pings, Medical Librarian, Wayne State University School of Medicine. This school's library currently receives over 1,131 serials (19) and has complete bound-volume sets for 351 U.S. and foreign serials from 1940 to the present. Advertising pages, except where interspersed with text pages, are removed before binding. From an alphabetical list of the 351 serials, a sample of every third title was taken; and the thickness of the issues for 1941, 1946, 1951, 1956, and 1961 was measured across the top of the bound volumes of the sample titles, excluding the thickness of the covers. At the time of measurement, one or more volumes of some sample serials for the selected years were not on the shelves; however, measurements of 110 serials could be made for each of the selected years. The primary data and a list of journals in the sample are given in the appendix (see footnote 6).

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[10] If all the serials for which the data source had only indefinite founding dates (a total of 185), were founded in 1950 or earlier, the percentage increase for the decade would be only 3.5%.

Physical growth of serial literature. Measurement of the shelf space occupied by bound serials provides statistics of practical importance to libraries that can also be used for assessing the growth of serial literature. By comparing the thickness of bound volumes of a sample of serials in different years, changes in the amount of material published by established serials may be evaluated. Table 2 indicates the changes, over the past two decades, in the average thickness of a year's issues of older biomedical serials found in an academic library. From these averages for a sample, the total shelf space required for the 1941 issues of all comparable serials in this library can be calculated as about 14 meters; whereas, the 1961 volumes of the same journals take 18 meters, an increase of about 13% over the 20-year period. The group of serials sampled is not representative of the world's biomedical serials; however, it is likely that the observed rate of increase is a fair approximation of the physical growth of well-established serials that are used with some frequency by U.S. biomedical scientists.[11]

The entire substantive serial collection of the National Library of Medicine (NLM) measured about 26,000 linear feet in 1962; 32% of this shelf space was taken by material published in the previous 16 years, and 68% by material published before 1946 (27). These figures indicate a doubling time of about 30 years for the collection, or a simple increase of roughly 30% each decade. This rate can be considered a close approximation of the overall physical growth rate of the world's biomedical serial literature, as conventionally defined, averaged over the centuries.[12] The NLM data reflect both the growth in the number of serials and in the thickness of these serials; whereas, the academic collection data in Table 2 isolate the latter factor.

If one assumes that the shelf space occupied by a sizable group of serials is roughly proportional to the number of papers they publish,[13] the academic collection data may be used to estimate average rates of increase in the number of papers published by older U.S. and foreign serials that have special merit in the eyes of academic users (see footnote 11). Likewise, the linear growth of NLM's serial collection may, with appropriate reservations, be viewed as an indirect measure of the rate at which papers are accumulating in the world's biomedical serial literature.

Number of biomedical papers. No one has actually counted all the papers published by all biomedical serials in a year; and only one of the recent estimates was based on methods that meet minimal standards for reliability. Brodman and Taine systematically sampled all the serials arriving at NLM and estimated that papers published in 1957 by the world's substantive biomedical serials totaled about 220,000; U.S. serials accounted for 54,000 (6).[14] The only comparable and reliable figure we found for any year prior to 1957 was Billings' estimate of 20,000 as the world's production of biomedical papers in the year 1879 (3). The annual production of papers increased roughly 10-fold in the 78 years between the two data points we have. Data suitable for direct determination of the rates of increase for periods in the recent past are lacking for U.S. serials as well. Shilling (37) recently analyzed the contents of 100 selected U.S. biological journals in 1950 and in 1960; 61 of the 100 journals can be classified as biomedical since they are indexed by *Index Medicus*. His data show that these 61 U.S. biomedical journals contained a total of 7,195 articles in 1950 and 9,321 in 1960, a 31% increase over the decade. Although this number of articles is a significant fraction of all U.S. biomedical papers, Shilling's data cannot be generalized either to world or to U.S. biomedical serials. The journals in his sample were not selected as representative of U.S. biomedical serials (37); they were examples of older, relatively large, national journals, oriented toward research.[15]

Length of papers. Appropriate data for assessing changes in the average length of biomedical papers typical of the world's literature were not found. Shilling's study (37) indicated that the average length of articles in his sample of U.S. biomedical journals decreased from 8.1 pages in 1950 to 6.7 pages in 1960. How much of this decrease can be attributed to greater brevity, and how much to printing more words per page, cannot be determined from his data. Replicable word counts on scientific publications in which considerable graphic and tabular material is interspersed with text are difficult to make; and only one study has reported reliable data on adequate samples of journals in various fields of science (29). This study found that from 1949 to 1959 the average number of words per

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[11] First, for the measurements desired, only serials at least 20 years old could be used. Second, it cannot be assumed that these serials are typical of all older periodicals, since the collection of any biomedical library, with the exception of NLM, is a selection of the world's biomedical literature based on judgments of relative utility. In 1961–1962 the library that cooperated in this study received 1,131 (19) of the more than 5,700 existing biomedical serials.

[12] NLM probably has the world's most complete collection of biomedical literature of all ages. Like most biomedical libraries, however, NLM does not confine its collection strictly to material conventionally classified as biomedical (6) (see page 1325 for a discussion of libraries' collection policies).

[13] The source of the data on NLM's serial collection (27) states: "Limited sampling indicates that such factors as increasing usage of thinner papers and type packing, as well as variant ratios of original articles to special features and advertising, would not substantially affect estimation of growth by linear footage measurement for the particular time periods studied."

[14] The authors state: ". . .We have used the maximum counts to be certain that we have not erred on the side of underestimation. Furthermore, no deductions have been made for the considerable quantity of articles in journals in such nonclinical fields as general science, general biology, and psychology which would . . . not have been indexed in a general medical index." About 12% of the papers they counted were in serials issued less frequently than annually; therefore, the 1957 production of what we would consider journal articles was closer to 195,000.

[15] Among the criteria for the selection of these journals was that they existed in 1950. In 1960, 94% of the articles in the 61 biomedical journals were reports of sponsored research (31). Whereas these journals published an average of 118 articles each in 1950 and 153 articles in 1960, the average for the world's biomedical serials in 1957 was 58.1, and the average for all U. S. serials in the latter year was 62.6 (6).

page in U.S. biological journals increased from 618 to 702 (14%). If this finding holds for biomedical journals of the type Shilling studied, the average number of words per article in his sample remained about constant, or decreased slightly, from 1950 to 1960.

Spot checks of the last 20 years' issues of a number of foreign and U.S. serials indicate that the use of various strategems for printing materially more words per page has been: *a*) more common among U.S. than foreign journals, *b*) mainly a post-1950 development, and *c*) generally restricted to journals that print relatively large numbers of copies (usually 10,000 or more).[16] For the relatively large, U.S. biomedical journals in Shilling's sample, word "packing" may have resulted in some change in the ratio of articles to shelf space since 1950; but, for the world's biomedical serials in general, most of which are small and are published in foreign countries (6), it seems unlikely that this development would have materially affected the validity of shelf space as a measure of the growth in number of papers. (See footnote 12 for a discussion of other mechanical factors that may influence shelf space.) Any world-wide trend toward brevity, however, would certainly affect this measure of growth.

Geographic and language distribution. The countries and languages accounting for the most biomedical serials and papers are shown in Table 3; the same six countries published almost two-thirds of all biomedical serials in both 1950–1951 and 1957. The rank order of these countries based on percentage of all biomedical papers is somewhat different than that based on percentage of all biomedical serials. Since the data for 1950–1951 and for 1957 are from different sources, the significance of the apparent decrease in the relative importance of the United States as a publisher of biomedical serials cannot be judged from these figures. Our analyses of titles in *Biomedical Serials, 1950–1960*, however, show no change from 1950 to 1960 in the ratio of U.S. to all biomedical serials; in both of these years the U.S. published close to one-fifth of all biomedical serials.[17]

The only notable change between the language pattern in 1950–1951 and in 1957 is an apparent trend away from English. Again, because different data sources are involved, the question of significance cannot be settled; and in this case, we have no independent check.

TABLE 3. *Distribution of biomedical serial literature by country of publication and language*

	1950–1951		1957			
	% of All Serials	Rank Order	% of All Serials	Rank Order	% of All Papers	Rank Order
Country						
United States	28	1	23	1	24	1
Italy	7	2	10	2	8	5
France	7	2	8	4	10	3
Germany	7	2	9	3	12	2
Great Britain	7	2	7	5	7	6
Japan	5	3	4	6	9	4
Language						
English	44	1	38	1	37	1
Spanish	13	2	10	3	6	5
German	9	3	11	2	13	2
French	9	3	11	2	11	3
Italian	7	4	10	3	8	4
Japanese	4	5	4	4	8	4

Percentages are based on the total numbers of biomedical serials and papers analyzed by the respective studies. All figures are rounded to nearest per cent. *Data sources:* For 1950–1951, the Welch Library Project (17), 4,454 serials analyzed, the percentages given here for language distribution are for serials in only one language (total 4,117); this study did not give a breakdown by papers. For 1957, Brodman and Taine (6), 3,597 serials and approximately 139,000 papers analyzed.

Types of papers. Table 4 compares the number of papers listed in a comprehensive bibliography of biomedical reviews with the total number of papers indexed during the same period by the *Current List of Medical Literature* (*CL*), or its successor, *Index Medicus* (*IM*).[18] The ratio of reviews to all papers appears to have increased over the period 1955 to 1962. If the serials covered by these indexing services were representative of all biomedical serials with respect to this ratio, and if these services had covered the same percentage of the world's biomedical papers throughout this period, one might conclude that the ratios shown held for all biomedical serials, and that the proportion of review papers had increased significantly. In view of the marked selectivity of these services, the first condition cannot be assumed. In 1957, *CL* covered 39% (1,508) of all substantive biomedical serials, but these serials carried almost 50% of all biomedical papers (6); if the proportion of review papers is related to the size and frequency of a serial, the first condition is violated. The second condition is likewise not met since the evidence suggests that the comprehensiveness of *Index Medicus* coverage has increased materially in recent years (32). On the basis of the present data, a conclusion that proportionately more review papers are being written is not justified.

Of the reviews listed in vol. 7 of the *Bibliography of Medical Reviews*, roughly half could be classified as "research-oriented" and the other half, "practice-oriented."[19] About 41% of the reviews listed in vol. 8 were in English, and 29% were from U.S. journals (11).

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[16] These observations can all be explained by the economics of printing. The last impression is supported by the study that reported word-counts (29); engineering journals had the highest circulation of any group of scientific journals (average 8,845 in 1959) and had the highest word-count per page (1,155).

[17] Of the 5,711 serials listed in this compilation as alive in 1960, 20% (1,159) were published in the United States; the percentage for serials alive in 1950 was similar. These figures are significantly lower than the percentages found in earlier studies (Table 3) and may indicate that foreign journals were somewhat underrepresented in those studies.

[18] Similar comparisons for the literatures of other broad fields of science show that the proportion of review papers is currently about 1% in physics, 2% in astronomy, and 6% in chemistry (11).

[19] A random 20% sample of the titles of the review papers was examined. When the title left doubt as to the proper classification, the general orientation of the journal in which the paper appeared was appraised. The 50–50 division we noted agrees well with an

TABLE 4. *Changes in the ratio of review papers to all biomedical papers indexed*

Bibliography of Medical Reviews		1 Total No. Review Papers Listed in *BMR*	2 No. of Review Papers in Serials Covered by *CL* or *IM*	3 Total No. Papers Indexed by *CL* or *IM*	4 Ratio of Review Papers to all Papers Indexed [Column 2 ÷ Column 3]
Vol. no.	Vol. year*				
1	1956	1,075	1,075	111,159	1.0%
2	1957	2,000	2,000	106,623	1.9%
3	1958	2,885 (587)	2,268	104,588	2.2%
4	1959	3,241 (434)	2,807	114,214	2.5%
5	1960	2,382 (338†)	2,044†	107,042	1.9%†
6	1961	3,300 (n.a.)		125,000	
7	1962	4,800 (n.a.)		140,000	
8	1963	6,633 (1,214)	5,419	145,786	3.7%

BMR = *Bibliography of Medical Reviews*, *CL* = *Current List of Medical Literature*, *IM* = *Index Medicus* (successor to *CL*). Column 1 gives the total number of review papers listed in the given volume of *BMR* (*Data sources:* for vols. 1–6, preface to vol. 6; for vols. 7 and 8, prefaces to the respective volumes.) With vol. 3, the compilers of *BMR* began scanning, for review papers, selected serials not covered by *CL* or *IM* (25); the parenthetical figures represent the contributions made to the respective totals by review papers in serials not covered by *CL* or *IM* (*Data sources: NLM Annual Reports* for fiscal years 1958 to 1963, no figures given for *BMR* vol. 6 and vol. 7.) Column 2 is derived from column 1 by subtracting the parenthetical figures when present. Column 3 gives the total number of papers indexed by *CL* or *IM* during the calendar year preceding the given volume year of *BMR* (*Data sources*: for 1955–1960, preface to *BMR* vol. 6; for 1961 and 1962, ref. 27.) Until September 1961, review papers in serials not covered by *CL* or *IM* were not indexed by these services (26). *This is the year the volume was issued; each volume covers the literature processed by NLM during the calendar year preceding its volume year. A given volume, however, contains papers published in several years, e.g., of all papers listed in vol. 8 (issued in 1963), 5% were published in 1960, 49% in 1961, and 44% in 1962 (11). † The parenthetical figure in column 1 is an incomplete count based on 2,068 of the 2,382 papers listed in vol. 5; therefore, the derived figure in column 2 is probably a little high, as is the per cent in column 4.

Books

In 1962 and 1963, U.S. production of "technical" books in biomedicine (i.e., books intended for scientifically trained readers) averaged about 480 new books (or new editions) annually.[20] Available statistics are unsuited for establishing the current world production rate for technical biomedical books and for assessing trends in production rates over the past few decades. In 1920, U.S. production of all books classified under "medicine and hygiene" (both popular and technical) totaled 207 (new books or new editions), 318 in 1930, 472 in 1940, 443 in 1950 (4); the figure for 1960 (776) is not comparable to those for earlier years (41).[21] If the ratio of technical to popular medical books remained constant from 1920 to 1950 (which seems doubtful in view of increasing public interest in medical subjects), U.S. production of technical biomedical books increased by 38% over three decades, or roughly 1% per year.

Data on NLM's collection of monographs can be used for a crude estimate of the rate at which the world's biomedical book literature is growing; however, since NLM collects popular as well as technical books, the same assumption of a constant ratio of technical to popular books is required. Two additional assumptions are necessary: that the subject scope of NLM's acquisition policy has not changed,[22] and that the completeness of the collection is uniform for books of various ages. As of June 1963, NLM held 88,645 bound monographs dated 1801 to 1913, and 169,894 dated 1914 to 1963 (27); if the assumptions are reasonably valid, the number of technical biomedical books published in the last 50 years is somewhat less than twice the number published in the entire 19th century plus the first decade of this century. Given that the growth rate was uniform in the 19th and 20th centuries, this would mean that the accumulation of biomedical books has been doubling about every 32 years. In contrast, during the same period, the shelf space occupied by NLM's book collection has doubled every 25 years (27). It would seem that in the 20th century biomedical books have become more bulky.

Technical Reports

History. The issuance and distribution of research reports by the sponsors of the work reported is a publication method that has been practiced for centuries by private (both nonprofit and commercial) and governmental institutions. Not until the past few decades, however, has the term "report literature" come into common use to differentiate this type of publication from other nonperiodic forms of literature, which are issued and distributed by professional societies or by nonprofit and commercial publishers. During this period, research by government scientists, and by scientists working in private institutions under government contract, expanded markedly. For various reasons, which will not be re-

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independent assessment by Fix, who analyzed a random 4% sample of papers listed in Vol. 8 of the same publication and found that about 42% of the reviews were "clinically oriented" and 56% were "preclinical" or "research-oriented" (11).

[20] This average was established by analyzing the books listed in *Stacey's Medical Books in Print: A Select List, 1963–1964* (Palo Alto, California: J. W. Stacey, Inc., 1963). This bibliography is considered reasonably comprehensive for the English-language, technical biomedical books that are "in print." Books by foreign publishers, and by specialized U.S. publishers known to handle primarily imported books, were excluded in counting. The U. S. books listed for 1960, 1961, 1962, and 1963 totaled 271, 320, 477, and 491, respectively. We have assumed that any book published in 1962 or 1963 would still be in print at the time this list was compiled; the counts for 1960 and 1961 undoubtedly do not include numerous books published in those years but no longer in print by 1963.

[21] Since 1959, the major source for statistics on U.S. book production, *Publisher's Weekly*, has used the Dewey Decimal Classification System, in which "medicine and hygiene" are assigned numbers 610 to 619 (4); this category is broader than the one used prior to 1959.

[22] In recent years at least, this policy has been changing, and the subject scope has broadened somewhat to include certain subject areas outside the biomedical field as this is conventionally defined (25, 27).

viewed here, the results of much of this government-sponsored research, particularly that supported by agencies[23] associated with the defense effort, have appeared as technical reports distributed largely through government channels. The predominance of government sponsorship of the work reported in this form has led many scientists to equate technical reports with documents issued and distributed by governmental agencies, but distinguished from other types of government publications in that technical reports are accounts of research and development, rather than educational material, reports of administrative activities, etc. It is the government-distributed type of technical report that we studied.

The technical report "system." A number of government services have developed to process (i.e., collect, announce, store, and retrieve) this form of literature. The issuing agencies and their processing services constitute a system that performs for report literature much the same functions as the system of traditional publishers, abstracting-indexing services, and libraries perform for journals and books. In the main, these two parallel systems operate in relative isolation from each other.

Practices and policies differ somewhat from one governmental agency to another, but a general pattern for handling technical reports can be described. The investigator, whether a government employee or a contractor, submits his report to the agency that sponsored his work. There its scientific quality may be reviewed, and the necessity for restricting its distribution for security or other reasons is considered. After approval, copies are reproduced and distributed to standard lists of recipients.[24] This "primary" distribution also provides copies for the depositories or document centers designated by the sponsoring agency. The main depository abstracts the report (if the investigator did not furnish an abstract), categorizes it by subject matter, and announces its availability in a periodical that covers the documents generated by, or of interest to, the scientists supported by the given agency.

Three agencies account for the bulk of technical reports on government-sponsored work: Department of Defense (DOD), Atomic Energy Commission (AEC), and National Aeronautics and Space Administration (NASA).[25] Each of these agencies has established a large, centralized service for handling technical reports and other types of documents containing the results of research and development. The three services evolved independently and are oriented primarily to the missions of their respective agencies.

TABLE 5. *Number of biomedical technical reports announced in 1962 issues of TAB, NSA, TPA, and USGRR*

Sponsor of Research Reported	No. Reports
Department of Defense*	930
Atomic Energy Commission†	525
National Aeronautics and Space Administration‡	117
Other§	43
Total	1,615

The subject headings used to identify the biomedical reports in each of the four announcement periodicals are given in the appendix (see footnote 6). Reports listed in more than one of the announcement periodicals were counted only once. The given agency's own announcement periodical was used as the authority for the total number of biomedical reports attributable to its sponsorship of research and development. * The figure for DOD represents the total number of DOD-sponsored biomedical reports listed in the "unlimited" document (no restrictions on distribution) and in the "limited" document (restricted distribution) sections of *TAB*; these two sections listed 609 and 321 reports, respectively. † Only reports listed in *NSA* and designated as AEC-supported. ‡ Only reports listed in *TPA* and designated as NASA-supported. § Reports announced in *USGRR* that were sponsored by government agencies other than DOD, AEC, and NASA; included here are also reports with joint sponsorship, e.g., Armed Forces-National Research Council, Navy-Public Health Service, Federal Aviation Agency-NASA-Air Force, and a few unsponsored reports issued by private research organizations. *Data sources:* Analyses of all 1962 issues of *TAB*, *NSA*, *TPA*, and *USGRR* (see "Methods and Sources").

Eligibility for special report services. An individual who is eligible for the extensive information services maintained by these agencies can, without charge, obtain copies of specific reports and can request searches of the depository's collection for any documents relevant to his work. Those who are ineligible for these special services may purchase copies of technical reports from the Office of Technical Services (OTS), which will also perform searches for a fee. A summary of the operations of each of these four technical report services is given in the appendix (see footnote 6).

At present, all investigators and organizations engaged in government-supported research are eligible for the special services provided by DOD, AEC, and NASA. In the past, the eligibility of grantees of the U.S. Public Health Service has not always been recognized, particularly with regard to the DOD report service; however, a recent directive has clarified their eligibility for the latter service.

Number of biomedical technical reports. Table 5 gives the number of biomedical reports that were listed in the four major report announcement periodicals during 1962 that may be classified as biomedical; the periodicals are the *Technical Abstract Bulletin* (*TAB*), *Nuclear Science Abstracts* (*NSA*), *Technical Publications Announcements* (*TPA*), and *U.S. Government Research Reports* (*USGRR*), issued by DOD, AEC, NASA, and OTS, respectively. Since, of these announcement periodicals, only *TAB* covers classi-

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[23] The term "agencies" is used here to mean governmental units of all sizes.

[24] In government research contracts, the reporting requirements are usually specified, including the format and the number of copies to be furnished to the sponsoring agency and to be distributed by the investigator's institution to recipients on standard lists supplied by the agency.

[25] The Department of Agriculture also supports work that generates considerable numbers of technical reports. These are collected by the National Agricultural Library and announced in the *Bibliography of Agriculture*, an indexing service that also covers the world's periodical and book literature on agriculture and related sciences. Copies of the reports announced are available from the National Agricultural Library on a prepaid basis.

TABLE 6. *Comparison of the number of biomedical reports announced in 1962 by the sponsoring agency in its own announcement periodical with the number of the agency's reports announced in 1962 by OTS in USGRR*

Sponsor of Research Reported	1 No. of Reports Announced by Sponsoring Agency	2 No. of Agency's Current Reports Announced by OTS*
Department of Defense	930	609 (983)
Atomic Energy Commission	525	193
National Aeronautics and Space Administration	117	39
Totals	1,572	841 (1,215)

* In addition to "current" reports (issued in previous few years), OTS also announces some older reports. The parenthetical figures give the total number of biomedical reports listed in 1962 issues of *USGRR* and include the older military reports listed in the section, "Non-Military and Older Military Research Reports." These are reports that had been declassified that year or that, for other reasons, had not been listed in *USGRR* earlier. During 1962 OTS announced several hundred reports of the Naval Medical Research Institute that had been issued in the 1940's and 1950's; these reports account for most of the difference (374) between the figures for current reports and parenthetical totals. *Data sources:* For column 1, see footnotes for Table 5; for column 2, analyses of all 1962 issues of *USGRR* (see "Methods and Sources").

fied reports, the figures for agencies other than DOD represent only nonclassified reports. No check was made of the government reports listed by the U.S. Government Printing Office to see whether OTS announced all of these documents that could be considered biomedical technical reports. Therefore, it is possible that some technical reports of biomedical interest sponsored by agencies, such as the Bureau of Mines, the Fish and Wildlife Service, and the Bureau of Standards, were missed. A few reports of biomedical research supported by the Department of Agriculture were announced in the "nonmilitary" section of *USGRR*, but a systematic review of the *Bibliography oj Agriculture* would undoubtedly have disclosed more.[26] If the aggregate number of biomedical technical reports not covered by the four major announcement periodicals used to compile Table 5 is estimated at 200, and classified reports of work sponsored by AEC and NASA are estimated at an equal number, the total production of both classified and nonclassified biomedical technical reports was around 2,000 for the period covered by 1962 issues of these announcement periodicals.[27]

TABLE 7. *Restrictions on distribution of DOD biomedical reports announced in 1962 issues of TAB*

Total no. of DOD reports announced in *TAB*	930 (100%)
No restrictions on distribution*	609 (65%)
Some restrictions on distribution†	321 (35%)
Restrictions for security (i.e., classified reports)	14 (2%)
Restrictions for other reasons	307 (33%)

* Listed in the "unlimited" document section of *TAB*, which is reproduced in *USGRR*. Only reports listed in *USGRR* are available to any U.S. and foreign scientists through OTS and, can, therefore, be considered to have no restrictions on distribution. † Listed in the "limited" document section of *TAB*, indicating that distribution is restricted in some way. These reports are not listed in *USGRR* and are not made available through OTS. *Data source:* Analyses of all 1962 issues of *TAB* (see "Methods and Sources").

Restrictions on distribution of biomedical reports. Table 6 compares the numbers of biomedical reports sponsored by DOD, AEC, and NASA, and announced in 1962 by their respective announcement periodicals, with the numbers of these agencies' reports that were listed in *USGRR*. Only the latter were available through OTS to all scientists regardless of their eligibility for the special report services of DOD, AEC, and NASA. The difference between the two sets of figures is a rough measure of the practical barriers to the use of these documents by the entire scientific community.[28] Since none of the AEC and NASA reports enumerated here was classified, considerations of national security cannot explain the differences shown for these two agencies. Whatever the reasons, the fact that OTS did not handle a higher percentage of AEC and NASA reports means that about two-thirds of their reports were not practically available to the general scientific community.

Table 7 analyzes the restrictions on distribution of DOD reports. For 25 of the 307 nonclassified DOD reports listed in the "limited" document section of *TAB*, the entry included some explicit restriction, such as, "no automatic release to foreign nationals"; the entries for the remainder of the reports tabulated here under "restrictions for other reasons" included no specific statement of restrictions.

Copyright infringement is seldom a problem with technical reports; therefore, it must be assumed that other considerations determined the restrictions that are automatically imposed when an agency does not release documents to OTS. In an effort to avoid unnecessary restrictions,[29] the following criteria for deciding when

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[26] Government-sponsored agricultural research generated about 5,000 documents in fiscal year 1961; approximately 10% (500) of these were technical reports by our definition (40).

[27] Only about 20% of all AEC reports are classified (40); if this ratio holds for biomedical reports, then it seems unlikely that all such classified reports of both AEC and NASA totaled more than 200 documents. Because of the delay between the issuance of a technical report and its announcement (see discussion page 1324), the total of 2,000 does not represent production during the calendar year 1962.

[28] Some of the difference between the number of reports announced by sponsoring agencies and the number listed by OTS might be explained as an artifact, in that the categories selected for counting biomedical reports in *USGRR* did not, in all cases, correspond exactly with those used for counting in *TAB*, *NSA*, and *TPA*. This explanation does not hold for current DOD reports at least, since the section of *USGRR* listing such reports is identical with the "unlimited" document section of the corresponding issue of *TAB*.

[29] A 1962 report to the President's Special Assistant for Science and Technology states: "We must mention our concern that the

limiting the distribution of a DOD report may be justified were recently specified: "when necessary in the interest of security, to protect corporate rights not protected by patents, to protect the proprietary rights of the Government, to minimize the liability of the Government or its employees, or for ethical reasons such as a protection of information regarding the relative merits of commercial products." (42).

Length and price of reports available through OTS. The average length of the 45 biomedical reports listed in one issue of *USGRR* was 43 pages (range, 2 to 273 pages). The average OTS price for a full-sized copy of these reports was $5.21 (range, $0.50 to $17.50) or 12 cents per page (range, 2 to 55 cents). Microfilm copies cost 4 cents per page for the first 20 pages, and 3 cents for each page over 20.

Fate of technical reports as regards journal publication. Of the 239 biomedical technical reports listed in the *Current List of Medical Literature* during the 6-month period, October 1950-April 1951, less than one-quarter had appeared as journal articles by 1953 (7). The average interval between the date of the report and its appearance as a journal article was 7 months. A more recent study (16) showed that only 28% of the biomedical technical reports issued in 1957 were published as journal articles within 3½ years (average interval 4–6 months); the fate of all technical reports was similar (22% were published as journal articles).

The Literatures of Biomedical Subfields and Disciplines

Growth patterns. The annual increments to the literature of selected biomedical research subfields are shown in Fig. 1. These subject areas were selected to illustrate different types of growth. The curve for cardiovascular agents after 1940 is an example of very active but irregular growth. Some of the peaks probably represent a flurry of publications following a new lead, e.g., the 1950 peak followed the discovery of the first potent antihypertensive agent (personal communication from Dr. Isaac Welt). The curve for psychopharmacology is too short to show the usual fluctuations in the rate of appearance of new publications that can be expected to occur in any relatively narrow subject area over an extended period. This curve does, however, illustrate the rapid initial growth followed by a relative slowing that is commonly seen in new research areas. Poliomyelitis literature exemplifies a growth pattern that is often forgotten—what happens in a research area when some of its important problems have been solved.[30]

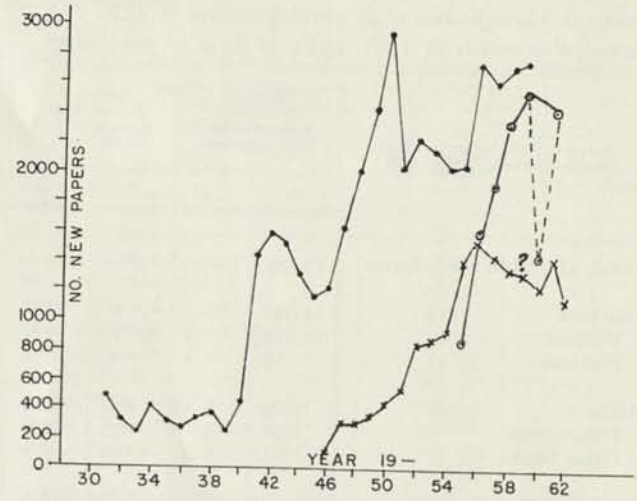

FIG. 1. Annual increments to the literatures of selected biomedical subfields. ●——● literature of cardiovascular agents; ○——○ literature of psychopharmacology; ×——× literature of poliomyelitis. The low figure for 1960 psychopharmacology papers may represent an incomplete collection for that year. Tabulations of all data are included in the appendix (see footnote 6). *Data sources:* For literature of cardiovascular agents—figures for 1931–1955, *Index Handbook of Cardiovascular Agents*, analysis of a 46% sample of all documents listed in vol. 1 (1931–1950) and a 31% sample of vol. 2 (1951–1955), part 1; figures for 1956–1959, supplied by Dr. Isaac D. Welt based on a count of documents in the files of the Cardiovascular Literature Project of the Institute for Advancement of Medical Communication. For literature of psychopharmacology—data supplied by Dr. Welt based on a count of documents in the collection of the Psychopharmacology Service Center of the National Institute of Mental Health. For literature of poliomyelitis—analysis of all documents listed in *Poliomyelitis Current Literature*, vols. 1–12, 1946–1958, and its successor, *Current Literature, Poliomyelitis and Related Diseases*, vols. 13–18, 1959–1962; all documents listed in these two publications were counted as poliomyelitis literature, although the subject coverage of the latter publication explicitly included diseases other than poliomyelitis.

Language and country of publication. During the period for which we have figures (1957–1959), the proportion of psychopharmacology documents[31] in English apparently decreased slightly (58 to 54%). It can be seen that, in the literature of this subfield, English is even more predominant than in the biomedical literature as a whole.

Most published studies on the language and geographic origin of the literatures of biomedical subfields and disciplines are based on cited documents and hence are not comparable with the data we have on biomedical literature as whole.[32] However, an excellent study of the

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. . . communication process is being increasingly impeded by a spectrum of restrictions which serve no essential national purpose." (39)

[30] It also illustrates what may be a general principle for bibliographic services in narrow subject areas: when research activity in a given subject area stabilizes or decreases, the bibliographic service specializing in this area either increases the scope of its subject coverage to include related areas or ceases operation. The bibliographic service for poliomyelitis apparently broadened its subject scope sometime in the late 1950's and ceased publication in 1962. The same principle is demonstrated by the services covering the literature on tuberculosis. (*Tuberculosis Index*, and *Chest Disease Index and Abstracts, Including Tuberculosis*.)

[31] The psychopharmacology collection contained many different types of documents. The term "document" is used in this paper to mean a recorded unit of scientific information intended for distribution by other than personal or administrative channels; it includes journal articles, abstracts of oral reports, papers in volumes of proceedings, technical reports, etc.

[32] The documents cited by authors presumably are selected by some value judgment; and literature samples based on citations are also known to be biased by the nationality and language of the citing population.

TABLE 8. *Classification of documents generated by U.S. biomedical scientists in 1961–1962, by form of publication*

Forms of Publication in which Sample Documents Appeared	Sample A (Documents Generated by NIH Grantees)		Sample B (Documents Generated by NIH Staff)	
	No. Documents	% of Sample	No. Documents	% of Sample
Total, all publication forms	15,979	100	1,622	100
Journals	14,340	89.7	1,341	82.7
Verified	14,275	89.3	1,337	82.4
Probable	65	0.4	4	0.3
Books	1,509	9.4	249	15.4
Proceedings	798	5.0	95	5.9
Other books	711	4.4	154	9.5
Technical reports	14	0.1	8	0.5
Other forms	53	0.3	1	0.1
Unclassifiable	63	0.4	23	1.4

Definitions of journals, books, and technical reports used here are those discussed on page 1311 of this paper. A "verified" journal is a publication described in at least one of the checking references as being issued more frequently than annually. Publications that could not be verified as journals in this manner, but that were considered likely to be bona fide journals, by our definition, were classified as "probable" journals. Annual publications and serials issued less than annually were counted as "books"; publications classified as "books" were further categorized as "proceedings" when their titles explicitly connected them with a meeting, and when we could confirm that they were bound collections of meeting papers. The category "other forms" here is limited to miscellaneous publications (other than journals, books, or technical reports) with titles that suggested some connection with a meeting, but which could not be positively identified as proceedings volumes; for Sample A, these titles were in most cases printed programs of meetings, and the documents were abstracts of oral reports. Some titles could not be classified because the citation was incomplete or patently incorrect, or because the title could not be found in checking references. The appendix to this paper (see footnote 6) contains a further breakdown of these categories and details of methods.

biochemical literature, based on all entries listed in two comprehensive bibliographic tools (*Chemical Abstracts* and *Chemisches Zentralblatt*) from 1880 to 1960 (36), provides data that can be compared with the 1957 data in Table 3. In 1960, the six countries ranking highest in number of biochemical papers published were: United States 30%, Japan 10%, England 9%, Germany 9%, U.S.S.R. 7%, and France 7%; these six countries accounted for 91% of all biochemical articles. The trend toward publication in countries other than the U.S. seems definite for the biochemical literature; the proportion published in the U.S. decreased from 41% in 1950 to 30% in 1960. The proportion in English, however, did not drop markedly (57% in 1950 vs. 53% in 1960). Six languages accounted for 93% of all papers in 1950 and 90% in 1960; during this decade Russian and Japanese moved up significantly as biochemical languages, whereas, French and Spanish declined. One of the most marked changes in the decade was the increase in the total number of languages from 21 to 46. Some of these changes may be explained, at least in part, by better coverage of the biomedical literature by the abstracting-indexing services.

Scatter. The 2,452 psychopharmacology documents published in 1961 were "scattered" among 140 different publications or "titles." The 7 titles containing the most documents relating to psychopharmacology (5% of all titles) accounted for 29% of all the documents; and the 14 top-ranking titles (10%) contained 42% of the documents. Whereas one-half of the titles accounted for 81% of all the documents, the remaining half contained only 19%. More complete data on the scatter of psychopharmacologic literature is given in the appendix (see footnote 6). These figures indicate that the literature for psychopharmacology is highly scattered relative to some other biomedical subfields, e.g., 26% of the more than 29,000 biochemistry papers published in 1960 appeared in 24 publications, which represented only 1% of all the titles (2,365) in which biochemistry papers were published that year (36).

FINDINGS RELATING TO BIOMEDICAL LITERATURE AS DEFINED BY GENERATORS

This section is devoted to characterizing the literature currently being generated by biomedical scientists. As two samples of this literature, we used the documents published in 1961–1962 by NIH grantees and by NIH intramural staff. The volume and growth of this literature has been analyzed elsewhere (31); here its other characteristics are analyzed.

The bibliographies used to establish the two document samples (see "Methods and Sources") differed in one important respect: the bibliography for NIH grantees included, in addition to journal articles and other types of "papers,"[33] many abstracts of oral reports submitted for meetings and printed in journals or meeting programs; whereas, the bibliography for NIH staff excluded oral report abstracts. This difference in the samples affects all of the analyses.

Forms of Publication

In Table 8 the documents generated by these two populations of biomedical scientists are classified by the forms of publication in which they appeared. The two samples are similar except that a higher percentage of the documents generated by NIH grantees was published in journals and relatively more of the NIH staff documents appeared in books that were not proceedings.

Journals Ranking Highest as Publication Outlets

For each sample the 10 journals containing the most documents are shown in Table 9, which is derived from

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[33] We reserve the term "article" for the conventional type of paper published in serials issued more frequently than annually, i.e., journals. The term "papers" is used in a more generic sense and includes all published documents, other than abstracts of oral reports. Thus a paper can be a journal article, a chapter in a book, an entire book, a technical report, a patent, thesis, etc.

TABLE 9. *The 10 journals containing the largest number of documents generated in 1961–1962 by NIH grantees and by NIH intramural staff*

Sample A—Documents Generated by NIH Grantees (Total no. verified journal documents = 14,275)			Sample B—Documents Generated by NIH Staff (Total no. verified journal documents = 1,337)		
Journal title	No. sample documents contained	% of all verified journal documents	Journal title	No. sample documents contained	% of all verified journal documents
Federation Proc.	1,064	7.4	*J. Biol. Chem.*	62	4.6
Proc. Soc. Exptl. Biol. Med.	475	3.3	*J. Nat. Cancer Inst.*	47	3.5
J. Biol. Chem.	429	3.0	*Biochim. Biophys. Acta*	46	3.4
Nature (London)	399	2.7	*Nature (London)*	43	3.2
Biochim. Biophys. Acta	387	2.7	*Proc. Soc. Exptl. Biol. Med.*	40	2.9
Am. J. Physiol.	296	2.0	*J. Clin. Invest.*	34	2.5
J. Clin. Invest.	241	1.6	*J. Org. Chem.*	29	2.1
J. Am. Chem. Soc.	213	1.4	*J. Am. Chem. Soc.*	28	2.0
Clin. Res.	187	1.3	*Cancer Chemotherapy Rep.*	26	1.9
Endocrinology	182	1.2	*Am. J. Physiol.*	26	1.9
Totals for 10 journals	3,873	27	Totals for 10 journals	381	28

For Sample A, 10 journals constitute 1.1% of all verified journals that contained sample documents; whereas, for Sample B, 10 journals represent 3.2% of all verified journals.

two lists of the "100" journals[34] ranking highest in regard to the numbers of sample documents they contained. The full lists are given in the appendix (see footnote 6). The journals in these two rank-order lists account for 66% and 67% of all the documents in Samples A and B, respectively. The titles in the two lists are notably similar; 67 journals appear in both lists. Most of the titles found only in the Sample B list reflect the known special interests of NIH intramural research staff.

Types of Documents

On comparing the list of 100 top-ranking journals for Sample A (the document output of NIH grantees) with that for Sample B (NIH staff), we noted that the rank order of certain journals was markedly different in the two lists. Some of these differences could be explained by the special emphases of NIH intramural research, but others semed to be related to the fact that the journals in question published relatively large numbers of abstracts of oral reports; such titles[35] ranked consistently higher in the Sample A list. This finding led us to believe that the proportion of oral report abstracts in Sample A was higher than we had appreciated before. Since Sample A was being used for comparing the publication rates of different populations of biomedical scientists (31), and most of the comparative data was in terms of "regular papers," it was necessary to establish the approximate percentage of oral report abstracts in this sample. All issues of *Federation Proceedings* for one year, starting with the July 1961 issue, were examined; they contained 2,990 oral report abstracts and 115 journal articles. Of the journal articles, 44 carried acknowledgements of NIH grants. If this ratio of oral report abstracts to articles holds for calender 1961 and 1962,[36] of the 1,064 documents from *Federation Proceedings* included in Sample A, over 1,000 must be oral report abstracts. Examinations of other journals represented in this sample indicated that the total number of oral report abstracts included among the journal documents of Sample A was 2,500 to 3,000, or 17–21% of all journal documents. The details of the procedure for this estimate are given in the appendix (see footnote 6). In addition to the oral report abstracts published in journals, we recognized that some of the Sample A documents in publications categorized in Table 8 as "proceedings" and "other forms" were also oral report abstracts. These considerations led us to estimate that roughly 20% of all NIH grantee-generated documents represented by this sample were oral report abstracts.[37]

Scatter of Documents

The 15,979 documents generated by NIH grantees appeared in 1,448 different publications; whereas, the 1,465 documents generated by NIH staff were published in 383 different titles. The "scatter" curves in Fig. 2 are concise expressions of the way the sample documents were distributed among different publications and are convenient for comparing the two samples with regard to this characteristic. The curve for each sample is based on only those documents appearing in publications we veri-

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[34] The list for Sample A actually includes 102 journals. In ranking journals by the number of sample documents they published, it happened that cutting off the list at 100 would exclude two journals that contained the same number of documents as the 99th and 100th journals. For the same reason, 107 journals are included in the list for Sample B.

[35] For example, *Federation Proceedings, Pharmacologist, Physiologist,* and *Clinical Research.*

[36] Sample A documents were published about equally in 1961 and 1962 and represent roughly one-half of all documents generated during 1961 and 1962 by NIH research grants (31).

[37] Since 5% of all Sample A documents were in proceedings volumes (Table 8), it can be seen that a total of about 25% of all the documents in this sample are direct by-products of meetings.

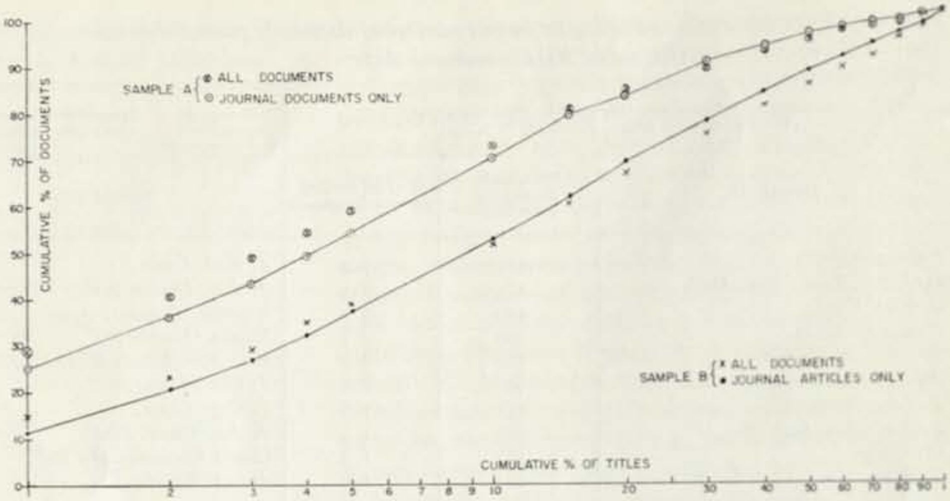

FIG. 2. Scatter of documents published by U.S. biomedical scientists in 1961–1962 among different titles (journals and other publications). Sample A — documents published by NIH grantees in 1961 or 1962 (all documents = 15,979, verified journal documents only = 14,275; all titles = 1,448, verified journal titles only = 891). Sample B — documents published by NIH intramural staff in 1961, with the exception of a few that appeared in 1960 (all documents = 1,622, verified journal articles only = 1,337; all titles = 479, verified journal titles only = 308). (See footnote 33 for distinction between "documents" and "articles.") To analyze the distribution of sample documents among different publications, all titles (names of journals, books, etc.) containing the documents in each sample were listed in order of the numbers of sample documents they contained, starting with the title containing the most. The number of titles in the two rank-order lists that resulted was then cumulated from the top down, as was the number of documents in successive titles. For each list, these cumulative totals for titles and for documents were divided by the total number of sample titles and the total number of sample documents, respectively, to obtain the cumulative percentages. To facilitate plotting, the cumulative percentages of documents corresponding to whole number cumulative percentages of titles were calculated by interpolation. The data plotted are given in tables in the appendix (see footnote 6).

Note: The cumulative percentages of documents are plotted on a linear scale; whereas, cumulative percentages of titles are on a logarithmic scale. The following examples illustrate how the figure can be read: For Sample A, the plotted values for "all documents" indicate that the top 10% (145) of all titles in the rank-order list contain about 73% (11,700) of all documents in this sample; and the curve for "journal documents only" shows that the top 10% (89) of all journal titles contain 70% (10,028) of all the sample documents that appeared in journals. *Data sources:* For documents published by NIH grantees, analysis of all documents listed in ref. 23; for documents published by NIH intramural staff, analysis of documents listed in ref. 24.

fied to be journals; however, the corresponding data for all documents are plotted; and, if these points were connected, the resulting curves would closely resemble those for verified journal documents only. The figure shows that the documents in Sample B are more highly scattered; about 9% of all the journals in which documents appeared are required to account for 50% of this sample's journal documents, as compared to only 4% of journal titles in Sample A.[38] The slopes of the "linear" portions of two curves (from 3% to 15% of titles) are identical; however, throughout this linear range, the journal document curve for Sample A is higher than the Sample B curve by an average of 17%. Since the two document samples are remarkably similar in most respects, and other minor differences could be largely explained by the fact that only Sample A contained abstracts of oral reports, it seemed likely that the difference in the scatter curves would also prove to be attributable to oral report abstracts.[39] This hypothesis seems to be confirmed. The 17% difference between the curves falls within the previously estimated limits for the percentage of oral report abstracts among Sample A journal documents (17–21%); and over the linear range, the corresponding average difference between the plotted values for all sample documents is 20%, which is the same figure we arrived at earlier. This evidence suggests that, if all the oral report abstracts were removed from Sample A, its scatter curve would be almost identical with the Sample B curve.

The Literature Generated by U.S. Research Workers

Sample A consists of roughly one year's document output for the NIH extramural grants program and represents the work of at least 17,000 professional-level, biomedical research workers, or over 40% of all U.S. biomedical research manpower.[40] The 12,800 papers in this sample (the total number of sample documents corrected for 20% oral report abstracts) represent about 50% of the total annual output estimated for the U.S. biomedical research effort (31). As a sample of all the documents resulting from U.S. biomedical research, it is somewhat biased in that the great majority of NIH grantees work in academic and nonprofit institutions; but such institutions provide the working environment

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[38] In terms of the absolute number of journals required to account for a given percentage of sample documents, there is less difference between the two samples. See the comparisons of the 10 and 100 top-ranking journals for each sample (Table 9 and page 1321). When calculated on the basis of journal documents alone, the top 100 journals for Samples A and B account for 73% and 81%, respectively.

[39] Previous work with scatter curves of this type (see page 1326) has shown that the curve for a given literature is almost like a fingerprint in that it is distinctive and relatively stable. Different samples of the same literature have very similar scatter curves. Sample A and Sample B are undoubtedly from the same document population.

[40] The principal and co-principal investigators on the NIH grants active in fiscal 1962 numbered 17,109 (31). Total U.S. biomedical research manpower in 1960 has been estimated at 39,700 professional workers (43).

for 62 % of the professional workers in U.S. biomedical research (43). The characteristics of the document output of industrial and government workers may differ somewhat; however, for NIH staff at least, the differences are small. It seems justified, therefore, to use this sample, with certain qualifications,[41] for characterizing the literature currently being produced by the research component of the entire U.S. biomedical community.

"*Core journals.*" In view of the relative stability of scientists' publication habits, the 100 journals ranking highest as publication outlets for Sample A documents may be considered to be the "core journals" for U.S. biomedical research. One can predict that, for the next few years at least, the bulk of all documents resulting from U.S. research will be published in these journals.[42] Eleven of the core journals are published in foreign countries, but the principal language of each of these journals is English; these foreign journals published about 9 % of the journal documents in the sample. Of these foreign journals, six are British and the remainder are "international" in the sense that their contributors reflect reasonably well the geographic distribution of workers in the journals' special fields. Of the core journals a disproportionate number publish large quantities of brief papers (less than 3,000 words), e.g., *Proc. Soc. Exptl. Biol. Med.*, *Nature*, *Science*, *Lancet*, *Experientia*, etc. The growing importance of these journals, which specialize in short papers and stress rapid publication, warrants further study of their characteristics.[43]

Comparison of the Literatures Defined by Generators and by Subject-Matter

Of the 891 journals represented in Sample A, only 66 % qualify as "biomedical" by a relatively narrow subject-based definition[44]; these journals contained 87 % of all the verified journal documents in the sample. The literature generated by the U.S. biomedical research community extends considerably beyond the confines of a narrow definition of biomedical literature and into the fields of chemistry, mathematics, and the social sciences. By the broader definition adopted for compiling *Biomedical Serials, 1950–1960* (28), 81 % of the 891 journals (containing 96 % of all sample journal documents) are biomedical. Of the 527 U.S. journals represented in Sample A, 410 are classified as biomedical by this broader definition; these U.S. journals, most of which may be described as "research-oriented," constitute about 40 % of all U.S. biomedical serials other than abstracting-indexing periodicals.[45] Regional, state, and local journals are underrepresented in the sample, as would be expected since these types of journals are generally "practice-oriented."

DISCUSSION AND CONCLUSIONS

Technical Reports as a Form of Scientific Literature

Comparison with journal articles. It seems useful to attempt an objective comparison of technical reports and journal articles and of how these literature forms are processed by their respective systems.

1) CONTENT AND FORM. Technical reports are usually labeled as either interim ("progress") or final; most are of the latter type (40). For journal articles, this distinction is not routinely made, at least explicitly. The average biomedical technical report contains six times as many pages as the average journal article (43 vs. 7); but since most technical reports are typewritten, double-spaced, the difference in the average number of words is much smaller. Typically, technical reports present data and methodology in greater detail than do journal articles, include more tabular material, and are more likely to be prefaced by an author abstract.[46]

2) CRITICAL REVIEW BEFORE DISTRIBUTION. The care with which a technical report is reviewed by the sponsoring agency before its distribution is approved, and the number and research competence of the reviewers, varies widely from agency to agency—probably even more widely than manuscript reviewing practices vary from journal to journal. Some governmental units have established procedures using outside experts as well as scientist employees to review the unit's technical reports and requiring as long as 3–4 months (40). In certain units, the reviewing standards are probably as high as those of excellent journals (33). In others, there is no technical review by qualified experts; but this can also be said of some biomedical journals. A report of the President's Science Advisory Committee (33) strongly recommended that all governmental agencies establish policies to insure that technical reports are reviewed

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[41] A small percentage of NIH grants are to foreign institutions; in 1962, these accounted for 6% of all grants (22). These foreign investigators would be expected to publish their results in foreign publications more frequently than do U.S. scientists. This means that foreign publications are slightly overrepresented in the sample; however, foreign grantees (some of whom publish in U.S. journals) probably do not account for more than 6 of the 18.5% of the sample documents published in foreign countries. Of all journals containing sample documents, 364 (41%) were foreign.

[42] This cut-off point for defining "core journals" is, of course, arbitrary. From Fig. 2, one can determine how many journals would be included if the cut-off were set at any given percentage of all research-generated journal documents. The relative stability of lists of this type, at least over periods of a few decades, has been shown repeatedly for the literatures of biomedical subfields, e.g., physiology (20) and biochemistry (36). The frequency with which the same journals appear on lists of the top-ranking journals in different biomedical subfields is also notable.

[43] This phenomenon, and the importance of the international journals, has been recognized in other analyses of scientific literatures, e.g., biochemistry where journals of this type, in recent decades, have tended to displace titles that publish only full-length articles (36).

[44] The definition referred to is that used by *Index Medicus* in selecting the serials it covers. In 1963, *Index Medicus* covered 66% of all the verified journals represented in Sample A (32).

[45] The 1,159 U.S. serials listed in *Biomedical Serials, 1950–1960* as alive in 1960 include a considerable number that are devoted primarily to abstracting-indexing.

[46] The majority of technical reports include an author abstract (40), as compared to a minority of biomedical journal articles; 19% of biological journals print author abstracts for all articles (29).

critically, and this recommendation is being implemented (10). Although the ranges of reviewing standards for technical reports and for journal articles may overlap to some degree, the review process for these two forms of literature differs in two important respects. First, report reviewing does not typically include the central decision a journal editor faces, i.e., whether to publish the manuscript (with or without revision) or to reject it entirely. Second, the reviewer of a technical report does not have to consider a document's merits relative to other documents that are competing for the limited space in a journal.

3) SPEED OF PUBLICATION. For transmitting information to potential users, the technical report is commonly considered to be considerably faster than a journal article. However, the available data do not support this general impression, at least in the biomedical field. Publication processing time (the interval from submission of a manuscript to distribution of the article) averages 6–7 months for biological and biomedical journals (30, 38); the comparable processing time for technical reports is not materially shorter, averaging perhaps a month or so less (40).

4) PRIMARY DISTRIBUTION. For technical reports, the average number of copies distributed automatically by either the sponsoring agency or the investigator's institution is considerably smaller than the average circulation of biomedical journals.[47] Aside from the copies routinely sent to the depositories for use in meeting later requests, the official distribution of a technical report averages only 135 addressees (40). In addition, if the report is not classified, the author may also send copies to colleagues with whom he routinely exchanges publications, just as he does with journal reprints (see footnote 50 for additional comments on primary distribution of reprints).

5) ANNOUNCEMENT. The average time-lag between the issuance of technical reports and their announcement by the major report services was 4–6 months in 1961–1962 (15, 40); the time required for U.S. journal articles to appear in *Index Medicus*, *Biological Abstracts*, and *Chemical Abstracts* also averages from 4 to 6 months (32). In general, technical reports are announced in periodicals that concentrate primarily on this form of literature (e.g., *TPA*, *TAB*, and *USGRR*),[48] and journal articles are announced by conventional abstracting-indexing services, which concentrate largely on journal literature. The major exceptions to this general statement about conventional abstracting-indexing services are the *Bibliography of Agriculture* and *Psychological Abstracts*, both of which attempt to cover all relevant technical reports and journal articles. A selective policy on covering technical reports is followed by *Chemical Abstracts* and *Biological Abstracts*, both of which are, however, steadily increasing their coverage of this form of literature. In a special section of *Index Medicus* ("Recent United States Publications"), a few technical reports are listed; but these are only a fraction of all biomedical technical reports.[49] *Excerpta Medica* covers only journal articles.

6) SECONDARY DISTRIBUTION. Distribution of technical reports in response to requests received after publication and initial distribution is, in certain respects, similar to that for journal articles, i.e., requests for specific documents may be directed either to the generating source (the author or his institution) or to the "publisher." In the case of technical reports, the publisher (the sponsoring agency) usually designates certain depositories, from which copies may be obtained. Journal articles (or an entire issue containing the desired articles) are sometimes purchased from publishers; more commonly they are borrowed or copied from the collections of colleagues or libraries.

Some idea of the amount of secondary distribution technical reports receive is provided by the experience of the Defense Documentation Center (the central depository for DOD) in answering requests; less than 10 requests are received for 80% of the reports deposited with this center, more than 10 requests for 10%, and no requests for the remaining 10% (40). No data on the average number of copies requested from authors of technical reports could be found. The secondary distribution of journal articles is highly decentralized, and no statistics are available for comparison with the data on DOD reports. Authors are probably the major source (12). A study of psychologists (1) established the median number of requests for reprints received by authors of journal articles as between 11 and 15.[50] This figure would seem reasonable for biomedical articles also.

Attitudes of scientists and document processors. Research workers, particularly academic scientists in basic research, often regard technical reports as "second-class" literature, both for use and as a medium for reporting their work. This attitude seems prevalent in most fields of science, though perhaps it is more frequently expressed in the biological sciences. One formal expression of this

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[47] Biomedical journals probably have a somewhat larger circulation than biological journals in general; circulation of the latter averaged 2,377 for U.S. journals in 1959 (38).

[48] *TPA* (now *STAR*) covers only technical reports, as does *USGRR*. Some but not all of the journal articles resulting from DOD support are announced in *TAB*. *NSA* is an exception to the general rule for report services in that it covers all relevant literature regardless of form or source of support.

[49] A recent study of report literature showed that the *Current List of Medical Literature* (the predecessor of *Index Medicus*) listed only 12% of the biological and medical technical reports issued in 1957; *Chemical Abstracts* covered only 6% of the chemical technical reports, and *Biological Abstracts* less than 1% of the biological and medical reports (16).

[50] This figure is for only the secondary distribution of reprints, i.e., upon request after publication. Primary distribution by psychologist authors is larger: 62% distribute reprints to some kind of a mailing list, and the median number of copies falls between 21 and 30 (1). If the 64 biological laboratories (biochemistry, microbiology, marine biology, pharmacology, and pharmacy) surveyed in a recent study (2) are representative of biomedical research institutions, the practice of sending out reprints automatically seems to be less common among biomedical scientists; less than one-third of the scientists in these laboratories admitted they had a "regular" mailing list, and when they did the number of colleagues on this list was small (median less than 10).

attitude is that some biological and biomedical journals do not permit authors to cite technical reports. From the user's point of view, the primary criticism of technical reports is that quality control is not as strict as for journal literature. On the positive side, the advantage of greater speed of publication is usually assumed, probably erroneously. The technical report has also been recognized as a superior source for details of methodology and for primary data (unpublished study performed for the Division of Technical Information, AEC); this advantage is obvious when one compares the amount of detail afforded by a technical report with the journal version of the same research.

The classic attitude of librarians toward report literature is to consider such material as "ephemera"; but librarians working in fields where there is considerable demand for technical reports have learned to use the special techniques and bibliographic tools (e.g., *TAB*) required to handle technical reports. Library schools are now teaching their students these techniques, particularly if the student plans to work in libraries associated with research activities. However, in an informal survey, we found that most academic biomedical libraries do not possess the requisite bibliographic tools and that many biomedical librarians view the problems of handling technical reports with dismay. The previously cited report of the President's Science Advisory Council (33), referring to the traditional types of abstracting-indexing services (and libraries), concluded:

> "The documentation community has taken an equivocal attitude toward . . . reports; in some cases the existence of these reports is acknowledged and their content abstracted in the abstracting journals. In other cases . . . reports are given no status; they are alleged to be not worth retaining as part of the permanent record unless their contents finally appear in a standard . . . journal."

Use by biomedical community. In some areas of science, particularly those where significant quantities of information are security classified, or where technologic development is a central interest, studies have shown that technical reports are a major medium of communication; however, systematically collected data on the use of technical reports by broad biomedical populations are not available. Informal evidence suggests that few academic biomedical workers are either knowledgeable about technical report literature or make any significant use of it.[51] In addition to the attitude of biomedical scientists toward technical reports, their general unfamiliarity with the resources of this form of literature, and the relatively poor capabilities of their libraries for handling technical reports, other factors have restricted use by the biomedical research community. First, if biomedical scientists who are not eligible for the free report services of DOD, AEC, and NASA (or are not aware of their eligibility) try to obtain technical reports, they will find that OTS cannot supply a significant proportion of the nonclassified documents that may be of interest to them. Second, the relatively high price of those reports that can be obtained from OTS is a deterrent.[52] When the recently clarified eligibility of Public Health Service grantees for the special report services becomes common knowledge, these two practical obstacles to the ready use of technical reports will be removed for a large proportion of U.S. biomedical research workers. For those whose work is not supported by any Federal agency, and for foreign scientists, the current efforts to eliminate unwarranted restrictions on the release of reports to OTS should help to reduce the first obstacle.

Currently the volume of technical reports of potential interest to biomedical scientists is small compared with that of journal articles, and a relatively small proportion of biomedical scientists probably would find much in the technical report literature that was directly relevant to their central interests. As biomedical research increasingly draws upon the physical sciences, and the space program entails more biomedical research, it is likely that the technical report literature will assume greater importance to the biomedical research community.

The Biomedical Literatures

Figure 3 depicts the logical relations among the biomedical literatures, or document universes, established by different definitions. In an effort to study by indirect means the document universe of primary interest, i.e., the literature useful to biomedical scientists, we assayed the characteristics of the three subuniverses represented by shaded circles. No schema of this type, however, can show the dynamic relations, such as the changes that occur in the literatures defined in terms of users and of generators and later affect the document universes established by subject classification. The broader subject-based definitions (e.g., those used for establishing the acquisition policies of libraries, or for selecting serials to be included in compilations like *Biomedical Serials, 1950–1960*) are influenced by the needs of biomedical scientists and with time expand to encompass the documents this scientific population has found to be useful. Even the narrower subject-based definitions, which mirror the patterns of medical education, expand as new subjects enter the standard curriculum. There is, however, an inherent lag in all these accommodation processes, and subject-based definitions always reflect past needs.

Scientists' citation patterns show that, for their docu-

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[51] The major exceptions to this general statement seem to be in relatively narrow subfields where considerable pioneering research and development has been sponsored by the military agencies, AEC, and NASA, e.g., physiological monitoring, biomedical engineering, radiation biology, and certain areas of psychology.

[52] The average OTS price of biomedical reports is comparable to that of a small book. However, unlike books, critical reviews are not generally available; and the report can seldom be inspected at local libraries before purchase. If the title and abstract of a report listed in *USGRR* looks interesting enough to warrant buying it, unlike the usual custom in technical book selling, a refund cannot be obtained should the report prove to be different than expected.

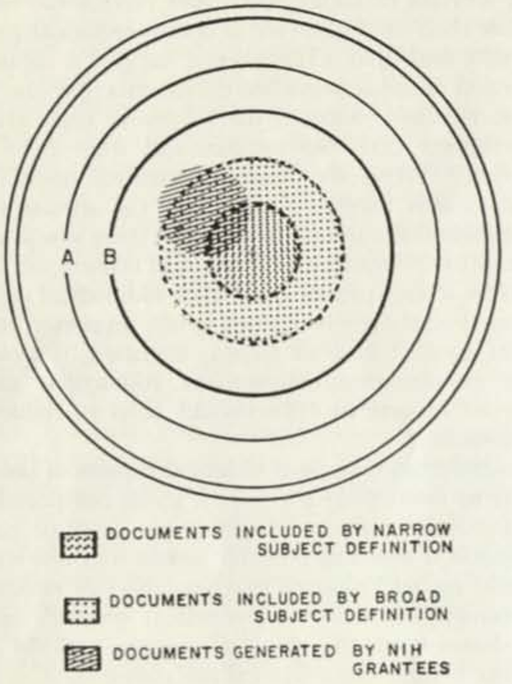

FIG. 3. Logical schema for the "biomedical literatures" established by different definitions. The double-walled circle encloses the universe of all documents generated by all scientists, i.e., what is usually called the "scientific literature"; circle A delineates the universe of all scientific documents used by biomedical scientists; circle B, all documents generated by biomedical scientists. The sizes of the circles are not proportional to the numbers of documents included in the various literatures.

ment needs, they often range far from their areas of specialization—even outside their branch of science. Although the "nonbiomedical" documents useful to biomedical scientists may be relatively few as compared to their total document needs, these "out-of-scope" documents can have a disproportionate value. As interdisciplinary and interscience barriers become more and more tenuous, such "fringe" documents assume greater importance. The document output of biomedical research workers sensitively indicates the direction in which the interests of biomedical scientists are turning; and simple analyses of this output, like those made in this study, are a convenient means of determining indirectly how their document needs are changing. However, practical direct methods for determining routinely, on a continuing basis, the literature used by biomedical scientists—or perhaps more importantly, the literature potentially useful to them—are also needed to guide the policies of libraries, abstracting-indexing services, and other biomedical information services.

Literature Characteristics of Special Concern to Users and Processors

The quantifiable literature characteristics of greatest interest to both scientists and the services that process documents and information, such as libraries, abstracting-indexing services, and information centers, seem to be: language, scatter, and volume, roughly in ascending order of expressed concern. It is appropriate, therefore, to discuss briefly the practical applications of our findings relating to these characteristics.

Language. Although presently available data on the biomedical literature as a whole do not reflect the rapid rise of Japanese and Russian as scientific languages that has occurred in some other scientific fields, the evidence from such biomedical subfields as biochemistry probably indicates a trend that will become general. An even more important trend, however, is the rapid increase in the number of "other" languages. Again the data on biochemistry literature should be considered an early warning of what will happen, or is happening, in other biomedical disciplines and subfields. The implications of these trends for U.S. biomedical research community are *a*) that the traditional pattern of learning one or two foreign languages will become progressively less satisfactory as it becomes more difficult to decide which languages to study and relatively less profitable to know any one or two foreign languages, and *b*) that individual scientists will become more dependent on translations. For abstracting-indexing services, the problems posed by the proliferation of scientific languages will be particularly difficult. Unfortunately, the progress in mechanical translation to date does not make one optimistic about the early prospects for a routine service capable of producing computer translations of the accuracy and precision required for most scientific uses.

Scatter. Because of the value of knowing which periodicals or other titles are most "productive" of documents in a given field, there have been many studies of what is usually called "reference scattering," using literature samples derived from authors' citations in journal articles, review volumes, exhaustive or selective bibliographies, abstracting-indexing services, holdings of specialized document collections, and records of the documents borrowed from libraries (18). When the samples are comparable, the scatter curves obtained in different studies of the same literature are very similar (8, 18); and the literature distribution pattern for a given field seems to be remarkably stable over decades, at least for disciplines and broad scientific fields (14, 18). The original mathematical "law of scattering" postulated by Bradford (5) has not proved accurate in predicting the scatter of literature in all scientific fields, but the general type of distribution it describes has been found in all subsequent studies (18). Cole noted that the slope of the linear portion of such curves for representative samples of a given literature tends to be a constant and suggested that the numerical expression of this slope be termed the "reference-scattering coefficient"; he felt that this single figure adequately described how a literature is distributed (8). Others, however, have pointed out that the initial, nonlinear portion of the scatter curve also differs from one literature to another (44) and that this part of the curve, which indicates to what extent the given literature is concentrated within a few journals, should also be specified in describing a literature (18).

Our scatter curves for the document output of biomedical scientists should not be compared closely with the results of other studies, none of which derived their samples from the bibliographies of scientists or institutions. Also, few if any of the previous studies included in their document sample as high a proportion of oral report abstracts as in our Sample A. Since this type of document is more highly concentrated than journal articles, the resulting curve gives an erroneous idea of the degree of scatter when compared with curves for samples that contain no oral report abstracts. However, we have shown that the curve for Sample B (NIH staff) is very similar to that for Sample A, except for the differences that stem from the oral report abstracts in the latter sample. One is therefore justified in using the Sample B curve to represent the distribution of Sample A documents other than oral report abstracts. When compared with the scatter curves established by studies of the literatures of other broad fields of science that used samples derived from exhaustive bibliographies, the Sample B curve is quite similar to those for biology and mathematics; but the biomedical literature it describes is definitely more scattered than the literature of either chemistry or physics (18).

For a scientist, the practical implications of the scatter of literature in his field are obvious. His ability to keep abreast of developments is undoubtedly influenced by how many periodicals he must scan to accomplish this end. Biomedical scientists in general operate under a greater scattering handicap than chemists or physicists, but among biomedical subfields there is considerable variation. In some narrow subfields one or two journals may contain most of the documents that interest specialized workers; whereas, psychopharmacology appears to be an example of a subfield with a relatively high dispersion of its literature. A high degree of scatter seems to be typical of new areas of research where several disciplines converge and the literature is not yet channeled into a relatively few "core journals," as in older research areas. The pressure to found new, highly specialized research journals is, in part, an expression of scientists' efforts to reduce the scatter of the literature they use. The use of alerting services, such as *Current Contents*, and reprint exchanges are other types of scatter-reducing mechanisms.

The scatter characteristics of the output of biomedical research have very important implications for any library or other information service that attempts to meet the needs of broad segments of the biomedical research community. If the Sample A curve typifies the document output of U.S. research, 10% of the journal titles (89 journals) contain over 70% of all the journal documents (articles and oral report abstracts) resulting from the entire U.S. effort, and over 50% of all the journal articles; 400 journals can be expected to include 85% of all the journal articles published by U.S. workers.[53] If one assumes that the same general pattern of scatter holds for the world output of biomedical research, of the 5,700 biomedical serials extant, some 570 will contain over 50% of all the journal articles resulting from research. This scatter curve also predicts the relative expenditures of money and manpower required to achieve any given degree of completeness in collecting or "covering" the body of literature it describes, e.g., one can see that, to have a "complete" collection of the literature from which this sample was taken, a library must buy and process twice as many journals as are required to have 85% of research journal literature, and 10 times as many as necessary to furnish 50% of the journal articles. By carefully concentrating on the most productive journals, a library or abstracting-indexing service serving biomedical scientists can provide the maximal service possible within the constraints of its resources.[54]

Growth

Figures on the size and growth of the literature of a scientific field, narrow or broad, must be interpreted cautiously when they are based on subject classifications. Although many scientists and librarians may feel they have a clear idea of the boundaries of a given field, one cannot assume that any two individuals are likely to agree exactly when asked to determine which of a group of documents they consider as falling within the field. Nor can one assume that the classification decisions of the same individual (or group) do not change with time. Indeed, these decisions should change unless the scientific field is static. In addition to these logical considerations, the great practical difficulties in approximating a complete enumeration of the documents in any field must be appreciated when one tries to assess the growth of a literature defined by the subjects it covers. Despite the inherent errors in any data that ultimately depend upon subject classification, and the difficulty of ensuring that such data for different time periods are comparable, in view of the prevalence of concern about the publication "explosion", it seems worthwhile to attempt as careful an assessment as possible of the growth of the biomedical literature as it is conventionally defined.

Estimate of current growth rate. In Fig. 4 the best data we could collect on the biomedical literature as a whole are summarized; for comparison, data on the literature of cardiovascular agents and estimates of the total document output of U.S. biomedical research are also shown. Measures of the growth of annual increments to the literature (the annual production of new documents), and measures of the growth of the total accumulation of documents (the librarian's concept of "the literature") are plotted in Parts A and B, respectively. In calculating

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[53] The figures relating to journal articles were obtained by using the Sample B curve, but multiplying the indicated percentages by the appropriate totals for Sample A.

[54] All of the statistics in this paragraph assume that the journals are chosen from the top of a rank-order list, such as was made to prepare Fig. 2. Ideally, these lists should be based on some kind of an objective "use index" specific for the given population served by the given library or information service.

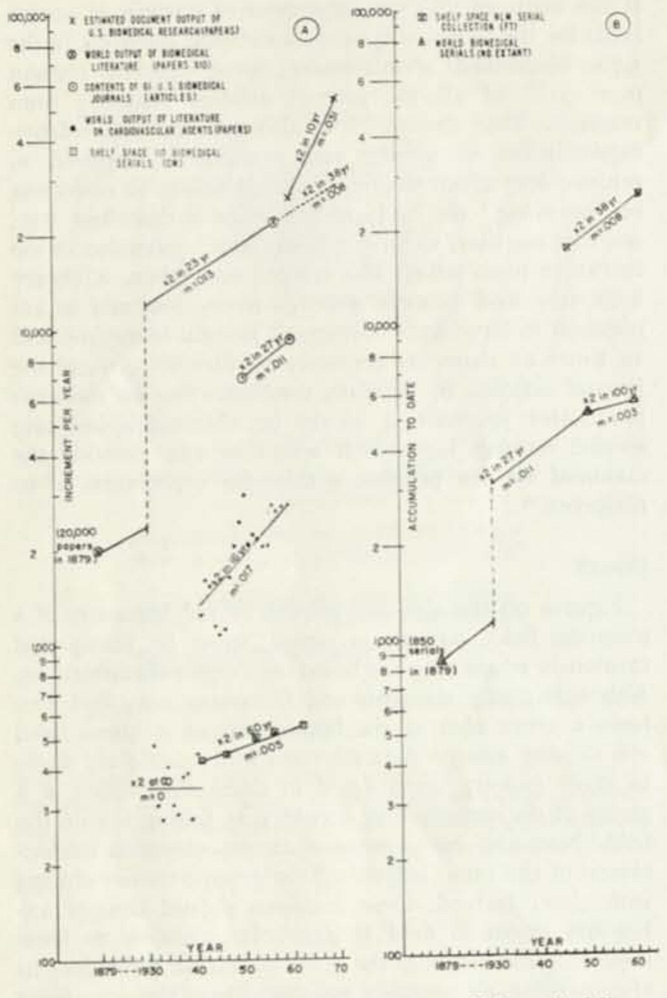

FIG. 4. Comparison of different measures of biomedical literature growth. Part A depicts growth in terms of annual increments to the literature, i.e. measures reflecting the annual rate at which documents are being produced; whereas, in Part B, measures of the literature accumulated to date are plotted. The units for each measure are given in the key. All solid-line curves assume steady exponential growth between data points. The first portion (1931–1940) of the discontinuous growth curve for the literature of cardiovascular agents was fitted by eye; the second portion (1941–1959) was fitted by the method of least squares. The dotted-line portion of the curve for the world output of biomedical papers after 1957 is a projection based on the physical growth of the NLM serial collection from 1946 to 1962 (see text). Values for the slopes of growth curves (m) are calculated from data by the formula $N = N_0 10^{m(T-T_0)}$, where N is the value of the given measure at time T, and N_0 the value at the starting time, T_0. The doubling time for each growth curve is given as "×2 in *Y* yr". *Data sources:* Part A—for estimated document output of U.S. biomedical research in 1960 and 1970, ref. 31; for world output of biomedical literature in 1879, ref. 3, and in 1957, ref. 6; for contents of 61 U.S. biomedical journals in 1950 and 1960, derived from data in ref. 37; for world output of literature on cardiovascular agents 1931–1959 (see legend to Fig. 1); for shelf space 110 biomedical serials in 1941, 1946, 1951, 1961 (see footnote to Table 2). Part B—for shelf space NLM serial collection, ref. 27; for the number of world biomedical serials extant in 1879, ref. 3; and for the number extant in 1950 and 1960, ref. 28.

growth rates, these two types of data have often been mistakenly treated as equivalent. Exponential growth rates determined from measures of the size of the accumulated store of all biomedical documents are valid also to express the growth of annual increments to this store; but growth rates calculated from annual increments do not necessarily apply to the accumulated store.[55]

For the reasons discussed previously, the plotted data on growth of papers published by the 61 selected U. S. biomedical journals are not representative of either U.S. or world biomedical serials; they are introduced to illustrate the growth in the number of articles published annually by the well-established, larger U.S. serials. The shelf space for 110 serials in an academic library, although somewhat biased, is probably the best index we now have for the increase in the annual production of papers by established biomedical serials throughout the world. When the growth in annual production of biomedical serial papers, as measured by this index, is combined with the growth in the number of world serials (Part B), the resulting curve may be considered an approximation of the growth in the world's production of biomedical papers. The growth rate computed for this curve is identical with that of the growth curve for shelf space of the NLM serial collection between 1946 and 1962 (Part B)[56]; we consider shelf-space measurements of this collection to be the best available single index for the over-all growth of biomedical serial literature. Thus, there is excellent agreement between two independent methods of estimation that the biomedical serial literature has been growing recently at a rate that will result in a doubling of annual production (and of the accumulated literature) every 38 years, or a 20% increase each decade. The projected future growth in world output of biomedical papers (shown as a dotted line in Part A) is based on this growth rate.

If the data for annual production of biomedical papers in 1879 are comparable with those for 1957, then growth must have slowed sometime before 1957. Unfortunately no suitable data are available to establish the shape of the world output curve between 1879 and 1957. The break in the growth curve for the number of biomedical

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[55] For example, the annual production of new documents in a given field may double (200 vs. 100 per year) over a period of five years (a doubling time of five years), but if the field has accumulated 1,000 documents at the start of the period, it will take much longer than five years to double this accumulation.

[56] Exponential growth rates may be expressed either as the value for the slope of the curve (m) or as the time required for doubling. The formula for computing the slope of the curve that results when the growth in the annual production of papers by individual serials is added to the growth in the number of serials extant is $P = P_0 10^{(m_s+m_l)(T-T_0)}$ where P = annual world production of biomedical papers at time T; P_0 is the annual production at some prior time, T_0; m_s is the slope of the growth curve for numbers of serials; and m_l is the slope of the growth curve for papers published annually by a representative sample of biomedical serials. The slope of the new curve is .008 ($m_s + m_l = .003 + .005$).

serials (Part B) suggests that this slowing may have occurred before 1950.

Price has pointed out that no natural growth process, biologic, social, or economic, is purely exponential; and that real growth curves are always logistic (s-shaped) functions; he has predicted that the growth rate of science and of its by-product, the scientific literature, would begin to stabilize in the near future, i.e., would depart from a purely exponential increase (34, 35). It would appear that, for the biomedical literature, this phase has already begun.

A paradox. Some segments of the biomedical literature, e.g., the literature of cardiovascular agents,[57] have grown much more rapidly than biomedical serial literature as a whole. The evidence that the literatures of many biomedical subfields are growing rapidly, while biomedical literature as a whole increases much more slowly, poses a superficial paradox. The explanation hinges mainly on three facts: first, the literatures of these subfields are not mutually exclusive, i.e., papers counted in one are often also included in others. Second, a part of the literature of some biomedical subfields falls outside the conventional boundaries of the biomedical literature, e.g., the literature of biochemistry, mental health, and other "bridging" fields. Finally, the expanding literatures of active fields are partially counterbalanced by contraction in other fields, e.g., poliomyelitis and tuberculosis.

Questionable literature growth rates. In describing the increase in scientific literature, the term "exponential" is often used; but unless the exponent is specified, the term has little significance. For most practical purposes, exponential growth at a rate that leads to doubling every 100 years is little different from simple arithmetic growth. When exponential growth rates have been given in statements on the growth in the number of serials and papers, either for scientific literature in general or for specific fields, these rates have usually been much higher than those we have offered; in terms of doubling times, such estimates have commonly been in the 10- to 15-year range, regardless of the scientific field. It is possible that the biomedical literature is growing much more slowly than the general scientific literature or the literatures of other broad scientific fields, such as chemistry. Most of these estimates, however, have been based on the numbers of documents processed by large indexing-abstracting services,[58] and are questionable unless it can be shown *a*) that the given service covered about the same proportion of the total literature throughout the period studied, and *b*) that the scope of its subject coverage did not change materially. These conditions have not been met. If one were to use the number of documents processed by *Index Medicus* in 1952 and 1962 as a measure of the increase in annual production of biomedical papers, the calculated doubling time would also be about 15 years,[59] however, during the 1950's, the relative completeness of coverage by this and other major U.S. abstracting-indexing services probably improved materially (32).

Another common basis for statements that the scientific literature is doubling very rapidly is the increase in the size of library collections. If data on library collections are used, the conditions for reliable estimates are even more difficult to meet. All the evidence indicates that the growth of library collections is strongly influenced by the age of the library.[60] The holdings of very few libraries can be considered as essentially complete for any broad area of science; it is only such "saturated" collections (e.g., NLM) that could be expected to grow at the same rate as the literature. *A priori* one would also think that library budgets would be an important factor.

Some kinds of data on the number of scientific serials may also be misleading if used to calculate growth rates since the high mortality of serials is often not appreciated. For example, Price plotted the total number of serials that had ever been founded as a function of time (35). This graph has been widely used as evidence that the number of scientific journals is doubling every 15 years, although Price has explicitly stated that these data do not represent the number of serials alive at any given time and that a loose definition of "scientific" periodicals was used (34).[61]

Implications of literature growth rates. For libraries and broad abstracting-indexing services, the knowledge that the biomedical literature as a whole is not growing as rapidly as most previous estimates indicated should be heartening and useful for some types of planning. However, their major problem is to meet increasing demands for performance with financial and manpower resources that are almost always inadequate. The growth of the literature is only one factor that affects how well they can meet the needs of their users and their own performance goals. For the working scientist, who is inter-

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[57] This same example, however, also illustrates how the production of documents pertaining to a relatively narrow subfield can remain constant during static phases of research and development (see period 1930–1940, Fig. 1).

[58] For example, the fact that, from 1940 to 1960, the numbers of abstracts produced by *Chemical Abstracts*, *Biological Abstracts*, and *Physics Abstracts* have increased at a rate that would lead to a doubling every 15 years (34) has often been cited as indicating that the literatures of the fields covered by these services are increasing at the same rate.

[59] *Index Medicus* processed 51% more documents in 1962 than in 1952 (32).

[60] From 1962–1963 statistics on U.S. and Canadian academic medical libraries (19), it can be calculated that the total number of volumes (serials and monographs) in their collections is increasing by an over-all average of 4.5% annually; but the average for the 13 largest collections (over 100,000 volumes) is 3.5%. The growth of the total NLM collection of bound volumes (serials and monographs) can be calculated from data in ref. 27 to have been 2.0% in fiscal year 1963. Doubling times based on these three figures would be 16, 20, and 35 years, respectively.

[61] Price's graph indicated that about 100,000 serials had been founded by 1960; whereas, the most reliable recent survey (13) gives a figure of about 35,000 for the number of scientific periodicals alive in the early 1960's. For another example of data not suited for determining growth rates, see footnote 8.

ested in using the literature and not in counting it, literature growth rates of the type we have been discussing probably have little practical meaning. For each individual user there is a corresponding universe of documents defined by his unique interests; it is this literature and its growth that concerns him. Not only are any general figures on growth, such as those offered here, likely to be only distantly related to his particular literature universe, but what was measured is really irrelevant to his literature problems, unless he feels compelled to read every paper that can possibly bear on his interests. Measures of the size of a literature in terms of the papers that have a reasonable probability of being useful would be more germane. When such measures are developed they will have practical implications for scientists.

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The biomedical information complex viewed as a system[1]

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Orr, Richard H., Gregory Abdian, Charles P. Bourne, Edwin B. Coyl, Alice A. Leeds, and Vern M. Pings. *The biomedical information complex viewed as a system.* Federation Proc. 23(5): 1133–1145, 1964.—To aid in visualizing and understanding the heterogeneous aggregate of interdependent operations, activities, and services that handle the information generated by, and used in, biomedical research, this complex was analyzed as a system from a viewpoint of the functions it performs. The result was a qualitative model with the following major functional components: *1*) generation and use, *2*) oral communication, *3*) recording and distribution, *4*) document processing, *5*) information processing, and *6*) control. Between generation and use, the flow of information through components (*2*), (*3*), (*4*), and (*5*) depends upon parallel and sequential chains of processing operations. The operations of each component depend, in general, upon the prior accomplishment of the operations of the preceding component. The capacity of a given component is limited to that of its slowest operation except where alternative paths exist. The costs of operating this complex are met by government, private foundations, industry, academic institutions, and user fees for services (such as subscription fees). The present trend is toward increasing dependence on government support. This crude model can serve as a framework for collecting the data required to develop a quantitative model and is useful in considering the problems of biomedical communication, determining their relative importance, and assessing possible solutions.

A DYNAMIC COMPLEX of interrelated processes, operations, activities, and services handles the information that the community of biomedical scientists generates and uses. An understanding of how this complex functions would seem to be as essential for identifying and attacking the communication problems of the biomedical research community as a knowledge of physiology is for diagnosing and treating disease. This paper represents an attempt to describe and analyze the complex as a functioning whole.

APPROACH

The biomedical information complex can be considered a "system" in the same sense that a living organism is a system. Both have evolved in response to needs and both are self-organizing; neither system was designed. Approaching the complex as a system facilitates analysis of the basic functions performed by this heterogeneous and seemingly amorphous aggregate and aids in visualizing the processes that underlie its operation. The goals are those of physiologic research: to correlate structure with function and to understand dynamic and interdependent processes.

Broadly defined, a system is a bounded complex of elements—men, machines, or objects—interrelated by processes and responding to events to achieve an objective. In the case of the biomedical information complex, the generators and users of the information must be considered parts of the system, as well as the men and devices handling biomedical information between its generation and its use. The objects in this system are "documents" in the most general sense of the term, i.e., all records of information on paper, film, magnetic tape, or on other physical media. The system's immediate objective has been aptly stated by Shaw (9): "The end product . . . must be the information needed by and usable to each scientist, wherever he may be and whatever his needs may be at the moment." Its ultimate purpose is to further the accumulation and application of biomedical knowledge.

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ASSUMPTIONS

Analyses of dynamic, complex systems usually require the adoption of simplifying assumptions and viewpoints. In the present instance, several decisions facilitated the analysis. First, we elected to view the biomedical information complex as a separate system, although it is actually a part of a larger system that serves all of science. Second, we chose to follow only the more important channels for the flow of information through the complex and to emphasize the sequence of operations occurring between generation and use. Third, since the terminology usually applied to organizations, activities, services, and people engaged in handling information often obscures their common features, the system's operations were to be described largely by function, rather than by performer, using terms selected for generality and for freedom from unwanted associations. Last, although the complex handles two kinds of information, we concentrated on one. If information resulting from scientific observation, experimentation, and reasoning is called "scientific" information, then information about research (i.e., news about scientists, support, equipment, and supplies, or messages related to the administration of research) may be termed "parascientific" information. Here the concern is primarily with the flow of scientific information.

FORM OF PRESENTATION

Our analysis is presented chiefly as block diagrams. The value of this type of diagram in physiology was recently emphasized by Gray (2):

> The engineer has developed one device for enforcing an elementary rigorousness that is refreshingly simple and general. This is the block diagram, a qualitative mathematical model which conveniently displays, without distracting detail, all the components and variables of a system together with their circuitry. . . .
>
> On several occasions I have had the opportunity to watch a fellow physiologist attempt to represent in this simple form, and at this elementary level, the system on which he is an expert. He is usually flabbergasted to discover that his ready knowledge is unequal to the task. He finds he is uncertain about numerous items suddenly revealed for the first time to be of key importance. The usual result is a period of cerebration more intense, novel, and cogent than any he had previously accorded the system, punctuated by trips to the library to find answers to questions never before asked. If a workable diagram is eventually formulated, the light it sheds may be truly exciting. One can suddenly see physiological flesh and blood as a coherent, determinate, functioning system . . . .

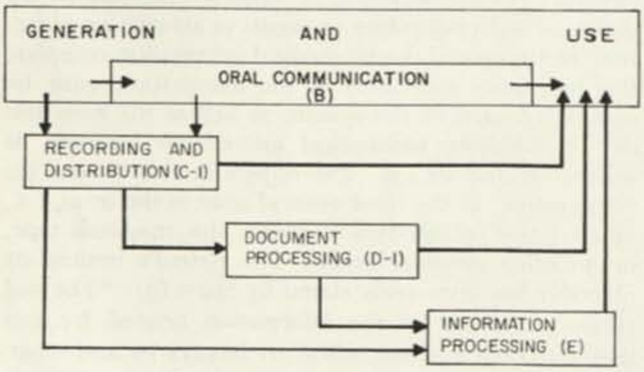

FIG. A. Over-all view of biomedical information complex. NOTE: In this and subsequent diagrams, the parenthetical letter-number combination in a box refers to another diagram that provides a further breakdown of the given operation.

We found this device to be equally valuable for studying the metabolism of biomedical information.

MAJOR FUNCTIONAL COMPONENTS OF THE SYSTEM

In Fig. A, five major functional components of the system are depicted:

1) Generation and Use—operations in which scientific information is generated and used, considered here as two phases of a single component.

2) Oral Communication—operations entailed in transmitting information orally.

3) Recording and Distribution—operations associated with the recording of scientific information and the distribution of the records thus produced.

4) Document Processing—operations performed in the collection; analysis and announcement; and the storage, retrieval, and delivery of information records (i.e., documents) after their production and initial distribution.

5) Information Processing—operations by which information is extracted from documents, evaluated, modified, or synthesized.

A sixth major functional component, which cannot be similarly depicted in this scheme, comprises the operations by which the system and its parts are controlled. Important operations related to system control and management are: *a)* maintaining the quality of "messages" handled by the system, *b)* improving the system, and *c)* supporting the system. Direct quality control is exercised in two ways—by evaluating the information in a message to see if it merits further processing and by improving the form or the content of a message. The more important points at which quality control is commonly exercised are identified in subsequent diagrams. Improving the system so that it functions more effectively and efficiently to achieve its immediate objective and ultimate purpose requires research on how the system works and development of improved methods for carrying out its various operations. Communication research and development cannot be localized in this scheme but will be covered briefly in the discussion of the system's support.

GENERATION AND USE

In Fig. A, the box labeled "generation and use" represents the thought processes of scientists engaged in biomedical research. These internal processes do not lend themselves to the approach of this analysis, and we have not attempted to analyze this component in detail.[5] The other components transmit information in the form

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[5] In Fig. G we do, however, suggest some general relations between successive stages in a research project and information generation and use.

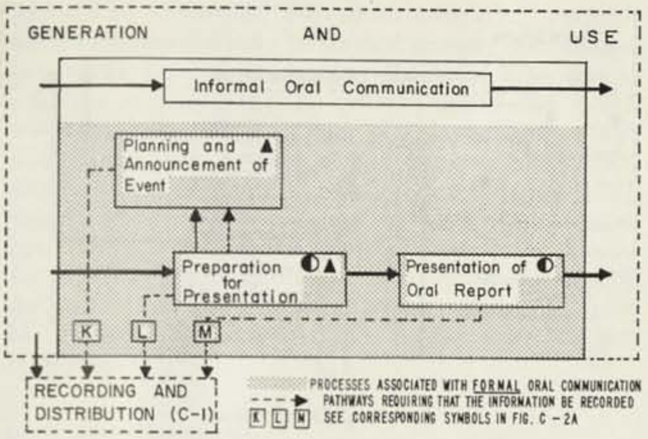

FIG. B. Formal and informal oral communication. NOTE: In this and subsequent diagrams, boxes with broken outlines and broken-line arrows represent, respectively, operations and processes that are outside the focus of the particular diagram. A small square enclosing a letter indicates that processes have been omitted to simplify the diagram and refers to the point in another diagram where the omitted processes are shown. Points at which quality control is commonly effected are designated by the following symbols: ▲ where a message may be evaluated and a yes-or-no decision made as to whether or not it will be processed further; ◐ where the content or form of the message may be modified by feedback from the generator's colleagues or from processors in the chain of operations required for transmission.

of unrecorded messages (oral communication), or of various physical records, from one scientist to another.

ORAL COMMUNICATION

The processes of formal and informal oral communication are analyzed in Fig. B. Informal oral communication comprises all face-to-face or telephone exchange other than that structured by the formalities of an "event" planned for oral communication, such as a scientific meeting, lecture, seminar, etc. The processes of formal oral communication include the planning and announcement of an oral communication event, as well as the activities of generators in preparing for and presenting oral reports. Quality control may be exercised during the planning of an event by selecting active participants (generators) on the basis of their past work or of an abstract of the oral report they wish to present. In most cases, some of the scientific information to be presented at the event is transmitted in oral or written form to the planners, who may incorporate this information in a written "announcement" of the event, e.g., as "abstracts"[6] in a meeting program (broken-line arrow designated K). In preparing to present an oral report, a scientist may have to get a decision from his institution as to whether his work is considered ready to be reported, and his presentation may be modified by feedback from institutional associates. Preparation for an oral presentation usually entails either making notes or writing out the full text. (The broken-line arrow designated L symbolizes these recording processes as well as that of preparing an abstract.) At the event, the presentations may be recorded (broken-line arrow designated M) verbatim or may be summarized by listeners who intend to give an oral or written account of the event later. Thus information transmitted by formal oral communication is recorded, in whole or part, by several routes, which will be covered in Fig. C-2A.

RECORDING AND DISTRIBUTION

Figure C-1 summarizes in broad terms the complete sequence of basic operations entailed in the recording of scientific information and the distribution of the records produced. Only channels within the specific focus of this diagram, i.e., those that are parts of this component, are shown. The details of processes required for recording, publication, and distribution are shown in Figs. C-2, C-3, and C-4, respectively.

Recording

The focus in Fig. C-2 is on the processes involved in the operation of recording. Informal documents include data and work sheets, photographs, notes or texts for oral presentations, manuscripts, letters, and any other form of recorded scientific information not intended for distribution outside administrative or personal channels. (Production of informal documents is shown in more detail in Fig. C-2A.) Some informal documents are used only by the generator; some are distributed as such; and a few are reviewed by the generator and his institution for publication and wide distribution to the scientific community. This intramural review may include a quality-control decision as well as other considerations, including protection of proprietary interests in industrial institutions and selection of the appropriate form for publication—a journal article, book, or technical report.

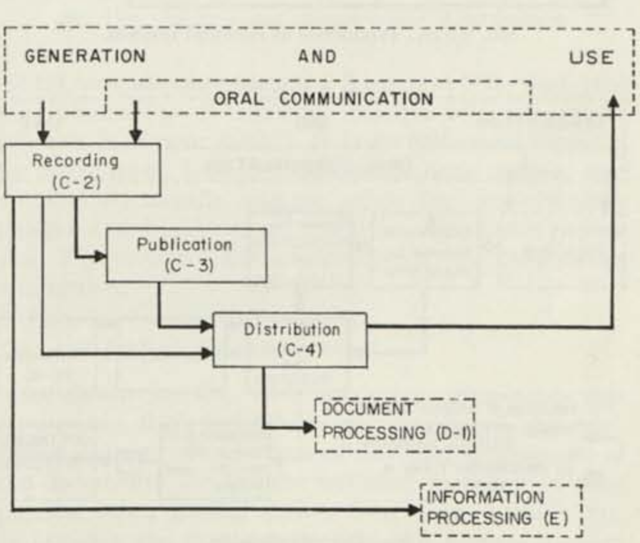

FIG. C-1. General scheme of recording and distribution.

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[6] Although commonly used in this sense, the term "abstract" is inappropriate and misleading, since the existence of a full report is implied. In reality, it usually represents only a summary of what the prospective speaker thinks he will say, or hopes he can say.

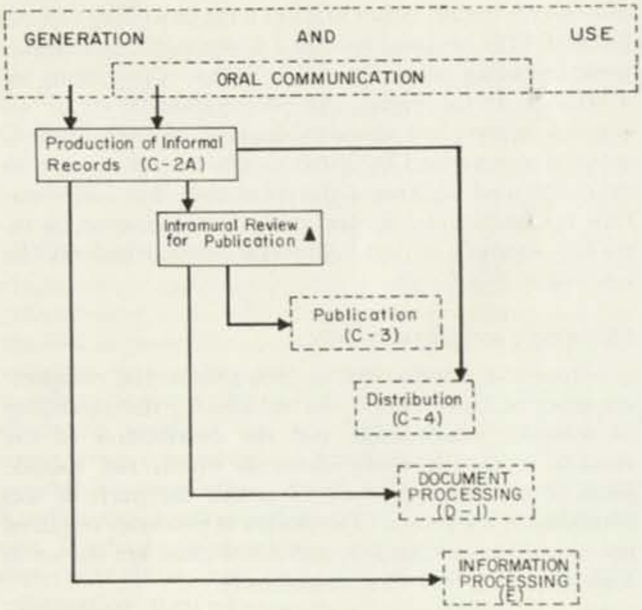

FIG. C-2. Recording.

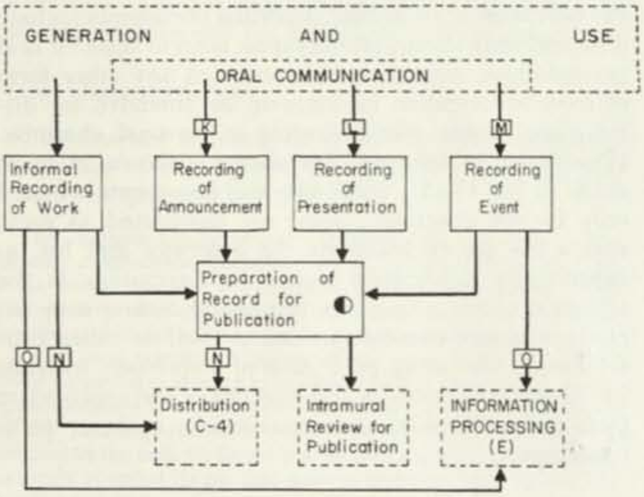

FIG. C-2A. Production of informal records.

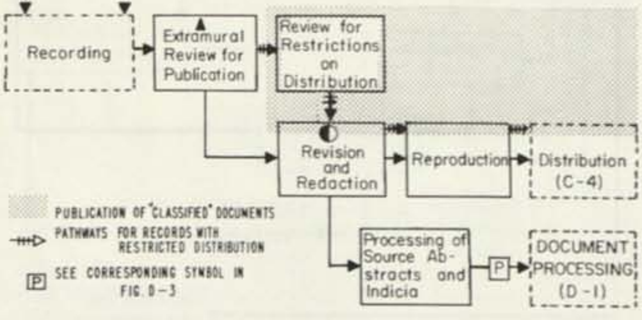

FIG. C-3. Publication.

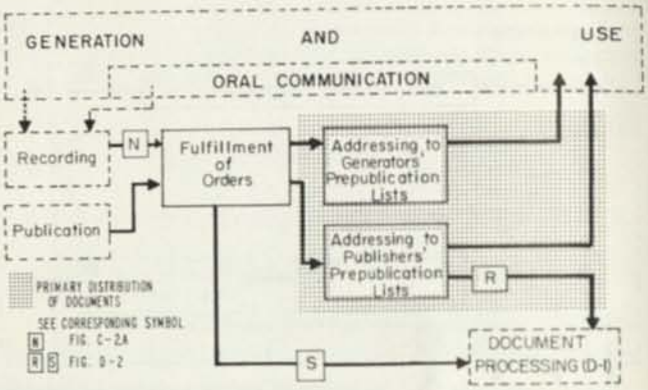

FIG. C-4. Distribution.

Production of informal records. Different types of informal documents created as by-products of formal oral communication are depicted in Fig. C-2A, together with those produced for other purposes. Although all the routes are not shown, any of these types of informal records may be distributed through administrative or personal channels. For example, a scientist may provide colleagues with his data sheets, with the abstract or notes for his oral presentation, or with a summary account of an event he has attended. If publication is contemplated, a certain amount of preparation is usual before committing the record to a definitive, intramural review. Drafts may be distributed to obtain opinions from local and distant colleagues, and feedback may modify successive drafts.

Publication

The operation of publication shown in Fig. C-3 converts informal documents, e.g., manuscripts, into forms suited for wide distribution and for storage and retrieval. We refer to the products of publication as formal documents. The manuscript is submitted for extramural review to a publisher (for a book), editorial board (journal article), or the agency that sponsored the work reported (technical report). For technical reports, this review includes a consideration of reasons for restricting distribution. If a report is classified for reasons of national security, all subsequent processes in the entire complex entail special precautions and special channels parallel to those for nonclassified reports. During revision and redaction, the form and content of the record is modified by feedback from publication processors, e.g., editorial reviewers and copy editors, to the generator. Multiple copies are then reproduced (printed, photocopied, etc.) for distribution.

Distribution

Figure C-4 analyzes the distribution of documents. For formal documents, the publisher, e.g., of a journal, fills prepublication orders for any copies that the generator (or his institution) distributes automatically to a standing list of colleagues or institutions, and that the publisher sends to a list of regular recipients, e.g., sub-

scribers to a journal. All such automatic, predetermined distribution may be termed primary distribution. Secondary distribution (arrow designated S) occurs in response to postpublication orders (requests) for a specific document, e.g., a reprint of a journal article, and is analyzed later as part of the document processing component. Informal documents (arrow designated N), though often given to only one recipient, e.g., a letter, may receive wider primary distribution by the generator. In addition, some secondary distribution of informal documents may occur to meet requests from those who have heard of the document in some way, often by word of mouth.

DOCUMENT PROCESSING

The major operations of document processing (document collection; analysis and announcement; and storage, retrieval, and delivery) are summarized in Fig. D-1 and analyzed in detail in Figs. D-2, D-3, and D-4. Both formal and informal documents are handled; however, conventional document processing services, e.g., libraries and abstracting-indexing services, usually consider informal documents having no historical value as "ephemera," and either discard them during the collection operation or store them without the extensive processing that formal documents receive. Other document processing activities, such as those represented by scientists' personal files and by specialized information evaluation services, may not make this distinction.

Document Collection

The processes in Fig. D-2 occur in building the small, personal collections of scientists as well as the extensive collections of great libraries. In acquiring documents by either primary or secondary distribution, quality-control decisions are usually made, i.e., the collector chooses to order only those documents considered likely to meet his quality standards. After receipt, a scientist collecting for his own use may discard a document if he finds that the information it contains, though relevant to his interests, is of poor quality. In large collections intended for many users, however, documents once ordered and received are usually retained unless they are obviously irrelevant or in a form not suited for subsequent processing. Decisions to discard documents are difficult for committees.

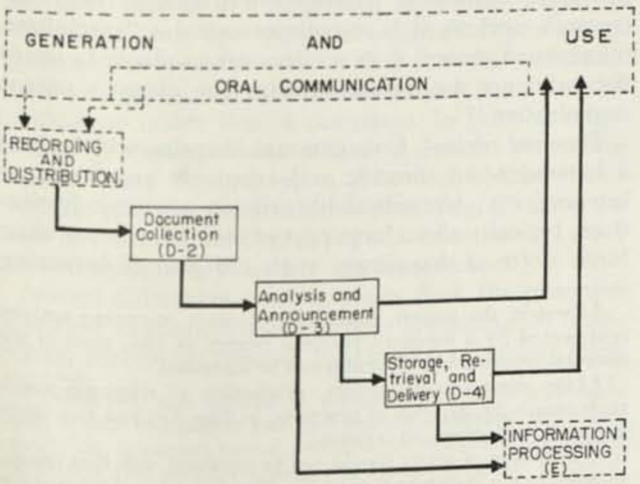

FIG. D-1. General scheme of document processing component.

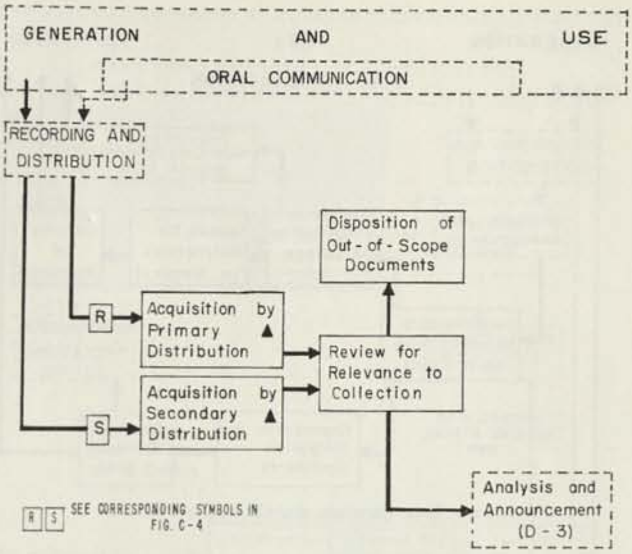

FIG. D-2. Document collection.

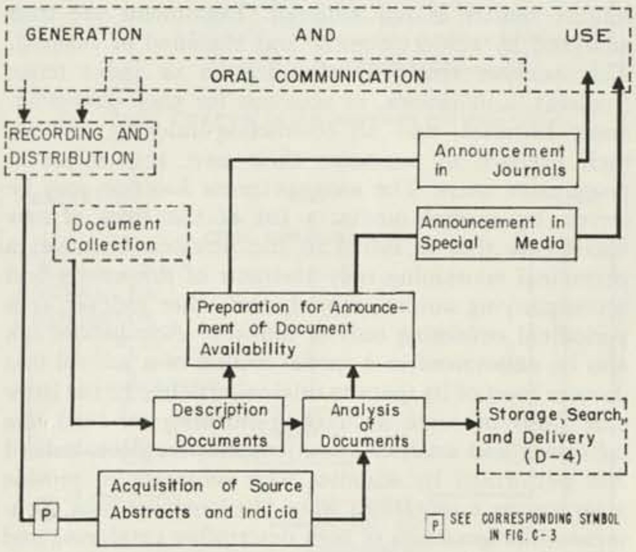

FIG. D-3. Analysis and announcement of documents.

Document Analysis and Announcement

As shown in Fig. D-3, analyzing documents and announcing their availability entails several processes. Before storage, in collections of any size, descriptions of the documents are usually recorded in terms of their physical form, issuing source, title, date, authors, etc. In libraries and document centers this process is called

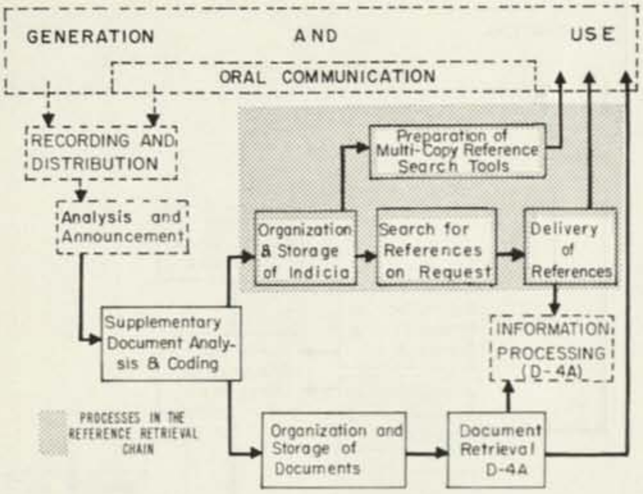

FIG. D-4. Storage, search, and retrieval.

descriptive cataloging and is essentially a "clerical" operation, in that an understanding of the documents' subject matter is not required. Documents are then analyzed by subject content and classified or indexed. This analysis results in classification or index terms (indicia), annotations, or abstracts for each document. Some libraries, and all abstracting-indexing services, then prepare to announce their new acquisitions to prospective users. The announcement function may be served by special media: a list of the titles of new documents that is issued to the service's clientele; a periodical containing only abstracts of documents and accompanying author, subject, and other indexes; or a periodical consisting only of indexes.[7] Acquisitions can also be announced in a special section of a journal that devotes most of its space to original articles. In the latter case (also in some abstracting-indexing services), the collection and analysis operations may be decentralized and performed by scientists who volunteer to provide abstracts or annotations when they receive new documents. The products of both descriptive cataloging and subject analysis are commonly used in announcement, e.g., *Index Medicus;* however, lists of documents prepared by permuting the words in their titles according to fixed rules (usually by computer), and copies of the tables of contents of journals, e.g., *Current Contents*, are examples of announcement by purely clerical processes. For any recorded announcement produced in multiple copies, the general processes required for publication and distribution, starting with revision and redaction, must take place (Figs. C-3 and C-4). Some documents are accompanied by "source" abstracts and indicia prepared either by the generator or by the publisher, e.g., journal articles prefaced by an abstract or synopsis. Source abstracts and indicia can also be acquired separately (input arrow designated P in Fig. D-3) by arrangement with the publisher, e.g., *Biological Abstracts* receives author abstracts on separate forms supplied to authors by cooperating journals.

Storage, Search, and Delivery

The operations of storage and retrieval, i.e., search and delivery of desired items on demand, are shown in Fig. D-4. Before storage, to insure efficient retrieval later, a more detailed subject analysis of the documents may be performed to supplement the analysis that sufficed for announcement purposes. Also the document descriptions and indicia may be coded or abbreviated. From here on, two processing chains exist in parallel: one stores document descriptions and indicia and retrieves, from this store, references, i.e., bibliographic descriptions of documents that may contain the information desired. The other chain stores the documents themselves and retrieves them once the desired references are specified. Any document processing activity or service must develop both chains to some degree,[8] but formal services usually devote more effort to one or the other.

Reference retrieval chain. Abstracting-indexing services concentrate on the reference retrieval chain. They prepare multiple-copy, reference search "tools," e.g., *Chemical Abstracts.*[9] Typically these services do not themselves maintain extensive stores of documents. Some specialized libraries, particularly those of industrial concerns engaged in research, develop their reference retrieval capabilities in narrow subject fields to a high degree. They supplement the standard reference search tools obtained from abstracting-indexing services with special tools produced by their own more detailed analysis of selected documents, which is tailored for their users. Such libraries also process informal documents, e.g., internal reports that are not handled by standard abstracting-indexing services. Their document collections are highly specialized and relatively small, and they must augment their document retrieval capabilities by calling on major, conventional libraries for loans or photocopies of documents. When a library builds an exhaustive or unique collection in a narrow field and provides outstanding reference retrieval services for research workers, it is sometimes called a "specialized information center" if its services are available to scientists who are not associated with the library's parent organization.[10]

Document retrieval. Conventional libraries, which serve a heterogeneous clientele and relatively broad subject interests, e.g., biomedical libraries in academic institutions, typically allot a large part of their effort to building large stores of documents, with the goal of becoming

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[7] A simple type of informal activity performing the function of announcement is one scientist telling another about an interesting document.

[8] Even in the modest, informal document processing activity represented by a scientist's personal library or files, most of the essential processes in both chains can be identified.

[9] Like announcement media, production of reference search tools entails the sequence of processes, in Figs. C-3 and C-4, starting with "redaction and revision."

[10] This type of center should not be confused with that recommended in the Weinberg Report (8). (See discussion of information processing, page 1139.)

more self-sufficient in providing their users with documents on demand. They purchase the standard reference search tools for journal literature from abstracting-indexing services rather than performing their own subject analysis of this type of document. Although most libraries undertake some descriptive cataloging and subject analysis of books, they also depend on the "ready-made" reference search tools for books that are produced by the large government libraries and by commercial services, e.g., the catalog cards distributed by the Library of Congress, the *National Library of Medicine Catalog*, and *Books in Print* (Bowker Co.). Document retrieval (see Fig. D-4A) employs search tools analogous to those for reference retrieval; given a reference, these tools indicate where the document referred to may be found. Library "shelf lists," which indicate the physical location of documents, are an example. Multiple copies of document retrieval tools may be produced; "union lists" of library holdings are prepared and published as regional or national efforts. These lists indicate which libraries have a given document and are used when a library wants to borrow a document that it does not have.

The secondary distribution of a document, i.e., delayed distribution to requestors who were not covered by the primary, or automatic, distribution of the document, depends on the document processing component in general, and on the document retrieval chain in particular. An activity or service that attempts to supply documents on request usually acquires and stores at least those in frequent demand. If the collection contains many different documents, storage must be organized for retrieval. The larger the collection and the more frequent and varied the requests, the more elaborate the operations of document processing become. In the large general library serving hundreds of research workers, the document retrieval chain must be highly developed.[11]

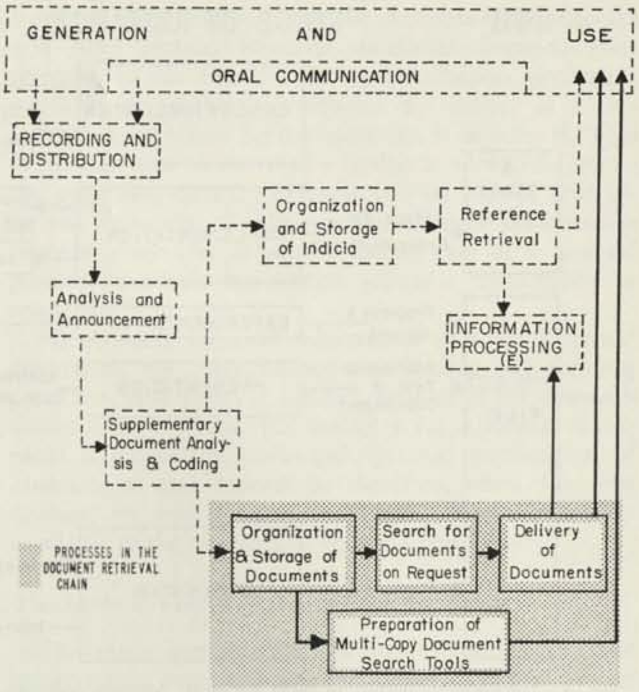

FIG. D-4A. Processes in the document retrieval chain.

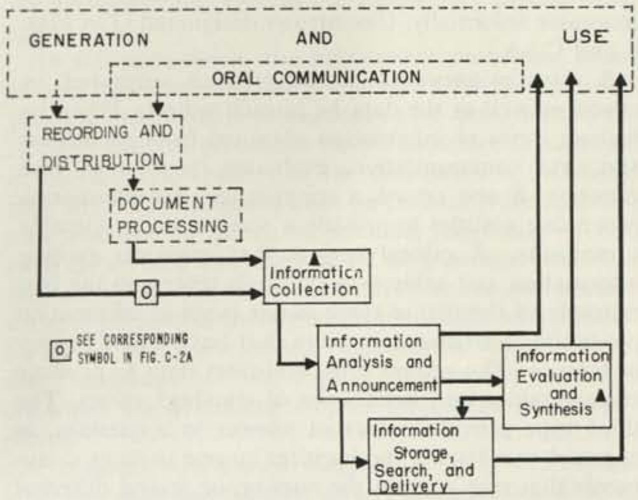

FIG. E. General scheme of information processing component.

INFORMATION PROCESSING

The function of information processing is to "metabolize" information and produce knowledge (11). It is, therefore, central to the growth of science. Figure E depicts the basic operations of information processing. Most of these operations are analogous to those of document processing, but the unit processed is an item of information rather than a document. In general, information processing starts where document processing leaves off and depends upon prior accomplishment of the basic operations of document processing. (Documents must be collected, analyzed, stored, and retrieved before the information they contain can be processed.)

Several differences exist, however. First, the processes of critical evaluation and synthesis are unique to information processing. Second, information processors must have the scientific background necessary to judge the quality and value of the information in a document, rather than having to depend completely on "screening" by subject-matter experts, such as is included, at least ideally, in producing formal documents (publication). Information processing services, therefore, can handle informal records and are less handicapped by the time lag inherent in publication. Third, an information processing service may itself record new scientific information rather than wait for scientists to produce and make available records of their work. For example, such a service may have an observer record oral presentations at scientific meetings, or may obtain oral data from a

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[11] Publishers, and individual scientists who order and store copies of their own papers and send reprints on request, represent, respectively, important formal and informal services for secondary distribution that perform basically the same document retrieval processes as libraries. Because the collections are relatively small, however, the store need not be elaborately organized.

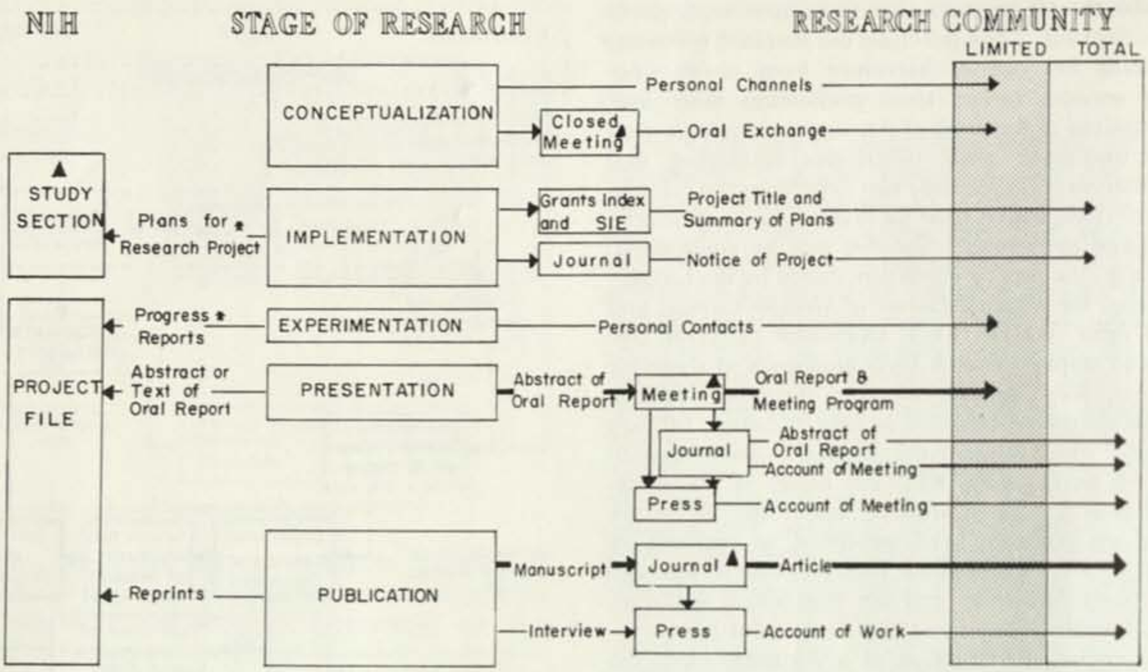

FIG. F. Information output of NIH projects. Asterisks indicate privileged channels. Thick arrows designate the more important channels carrying substantive reports of research results.

generator informally. (See arrows designated O in Figs. E and C-2A.)

A scientist processes the information generated by others as well as the data he himself collects. When he reviews items of information obtained from documents and oral communication, evaluates these items, and generates a new record, a scientist uses his information processing abilities to provide a service to the scientific community. A critical review that evaluates existing information and achieves a synthesis represents the best example of the first of three major types of information processing activities or services that have a long history in science. The second type evaluates data to produce critical tables and handbooks of standard values. The third type provides a factual answer to a question, as opposed to referring the inquirer to one or more documents that may contain the answer, or several different answers. Scientists have always answered colleagues' questions, using their own experience to sift available, often conflicting, information and arrive at the "best" answer; but until fairly recently, such an activity was not commonly formalized or "institutionalized" as a service capable of meeting a large volume of demands from a sizable group of research workers. Currently the trend is toward increasing numbers of institutionalized services that produce critical reviews, critical data compilations, and authoritative answers in specialized fields (8). Services that provide any or all of these products may be termed "specialized information evaluation services,"[12] to differentiate them from document processing services, such as conventional libraries, document centers, and other activities that do not involve evaluation and synthesis. Some, but not all, of the "specialized information services" that have recently been identified (4) qualify as information evaluation services.

During the process of information collection, documents are reviewed, and relevant information is extracted. Some services (e.g., the Cardiovascular Literature Project, which produces the *Index-Handbook of Cardiovascular Agents*) extract, analyze, and store items of information to produce multiple-copy, search tools that can be used for either reference or information retrieval, but leave it for the user to evaluate and synthesize the information he retrieves.[13] Such a service falls somewhere between the typical document processing services (those that concentrate on reference or document retrieval) and the specialized information evaluation centers.

QUALITY CONTROL AND CHANNEL LIMITATIONS

The major points at which the output of a typical project of the National Institutes of Health (NIH) may be subjected to quality control decisions, and the limitations of various output channels, are summarized in

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[12] Or centers, if the information processors are gathered in one location.

[13] In so far as an abstract may contain all the data or information needed to answer certain types of questions, without recourse to the source document, an abstracting publication can also be used for information retrieval. Information retrieval in this sense should not be confused with the more common usage of the term. One often hears of "information retrieval" machines, systems, and services that, more precisely, retrieve only references and/or documents.

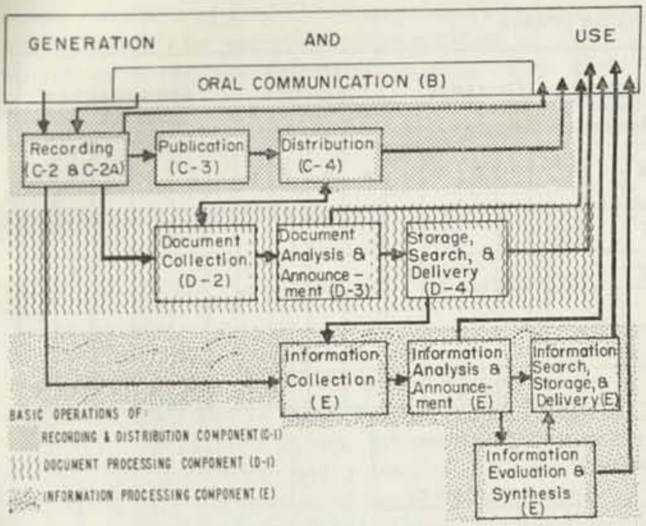

FIG. G. Recapitulation of major components and basic processes.

Fig. F. Administrative channels are shown on the left; major channels to the scientific community are on the right. NIH Study Sections exert quality control over the dissemination of information regarding a scientist's research plans, in that only approved projects are listed in the *NIH Research Grants Index* and disclosed by the Science Information Exchange (SIE) on inquiry. Quality control is exercised by the scientific community at three main points. First, when an investigator is formulating a project and wants to discuss his concepts and plans, he will not have the forum provided by small, closed meetings of leaders in his field unless he qualifies for inclusion in the group and is invited to their meetings. Second, his paper will not be accepted for presentation at a meeting unless the abstract he submits to the meeting planners fulfills their criteria for acceptable quality. Finally, a journal will not publish his manuscript if it does not measure up to the editorial board's standards. Some measure of quality control is exerted by most meeting planners[14] and most journals; however, with enough persistence, a scientist can usually find some meeting at which he can give his paper and some journal that will publish his manuscript. For each of the two main output channels (meetings and journals), therefore, the quality filter can be pictured as having holes of varying size that collectively pass almost all the material presented to them.

These three mechanisms for quality control, and the several others suggested in Figs. B, C-2, C-2A, C-3, and D-2, are not the only ones that maintain the quality of scientific messages flowing in the system over the long term. Two less direct and slower, but more effective, mechanisms operate before and after the messages are generated and initially distributed. First, by selecting and training new generators, the scientific community increases the likelihood that the messages they generate will meet certain minimal standards. Second, each scientist, in his capacity as an information processor, explicitly or implicitly evaluates the quality of a colleague's work when he comments on it or cites it. This evaluation acts as corrective feedback when relayed to the generator directly or indirectly by formal and informal channels. Evaluation by formal information processing services is only a special case of a general process in which the entire scientific community is engaged.

All channels for oral information and for informal documents, e.g., unpublished manuscripts and meeting programs, reach only a limited segment of the research community; whereas, the audience for a formal document is potentially unlimited. Journal publication of abstracts of oral reports is, therefore, often the first channel by which new information becomes widely available to the biomedical research community.

The System as Viewed by the User

The major components and basic operations of the entire system are recapitulated in Fig. G. Thus far the system's channels have been viewed only from the generation end. At this stage it is interesting to reverse the viewpoint and look at the system very briefly from the use end.

In this perspective, the information processing component is seen as using the products of all the other components. Information processing, as we have defined it, requires that the processors have substantive knowledge of the scientific content of the documents with which they work. Key processes must be performed by individuals who are the peers, in scientific judgment, of the clientele served, i.e., they must be scientists who are themselves active in research. Such scientists, who devote varying portions of their time to processing information for others, are the scientific "middlemen" described as the "backbone" of the type of information center[15] on which the Weinberg Report (8) placed great emphasis.

The model, which these diagrams of the system represent, also illustrates the rich variety of channels available to the user. To obtain the information he desires, a scientist may utilize the products of any or all of the four components. The system is highly redundant, but in a useful way. The information on a given subject carried by different channels varies in currency, quality, condensation, specificity, etc. He may choose the channel best suited for his individual needs and habits. His freedom of choice is, however, limited somewhat in that, at the time he wants it, the information may be available through only a few channels; and no one component can meet all of his needs. For example, if he wants to know what a colleague has done in the previous few months, he must usually rely on oral communication or on ac-

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[14] Limiting presentations at society meetings to members (or individuals sponsored by members) is a means of quality control if the members are selected for scientific achievement.

[15] In our terminology, such centers would be called specialized information evaluation centers (or services).

years, more rapidly than the number of biomedical scientists;[23] but any conclusions based on the inadequate data now available must be very tentative. Even the data on federal support are unreliable for assessing trends, since the methods used to obtain these data have been changing and the completeness with which agencies report expenditures for information activities has been increasing (3). However, trends in the over-all pattern of support are clear. As government sponsorship of biomedical research has grown to its present dominance, the operations of the biomedical information complex have become, in general, relatively more dependent on federal support and less dependent on user fees and academic institutions. All indications are that this shift is accelerating. If the system's users have, through direct payment of user fees, played an important role in managing the system, it would seem that a substitute for this control mechanism should be developed.

USES AND IMPLICATIONS OF MODEL

The model represented by the diagrams is crude and qualitative. It does, however, provide a framework for collecting data on volume of flow in the various channels, on time requirements for processing operations, and on manpower, money, etc. These data are required to develop the quantitative model that would seem to be one prerequisite for intelligent decisions on any long-term policies that may affect the operation of the entire system. Even in its present form, the model has a number of uses. Among those we have explored tentatively and found to be promising are:

1) To identify critical operations and activities where limited capacity may disrupt the functioning of whole components or of the entire system. When these points are identified, action can be directed toward overcoming the bottlenecks. For example, an analysis of document retrieval operations in biomedical libraries apparently indicates that the capacity of this chain is inadequate to handle the demands that will be generated by the rapid improvement in reference retrieval services now taking place (6).

2) To specify the type of processor required for different services. Once the operations are analyzed by processes, it is easier to determine which jobs are essentially clerical (hence potentially amenable to automation) and which require a high degree of subject-matter knowledge or other special qualifications (such as education in library techniques). Activities that cannot be delegated by biomedical scientists to others can also be identified. The model shows that, regardless of automation, any increase in information processing services will require additional scientific manpower. The anticipated returns must, therefore, be weighed against competing demands for this limited resource.

3) To determine where innovations may be advantageous and to predict their effects on other parts of the system. The model helps to predict the probable gross effects of an innovation on preceding or subsequent operations in the given processing sequence, or on operations in parallel chains. For example, the model calls attention to a major difficulty that arises when some, but not all, of the operations in the reference retrieval chain are automated. Greatly increased capacity for preparing reference search tools, such as printed indexes, will not result in commensurate improvement in the service provided by the entire chain unless the capacity for document analysis is correspondingly increased (see Figs. D-3 and D-4). The first operation has proved to be much more readily automated than the latter. Subject analysis of documents will remain, at least for the near future, an intellectual operation—one for which the present acute shortage of qualified personnel is unlikely to be remedied quickly unless new approaches are adopted, e.g., author indexing.

4) To assess mechanisms for coordinating components, operations, and activities. The performance of the system depends upon effective coordination of its parts. Certain formal mechanisms at present insure some degree of horizontal coordination among different organizations performing the same basic operations (e.g., for publication, the Conference of Biological Editors; for abstracting-indexing, the National Federation of Science Abstracting and Indexing Services). Mechanisms to effect coordination among the major functional components of the biomedical information complex, e.g., between generation-use and document processing, are largely nonexistent. However, the efforts of the Office of Science Information Service of the National Science Foundation to promote this type of vertical coordination in the larger science information complex are seen as an important influence on the biomedical system.

5) To provide a holistic perspective for examining the problems of biomedical communication. Only within the framework of the total complex can the relative importance of these problems be judged and sound decisions in allocating resources be made. Not until the quantitative aspects of the model are better developed can some of the major questions about the relative importance of various channels and operations be answered definitively; but from what is now known, it appears that the problems of reference retrieval have received a disproportionate share of attention and of the money and effort devoted to communication research and development.

Another use of the model, which does not lend itself to specific illustrative examples but could prove of major

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[23] Considering the annual cost of conducting hundreds of biomedical research meetings, of publishing some 1000 U.S. biomedical journals and several hundred books, of running scores of abstracting-indexing services that process biomedical literature, and of maintaining over 500 biomedical libraries and various other types of document or information processing services, an estimate of \$50 million for the cost of the biomedical information complex (about 6% of total U.S. expenditures for biomedical research) is obviously conservative. The total may well be twice this figure. Either estimate represents only operating expenses and not the capital investment. If the operating cost per research worker has not increased in recent years, it is an exception to the general trend of research costs.

importance for future improvement of the system, is to demonstrate to biomedical scientists how the biomedical information complex and each of its components are integral parts of their research effort; how they, as scientists, are now involved in all of the system's major operations; and why technologic advances, expanding budgets for information services, and larger numbers of highly trained "information specialists," will increase rather than decrease the system's dependence upon their active, informed participation in all of its basic processes.

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The biomedical information complex viewed as a system[1]

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Institute for Advancement of Medical Communication, Federation of American Societies for Experimental Biology, Bethesda, Maryland; Systems Engineering Department, Stanford Research Institute, Menlo Park, California; Division of Medical Sciences, National Academy of Sciences—National Research Council, Washington, D.C.; and Wayne State University School of Medicine, Detroit, Michigan

ORR, RICHARD H., GREGORY ABDIAN, CHARLES P. BOURNE, EDWIN B. COYL, ALICE A. LEEDS, AND VERN M. PINGS. *The biomedical information complex viewed as a system.* Federation Proc. 23(5): 1133–1145, 1964.—To aid in visualizing and understanding the heterogeneous aggregate of interdependent operations, activities, and services that handle the information generated by, and used in, biomedical research, this complex was analyzed as a system from a viewpoint of the functions it performs. The result was a qualitative model with the following major functional components: *1)* generation and use, *2)* oral communication, *3)* recording and distribution, *4)* document processing, *5)* information processing, and *6)* control. Between generation and use, the flow of information through components (*2*), (*3*), (*4*), and (*5*) depends upon parallel and sequential chains of processing operations. The operations of each component depend, in general, upon the prior accomplishment of the operations of the preceding component. The capacity of a given component is limited to that of its slowest operation except where alternative paths exist. The costs of operating this complex are met by government, private foundations, industry, academic institutions, and user fees for services (such as subscription fees). The present trend is toward increasing dependence on government support. This crude model can serve as a framework for collecting the data required to develop a quantitative model and is useful in considering the problems of biomedical communication, determining their relative importance, and assessing possible solutions.

A DYNAMIC COMPLEX of interrelated processes, operations, activities, and services handles the information that the community of biomedical scientists generates and uses. An understanding of how this complex functions would seem to be as essential for identifying and attacking the communication problems of the biomedical research community as a knowledge of physiology is for diagnosing and treating disease. This paper represents an attempt to describe and analyze the complex as a functioning whole.

APPROACH

The biomedical information complex can be considered a "system" in the same sense that a living organism is a system. Both have evolved in response to needs and both are self-organizing; neither system was designed. Approaching the complex as a system facilitates analysis of the basic functions performed by this heterogeneous and seemingly amorphous aggregate and aids in visualizing the processes that underlie its operation. The goals are those of physiologic research: to correlate structure with function and to understand dynamic and interdependent processes.

Broadly defined, a system is a bounded complex of elements—men, machines, or objects—interrelated by processes and responding to events to achieve an objective. In the case of the biomedical information complex, the generators and users of the information must be considered parts of the system, as well as the men and devices handling biomedical information between its generation and its use. The objects in this system are "documents" in the most general sense of the term, i.e., all records of information on paper, film, magnetic tape, or on other physical media. The system's immediate objective has been aptly stated by Shaw (9): "The end product . . . must be the information needed by and usable to each scientist, wherever he may be and whatever his needs may be at the moment." Its ultimate purpose is to further the accumulation and application of biomedical knowledge.

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ASSUMPTIONS

Analyses of dynamic, complex systems usually require the adoption of simplifying assumptions and viewpoints. In the present instance, several decisions facilitated the analysis. First, we elected to view the biomedical information complex as a separate system, although it is actually a part of a larger system that serves all of science. Second, we chose to follow only the more important channels for the flow of information through the complex and to emphasize the sequence of operations occurring between generation and use. Third, since the terminology usually applied to organizations, activities, services, and people engaged in handling information often obscures their common features, the system's operations were to be described largely by function, rather than by performer, using terms selected for generality and for freedom from unwanted associations. Last, although the complex handles two kinds of information, we concentrated on one. If information resulting from scientific observation, experimentation, and reasoning is called "scientific" information, then information about research (i.e., news about scientists, support, equipment, and supplies, or messages related to the administration of research) may be termed "parascientific" information. Here the concern is primarily with the flow of scientific information.

FORM OF PRESENTATION

Our analysis is presented chiefly as block diagrams. The value of this type of diagram in physiology was recently emphasized by Gray (2):

> The engineer has developed one device for enforcing an elementary rigorousness that is refreshingly simple and general. This is the block diagram, a qualitative mathematical model which conveniently displays, without distracting detail, all the components and variables of a system together with their circuitry. . . .
>
> On several occasions I have had the opportunity to watch a fellow physiologist attempt to represent in this simple form, and at this elementary level, the system on which he is an expert. He is usually flabbergasted to discover that his ready knowledge is unequal to the task. He finds he is uncertain about numerous items suddenly revealed for the first time to be of key importance. The usual result is a period of cerebration more intense, novel, and cogent than any he had previously accorded the system, punctuated by trips to the library to find answers to questions never before asked. If a workable diagram is eventually formulated, the light it sheds may be truly exciting. One can suddenly see physiological flesh and blood as a coherent, determinate, functioning system . . . .

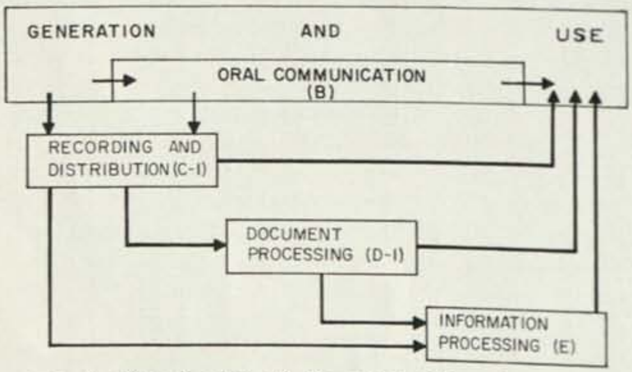

FIG. A. Over-all view of biomedical information complex. NOTE: In this and subsequent diagrams, the parenthetical letter-number combination in a box refers to another diagram that provides a further breakdown of the given operation.

We found this device to be equally valuable for studying the metabolism of biomedical information.

MAJOR FUNCTIONAL COMPONENTS OF THE SYSTEM

In Fig. A, five major functional components of the system are depicted:

1) Generation and Use—operations in which scientific information is generated and used, considered here as two phases of a single component.

2) Oral Communication—operations entailed in transmitting information orally.

3) Recording and Distribution—operations associated with the recording of scientific information and the distribution of the records thus produced.

4) Document Processing—operations performed in the collection; analysis and announcement; and the storage, retrieval, and delivery of information records (i.e., documents) after their production and initial distribution.

5) Information Processing—operations by which information is extracted from documents, evaluated, modified, or synthesized.

A sixth major functional component, which cannot be similarly depicted in this scheme, comprises the operations by which the system and its parts are controlled. Important operations related to system control and management are: *a*) maintaining the quality of "messages" handled by the system, *b*) improving the system, and *c*) supporting the system. Direct quality control is exercised in two ways—by evaluating the information in a message to see if it merits further processing and by improving the form or the content of a message. The more important points at which quality control is commonly exercised are identified in subsequent diagrams. Improving the system so that it functions more effectively and efficiently to achieve its immediate objective and ultimate purpose requires research on how the system works and development of improved methods for carrying out its various operations. Communication research and development cannot be localized in this scheme but will be covered briefly in the discussion of the system's support.

GENERATION AND USE

In Fig. A, the box labeled "generation and use" represents the thought processes of scientists engaged in biomedical research. These internal processes do not lend themselves to the approach of this analysis, and we have not attempted to analyze this component in detail.[3] The other components transmit information in the form

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[3] In Fig. G we do, however, suggest some general relations between successive stages in a research project and information generation and use.

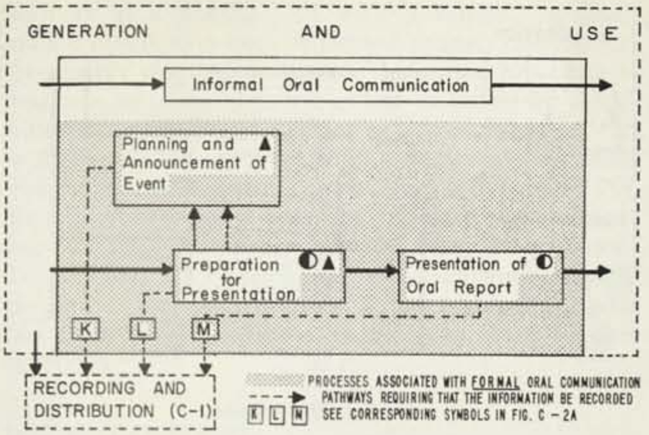

FIG. B. Formal and informal oral communication. NOTE: In this and subsequent diagrams, boxes with broken outlines and broken-line arrows represent, respectively, operations and processes that are outside the focus of the particular diagram. A small square enclosing a letter indicates that processes have been omitted to simplify the diagram and refers to the point in another diagram where the omitted processes are shown. Points at which quality control is commonly effected are designated by the following symbols: ▲ where a message may be evaluated and a yes-or-no decision made as to whether or not it will be processed further; ◐ where the content or form of the message may be modified by feedback from the generator's colleagues or from processors in the chain of operations required for transmission.

of unrecorded messages (oral communication), or of various physical records, from one scientist to another.

ORAL COMMUNICATION

The processes of formal and informal oral communication are analyzed in Fig. B. Informal oral communication comprises all face-to-face or telephone exchange other than that structured by the formalities of an "event" planned for oral communication, such as a scientific meeting, lecture, seminar, etc. The processes of formal oral communication include the planning and announcement of an oral communication event, as well as the activities of generators in preparing for and presenting oral reports. Quality control may be exercised during the planning of an event by selecting active participants (generators) on the basis of their past work or of an abstract of the oral report they wish to present. In most cases, some of the scientific information to be presented at the event is transmitted in oral or written form to the planners, who may incorporate this information in a written "announcement" of the event, e.g., as "abstracts"[6] in a meeting program (broken-line arrow designated K). In preparing to present an oral report, a scientist may have to get a decision from his institution as to whether his work is considered ready to be reported, and his presentation may be modified by feedback from institutional associates. Preparation for an oral presentation usually entails either making notes or writing out the full text. (The broken-line arrow designated L symbolizes these recording processes as well as that of preparing an abstract.) At the event, the presentations may be recorded (broken-line arrow designated M) verbatim or may be summarized by listeners who intend to give an oral or written account of the event later. Thus information transmitted by formal oral communication is recorded, in whole or part, by several routes, which will be covered in Fig. C-2A.

RECORDING AND DISTRIBUTION

Figure C-1 summarizes in broad terms the complete sequence of basic operations entailed in the recording of scientific information and the distribution of the records produced. Only channels within the specific focus of this diagram, i.e., those that are parts of this component, are shown. The details of processes required for recording, publication, and distribution are shown in Figs. C-2, C-3, and C-4, respectively.

Recording

The focus in Fig. C-2 is on the processes involved in the operation of recording. Informal documents include data and work sheets, photographs, notes or texts for oral presentations, manuscripts, letters, and any other form of recorded scientific information not intended for distribution outside administrative or personal channels. (Production of informal documents is shown in more detail in Fig. C-2A.) Some informal documents are used only by the generator; some are distributed as such; and a few are reviewed by the generator and his institution for publication and wide distribution to the scientific community. This intramural review may include a quality-control decision as well as other considerations, including protection of proprietary interests in industrial institutions and selection of the appropriate form for publication—a journal article, book, or technical report.

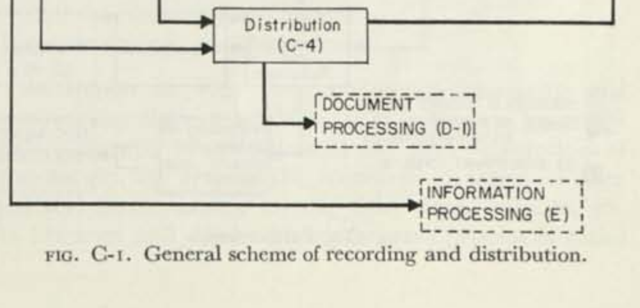

FIG. C-1. General scheme of recording and distribution.

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[6] Although commonly used in this sense, the term "abstract" is inappropriate and misleading, since the existence of a full report is implied. In reality, it usually represents only a summary of what the prospective speaker thinks he will say, or hopes he can say.

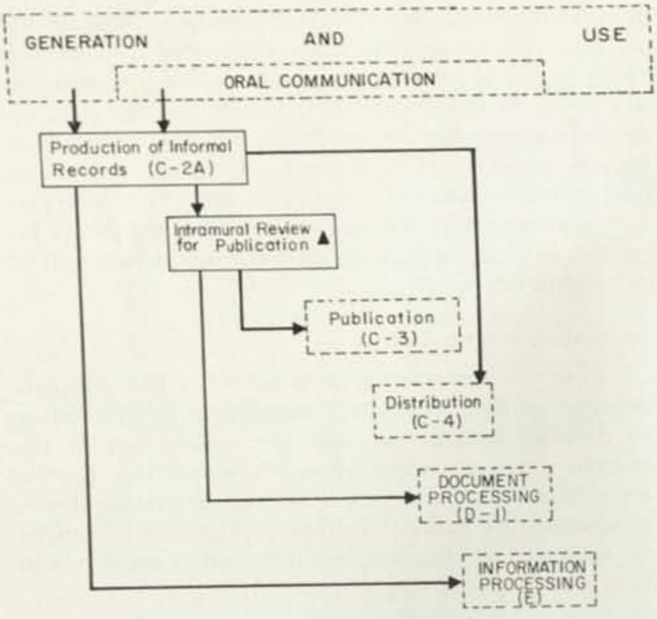

FIG. C-2. Recording.

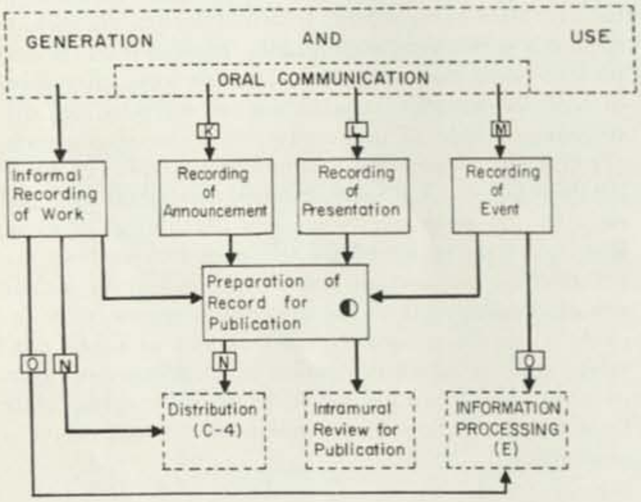

FIG. C-2A. Production of informal records.

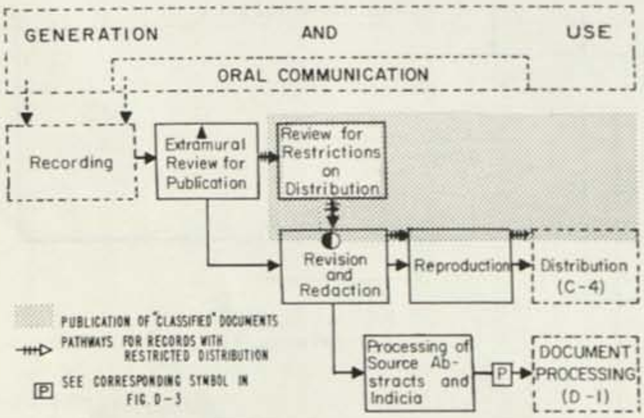

FIG. C-3. Publication.

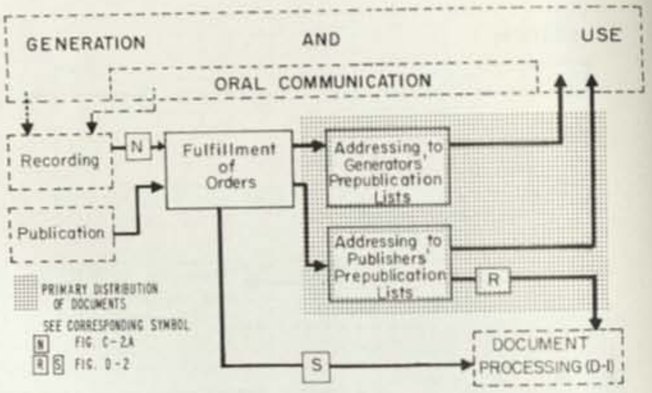

FIG. C-4. Distribution.

Production of informal records. Different types of informal documents created as by-products of formal oral communication are depicted in Fig. C-2A, together with those produced for other purposes. Although all the routes are not shown, any of these types of informal records may be distributed through administrative or personal channels. For example, a scientist may provide colleagues with his data sheets, with the abstract or notes for his oral presentation, or with a summary account of an event he has attended. If publication is contemplated, a certain amount of preparation is usual before committing the record to a definitive, intramural review. Drafts may be distributed to obtain opinions from local and distant colleagues, and feedback may modify successive drafts.

Publication

The operation of publication shown in Fig. C-3 converts informal documents, e.g., manuscripts, into forms suited for wide distribution and for storage and retrieval. We refer to the products of publication as formal documents. The manuscript is submitted for extramural review to a publisher (for a book), editorial board (journal article), or the agency that sponsored the work reported (technical report). For technical reports, this review includes a consideration of reasons for restricting distribution. If a report is classified for reasons of national security, all subsequent processes in the entire complex entail special precautions and special channels parallel to those for nonclassified reports. During revision and redaction, the form and content of the record is modified by feedback from publication processors, e.g., editorial reviewers and copy editors, to the generator. Multiple copies are then reproduced (printed, photocopied, etc.) for distribution.

Distribution

Figure C-4 analyzes the distribution of documents. For formal documents, the publisher, e.g., of a journal, fills prepublication orders for any copies that the generator (or his institution) distributes automatically to a standing list of colleagues or institutions, and that the publisher sends to a list of regular recipients, e.g., sub-

scribers to a journal. All such automatic, predetermined distribution may be termed primary distribution. Secondary distribution (arrow designated S) occurs in response to postpublication orders (requests) for a specific document, e.g., a reprint of a journal article, and is analyzed later as part of the document processing component. Informal documents (arrow designated N), though often given to only one recipient, e.g., a letter, may receive wider primary distribution by the generator. In addition, some secondary distribution of informal documents may occur to meet requests from those who have heard of the document in some way, often by word of mouth.

DOCUMENT PROCESSING

The major operations of document processing (document collection; analysis and announcement; and storage, retrieval, and delivery) are summarized in Fig. D-1 and analyzed in detail in Figs. D-2, D-3, and D-4. Both formal and informal documents are handled; however, conventional document processing services, e.g., libraries and abstracting-indexing services, usually consider informal documents having no historical value as "ephemera," and either discard them during the collection operation or store them without the extensive processing that formal documents receive. Other document processing activities, such as those represented by scientists' personal files and by specialized information evaluation services, may not make this distinction.

Document Collection

The processes in Fig. D-2 occur in building the small, personal collections of scientists as well as the extensive collections of great libraries. In acquiring documents by either primary or secondary distribution, quality-control decisions are usually made, i.e., the collector chooses to order only those documents considered likely to meet his quality standards. After receipt, a scientist collecting for his own use may discard a document if he finds that the information it contains, though relevant to his interests, is of poor quality. In large collections intended for many users, however, documents once ordered and received are usually retained unless they are obviously irrelevant or in a form not suited for subsequent processing. Decisions to discard documents are difficult for committees.

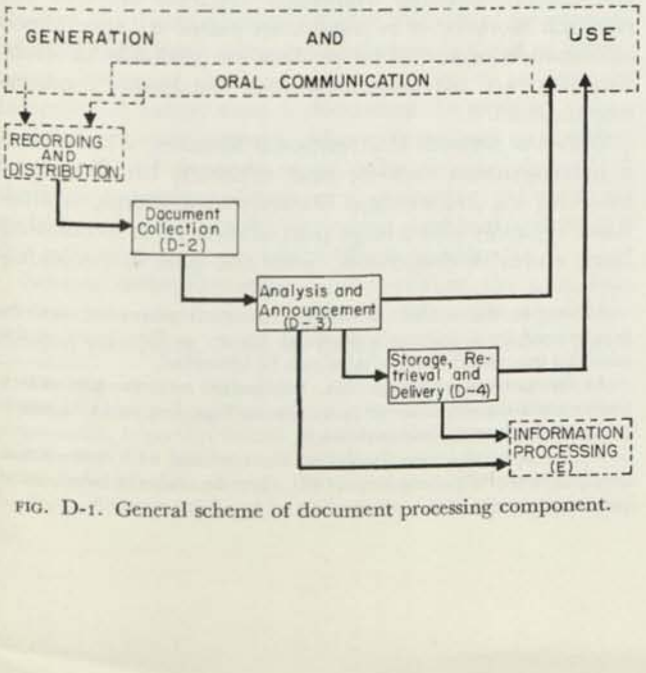

FIG. D-1. General scheme of document processing component.

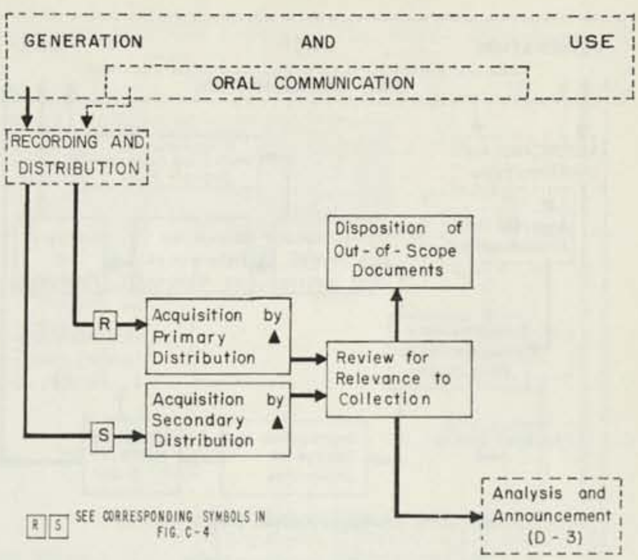

FIG. D-2. Document collection.

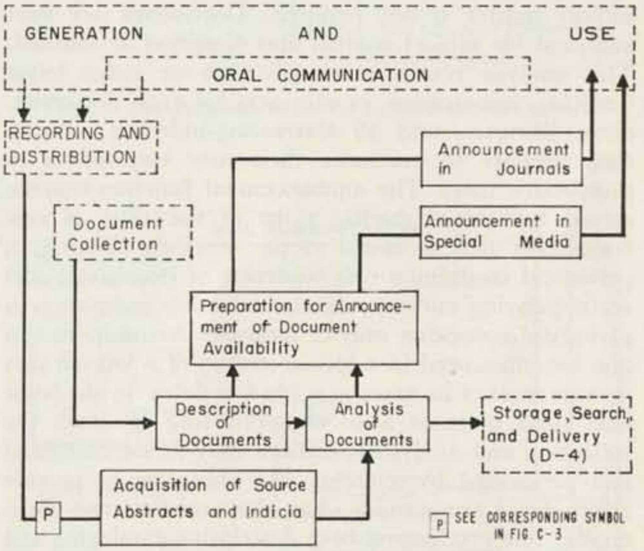

FIG. D-3. Analysis and announcement of documents.

Document Analysis and Announcement

As shown in Fig. D-3, analyzing documents and announcing their availability entails several processes. Before storage, in collections of any size, descriptions of the documents are usually recorded in terms of their physical form, issuing source, title, date, authors, etc. In libraries and document centers this process is called

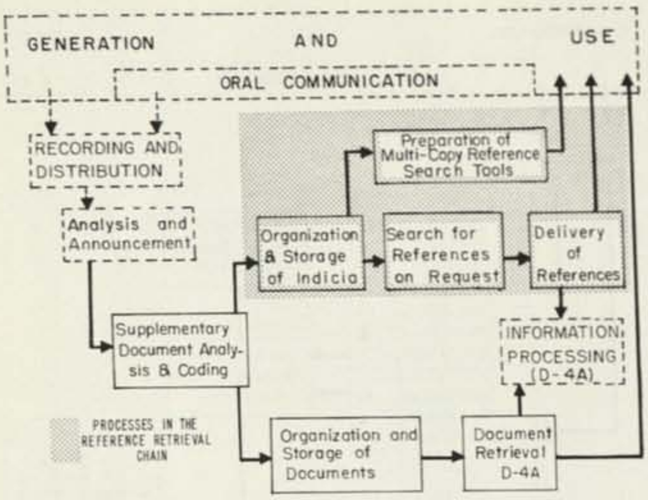

FIG. D-4. Storage, search, and retrieval.

descriptive cataloging and is essentially a "clerical" operation, in that an understanding of the documents' subject matter is not required. Documents are then analyzed by subject content and classified or indexed. This analysis results in classification or index terms (indicia), annotations, or abstracts for each document. Some libraries, and all abstracting-indexing services, then prepare to announce their new acquisitions to prospective users. The announcement function may be served by special media: a list of the titles of new documents that is issued to the service's clientele; a periodical containing only abstracts of documents and accompanying author, subject, and other indexes; or a periodical consisting only of indexes.[7] Acquisitions can also be announced in a special section of a journal that devotes most of its space to original articles. In the latter case (also in some abstracting-indexing services), the collection and analysis operations may be decentralized and performed by scientists who volunteer to provide abstracts or annotations when they receive new documents. The products of both descriptive cataloging and subject analysis are commonly used in announcement, e.g., *Index Medicus;* however, lists of documents prepared by permuting the words in their titles according to fixed rules (usually by computer), and copies of the tables of contents of journals, e.g., *Current Contents*, are examples of announcement by purely clerical processes. For any recorded announcement produced in multiple copies, the general processes required for publication and distribution, starting with revision and redaction, must take place (Figs. C-3 and C-4). Some documents are accompanied by "source" abstracts and indicia prepared either by the generator or by the publisher, e.g., journal articles prefaced by an abstract or synopsis. Source abstracts and indicia can also be acquired separately (input arrow designated P in Fig. D-3) by arrangement with the publisher, e.g., *Biological Abstracts* receives author abstracts on separate forms supplied to authors by cooperating journals.

Storage, Search, and Delivery

The operations of storage and retrieval, i.e., search and delivery of desired items on demand, are shown in Fig. D-4. Before storage, to insure efficient retrieval later, a more detailed subject analysis of the documents may be performed to supplement the analysis that sufficed for announcement purposes. Also the document descriptions and indicia may be coded or abbreviated. From here on, two processing chains exist in parallel: one stores document descriptions and indicia and retrieves, from this store, references, i.e., bibliographic descriptions of documents that may contain the information desired. The other chain stores the documents themselves and retrieves them once the desired references are specified. Any document processing activity or service must develop both chains to some degree,[8] but formal services usually devote more effort to one or the other.

Reference retrieval chain. Abstracting-indexing services concentrate on the reference retrieval chain. They prepare multiple-copy, reference search "tools," e.g., *Chemical Abstracts.*[9] Typically these services do not themselves maintain extensive stores of documents. Some specialized libraries, particularly those of industrial concerns engaged in research, develop their reference retrieval capabilities in narrow subject fields to a high degree. They supplement the standard reference search tools obtained from abstracting-indexing services with special tools produced by their own more detailed analysis of selected documents, which is tailored for their users. Such libraries also process informal documents, e.g., internal reports that are not handled by standard abstracting-indexing services. Their document collections are highly specialized and relatively small, and they must augment their document retrieval capabilities by calling on major, conventional libraries for loans or photocopies of documents. When a library builds an exhaustive or unique collection in a narrow field and provides outstanding reference retrieval services for research workers, it is sometimes called a "specialized information center" if its services are available to scientists who are not associated with the library's parent organization.[10]

Document retrieval. Conventional libraries, which serve a heterogeneous clientele and relatively broad subject interests, e.g., biomedical libraries in academic institutions, typically allot a large part of their effort to building large stores of documents, with the goal of becoming

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[7] A simple type of informal activity performing the function of announcement is one scientist telling another about an interesting document.

[8] Even in the modest, informal document processing activity represented by a scientist's personal library or files, most of the essential processes in both chains can be identified.

[9] Like announcement media, production of reference search tools entails the sequence of processes, in Figs. C-3 and C-4, starting with "redaction and revision."

[10] This type of center should not be confused with that recommended in the Weinberg Report (8). (See discussion of information processing, page 1139.)

more self-sufficient in providing their users with documents on demand. They purchase the standard reference search tools for journal literature from abstracting-indexing services rather than performing their own subject analysis of this type of document. Although most libraries undertake some descriptive cataloging and subject analysis of books, they also depend on the "ready-made" reference search tools for books that are produced by the large government libraries and by commercial services, e.g., the catalog cards distributed by the Library of Congress, the *National Library of Medicine Catalog*, and *Books in Print* (Bowker Co.). Document retrieval (see Fig. D-4A) employs search tools analogous to those for reference retrieval; given a reference, these tools indicate where the document referred to may be found. Library "shelf lists," which indicate the physical location of documents, are an example. Multiple copies of document retrieval tools may be produced; "union lists" of library holdings are prepared and published as regional or national efforts. These lists indicate which libraries have a given document and are used when a library wants to borrow a document that it does not have.

The secondary distribution of a document, i.e., delayed distribution to requestors who were not covered by the primary, or automatic, distribution of the document, depends on the document processing component in general, and on the document retrieval chain in particular. An activity or service that attempts to supply documents on request usually acquires and stores at least those in frequent demand. If the collection contains many different documents, storage must be organized for retrieval. The larger the collection and the more frequent and varied the requests, the more elaborate the operations of document processing become. In the large general library serving hundreds of research workers, the document retrieval chain must be highly developed.[11]

INFORMATION PROCESSING

The function of information processing is to "metabolize" information and produce knowledge (11). It is, therefore, central to the growth of science. Figure E depicts the basic operations of information processing. Most of these operations are analogous to those of document processing, but the unit processed is an item of information rather than a document. In general, information processing starts where document processing leaves off and depends upon prior accomplishment of the basic operations of document processing. (Documents must be collected, analyzed, stored, and retrieved before the information they contain can be processed.)

Several differences exist, however. First, the processes of critical evaluation and synthesis are unique to information processing. Second, information processors must have the scientific background necessary to judge the quality and value of the information in a document, rather than having to depend completely on "screening" by subject-matter experts, such as is included, at least ideally, in producing formal documents (publication). Information processing services, therefore, can handle informal records and are less handicapped by the time lag inherent in publication. Third, an information processing service may itself record new scientific information rather than wait for scientists to produce and make available records of their work. For example, such a service may have an observer record oral presentations at scientific meetings, or may obtain oral data from a

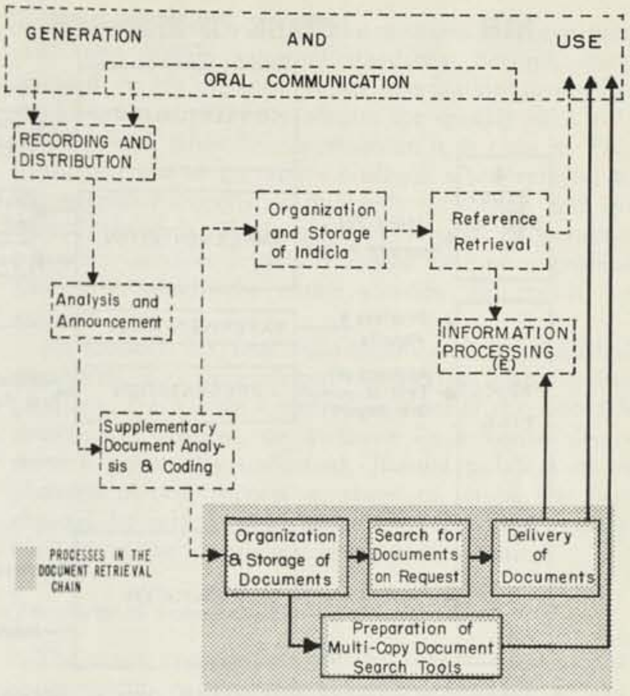

FIG. D-4A. Processes in the document retrieval chain.

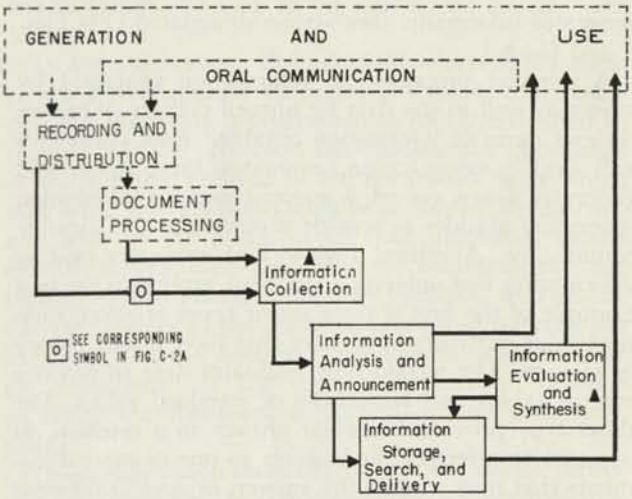

FIG. E. General scheme of information processing component.

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[11] Publishers, and individual scientists who order and store copies of their own papers and send reprints on request, represent, respectively, important formal and informal services for secondary distribution that perform basically the same document retrieval processes as libraries. Because the collections are relatively small, however, the store need not be elaborately organized.

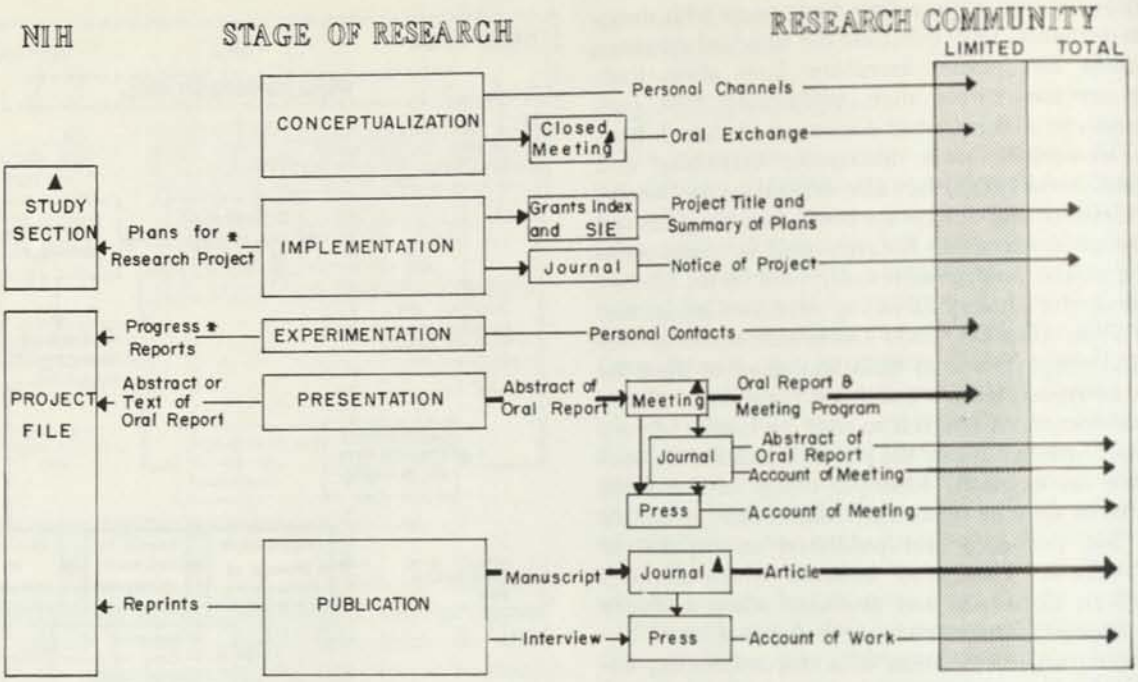

FIG. F. Information output of NIH projects. Asterisks indicate privileged channels. Thick arrows designate the more important channels carrying substantive reports of research results.

generator informally. (See arrows designated O in Figs. E and C-2A.)

A scientist processes the information generated by others as well as the data he himself collects. When he reviews items of information obtained from documents and oral communication, evaluates these items, and generates a new record, a scientist uses his information processing abilities to provide a service to the scientific community. A critical review that evaluates existing information and achieves a synthesis represents the best example of the first of three major types of information processing activities or services that have a long history in science. The second type evaluates data to produce critical tables and handbooks of standard values. The third type provides a factual answer to a question, as opposed to referring the inquirer to one or more documents that may contain the answer, or several different answers. Scientists have always answered colleagues' questions, using their own experience to sift available, often conflicting, information and arrive at the "best" answer; but until fairly recently, such an activity was not commonly formalized or "institutionalized" as a service capable of meeting a large volume of demands from a sizable group of research workers. Currently the trend is toward increasing numbers of institutionalized services that produce critical reviews, critical data compilations, and authoritative answers in specialized fields (8). Services that provide any or all of these products may be termed "specialized information evaluation services,"[12] to differentiate them from document processing services, such as conventional libraries, document centers, and other activities that do not involve evaluation and synthesis. Some, but not all, of the "specialized information services" that have recently been identified (4) qualify as information evaluation services.

During the process of information collection, documents are reviewed, and relevant information is extracted. Some services (e.g., the Cardiovascular Literature Project, which produces the *Index-Handbook of Cardiovascular Agents*) extract, analyze, and store items of information to produce multiple-copy, search tools that can be used for either reference or information retrieval, but leave it for the user to evaluate and synthesize the information he retrieves.[13] Such a service falls somewhere between the typical document processing services (those that concentrate on reference or document retrieval) and the specialized information evaluation centers.

QUALITY CONTROL AND CHANNEL LIMITATIONS

The major points at which the output of a typical project of the National Institutes of Health (NIH) may be subjected to quality control decisions, and the limitations of various output channels, are summarized in

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[12] Or centers, if the information processors are gathered in one location.

[13] In so far as an abstract may contain all the data or information needed to answer certain types of questions, without recourse to the source document, an abstracting publication can also be used for information retrieval. Information retrieval in this sense should not be confused with the more common usage of the term. One often hears of "information retrieval" machines, systems, and services that, more precisely, retrieve only references and/or documents.

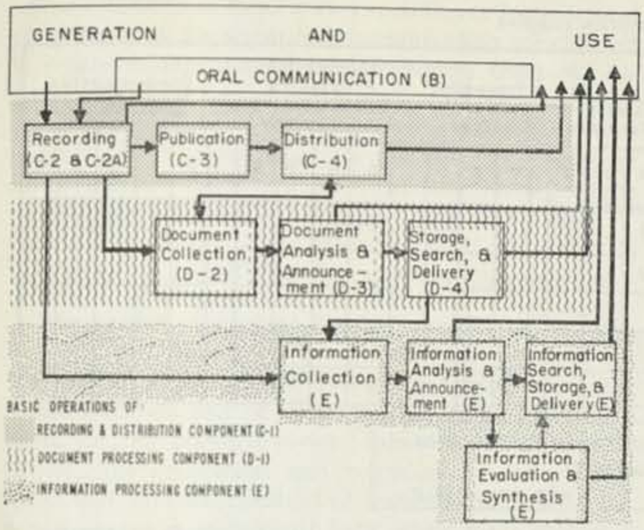

FIG. G. Recapitulation of major components and basic processes.

Fig. F. Administrative channels are shown on the left; major channels to the scientific community are on the right. NIH Study Sections exert quality control over the dissemination of information regarding a scientist's research plans, in that only approved projects are listed in the *NIH Research Grants Index* and disclosed by the Science Information Exchange (SIE) on inquiry. Quality control is exercised by the scientific community at three main points. First, when an investigator is formulating a project and wants to discuss his concepts and plans, he will not have the forum provided by small, closed meetings of leaders in his field unless he qualifies for inclusion in the group and is invited to their meetings. Second, his paper will not be accepted for presentation at a meeting unless the abstract he submits to the meeting planners fulfills their criteria for acceptable quality. Finally, a journal will not publish his manuscript if it does not measure up to the editorial board's standards. Some measure of quality control is exerted by most meeting planners[14] and most journals; however, with enough persistence, a scientist can usually find some meeting at which he can give his paper and some journal that will publish his manuscript. For each of the two main output channels (meetings and journals), therefore, the quality filter can be pictured as having holes of varying size that collectively pass almost all the material presented to them.

These three mechanisms for quality control, and the several others suggested in Figs. B, C-2, C-2A, C-3, and D-2, are not the only ones that maintain the quality of scientific messages flowing in the system over the long term. Two less direct and slower, but more effective, mechanisms operate before and after the messages are generated and initially distributed. First, by selecting and training new generators, the scientific community increases the likelihood that the messages they generate will meet certain minimal standards. Second, each scientist, in his capacity as an information processor, explicitly or implicitly evaluates the quality of a colleague's work when he comments on it or cites it. This evaluation acts as corrective feedback when relayed to the generator directly or indirectly by formal and informal channels. Evaluation by formal information processing services is only a special case of a general process in which the entire scientific community is engaged.

All channels for oral information and for informal documents, e.g., unpublished manuscripts and meeting programs, reach only a limited segment of the research community; whereas, the audience for a formal document is potentially unlimited. Journal publication of abstracts of oral reports is, therefore, often the first channel by which new information becomes widely available to the biomedical research community.

The System as Viewed by the User

The major components and basic operations of the entire system are recapitulated in Fig. G. Thus far the system's channels have been viewed only from the generation end. At this stage it is interesting to reverse the viewpoint and look at the system very briefly from the use end.

In this perspective, the information processing component is seen as using the products of all the other components. Information processing, as we have defined it, requires that the processors have substantive knowledge of the scientific content of the documents with which they work. Key processes must be performed by individuals who are the peers, in scientific judgment, of the clientele served, i.e., they must be scientists who are themselves active in research. Such scientists, who devote varying portions of their time to processing information for others, are the scientific "middlemen" described as the "backbone" of the type of information center[15] on which the Weinberg Report (8) placed great emphasis.

The model, which these diagrams of the system represent, also illustrates the rich variety of channels available to the user. To obtain the information he desires, a scientist may utilize the products of any or all of the four components. The system is highly redundant, but in a useful way. The information on a given subject carried by different channels varies in currency, quality, condensation, specificity, etc. He may choose the channel best suited for his individual needs and habits. His freedom of choice is, however, limited somewhat in that, at the time he wants it, the information may be available through only a few channels; and no one component can meet all of his needs. For example, if he wants to know what a colleague has done in the previous few months, he must usually rely on oral communication or on ac-

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[14] Limiting presentations at society meetings to members (or individuals sponsored by members) is a means of quality control if the members are selected for scientific achievement.

[15] In our terminology, such centers would be called specialized information evaluation centers (or services).

TABLE 1. *Performance and support of functions of biomedical information complex*

		Generation plus Recording			Oral Communication (Formal only)		Publication and Distribution		Document Processing*						Information Processing (Extramural † services only)				Communication Research and Development				
									Local Services			General Services											
	PERFORMING ORGANIZATION	A	I	G	A	P	P	C	A	I	G	P	C	G	A	G	P	C	A	I	G	P	C
SOURCE OF SUPPORT	Government (G)	▨	≀≀≀	▨	▨	≀≀≀	≀≀≀	?	?		▨	≀≀≀		▨	▨	▨	≀≀≀	?	▨	≀≀≀	▨	▨	▨
	Foundations ‡	≀≀≀			≀≀≀	≀≀≀	?		?										≀≀≀			?	?
	Industry (I)	≀≀≀	▨		≀≀≀	≀≀≀				▨										▨			
	Academic (A)	≀≀≀			≀≀≀				▨								≀≀≀						
	User Fees §	X	X	X	≀≀≀	▨	▨	▨				▨	▨		?		▨	▨	X	X	X	X	X

▨ PRIMARY SOURCE OF SUPPORT FOR GIVEN TYPE OF PERFORMING ORGANIZATION
≀≀≀ SECONDARY SOURCE (PROBABLY > 10% OF TOTAL SUPPORT)
? POSSIBLY QUALIFIES AS SECONDARY SOURCE
X NOT APPLICABLE

A = Academic institutions and nonprofit research organizations. I = Biomedical industrial organizations, principally pharmaceutical companies. G = Federal Government. P = Professional societies. C = Commercial organizations: publishers, information services, and companies performing contract research and development in scientific communication. * "Local" services are those intended primarily for local biomedical communities, e.g., institutional libraries; whereas, "general" services are for the entire biomedical community, e.g., abstracting-indexing services, National Library of Medicine, etc. † e.g., Psychopharmacology Service Center of National Institute of Mental Health, review publications, handbooks of biological data, etc. ‡ Includes voluntary health associations. § Subscriptions, meeting registration fees, membership dues, and other direct charges on users of information services.

quiring informal documents by correspondence, since a time lag is inherent in the production of the formal records handled by document processing services. If all he wants is a simple answer to a specific, but unusual, question, such as "What is the LD_{50} dose of morphine for salamanders?", it is unlikely he will find an information processing service that can quickly meet his need from its data compilations. He will probably have to try the document processing services and attempt to find the answer somewhere in the documents they will supply. Finally, he may find that, with a reasonable expenditure of time and effort on his part, the system will not be able to supply this information. In which case, if the information is important to his work, he may decide to establish the dosage himself by experiment.

THE SYSTEM'S SUPPORT

Table 1 presents a rough and tentative estimate of the relative importance of the different sources from which the system draws support. The data required for a definitive assessment are not available. This analysis is in terms of immediate, rather than ultimate, sources of funds, e.g., although scientists may use federal grant funds to pay for journal subscriptions, the immediate source of support is classified here as "user fees."

Federal Support

In recent years data on expenditures by federal agencies for scientific communication have improved. It is now possible to get some idea of the federal contribution to the support of the scientific information complex. For fiscal 1963, total federal obligations for scientific and technical information activities amounted to some $125 million (3).[16] About 40 of the $125 million went to private organizations (including commercial corporations) as direct support for information services and activities. The Public Health Service alone provided almost $7 million for "extramural" information services performed by private organizations. (Expenditures for "intramural" information activities of the Public Health Service were around $15 million.) Of this $7 million, approximately 15% went for activities we have classified as formal oral communication, 12% for publication and distribution, 46% to document and information processing, and 28% to research and development in scientific communication. An unknown but significant proportion of certain other federal agencies'[17] intramural and extramural expenditures on scientific information activities also represents direct support of the biomedical information complex. Their contribution to support of the biomedical complex is probably of greatest relative importance in the area of research and development in scientific communication, where many of the findings apply generally to all fields of science.

Other Sources of Support

Data on sources of support other than the Federal Government are largely lacking, and the various pub-

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[16] This figure does not include research grant or contract funds that were used by grantees or contractors for information services, e.g., to attend meetings or to purchase journals. It represents only the readily identifiable portion of the Federal Government's financial contribution as an immediate source of support and is known to be a low estimate.

[17] Agencies sponsoring considerable amounts of biomedical research, such as the Atomic Energy Commission, National Science Foundation, Office of Vocational Rehabilitation, Department of Agriculture, National Aeronautics and Space Administration, and Department of Defense.

lished estimates of total U.S. expenditures (private and governmental) for scientific communication are difficult to relate to the biomedical information complex. Although the total cost of each or all of the system's components is not known precisely,[18] it is possible to rank roughly the relative importance of different sources of support for the major types of organizations that perform the system's functions.

Support for Generation, Recording, and Oral Communication

The pattern of support for the operations of generation and recording is, of course, identical with that for biomedical research itself. The support pattern for oral communication can be assessed only for its formal aspects, i.e., for planned events; informal oral communication, like generation and recording, is inextricably associated with the conduct of research. At present, for ad hoc research meetings[19] held under the auspices of academic or professional organizations, the major source of support is probably federal funds; whereas, for regularly scheduled meetings of professional organizations, registration charges (user fees) are still the major source.[20]

Publication and Distribution

The Federal Government supports the operations of publication and distribution directly by subsidies to publishers and, more recently, by paying page charges levied by journals on authors. Although page charges by commercial publishers of journals are not generally allowable as direct costs on government grants and contracts (10), publishing companies receive some federal support as subsidies for publication of proceedings and as charges for excess illustrations, tables, etc., paid from research grants and contracts. Industry contributes primarily by buying advertising space in journals.

Document Processing

At present, the operations of "local" document processing services (primarily institutional libraries) are not receiving direct federal subsidy; but an unknown proportion of overhead funds on research grants and contracts is used to support these services. Although the percentage of overhead funds allotted by research institutions to their libraries may be small, the total contribution from this source may well cover a significant fraction of the total operating costs of academic libraries. Industrial and academic institutions contribute importantly to supporting the "general" document processing services (in particular, abstracting-indexing services) through the payment of subscription fees.[21] Institutional subscriptions account for most of the subscription revenue of the more expensive services. Although not depicted in the system diagrams, translation activities may be considered a special type of document processing. Both the Federal Government and industry currently spend large sums for translations provided by professional societies and commercial services.

Support for Information Processing

A recent compilation (4) lists approximately 50 U.S. services that may meet our criteria for biomedical information processing services, or specialized information evaluation centers. About half are associated with academic institutions or professional organizations. It is obvious, from the descriptions given in this compilation, that most of the 50 services are actually by-products of intramural research programs and are not supported primarily for providing service to scientists not affiliated with the parent organization, although such extramural services are provided to the extent possible. Not included in the compilation are biomedical review publications issued by professional societies and commercial publishers, and services that are strictly intramural, as are most pharmaceutical company services.

Support for Communication Research and Development

Private and governmental support for research and development aimed at improving scientific communication may currently total as much as $25 million a year (12). The result of much of this work is directly or indirectly relevant to the biomedical information complex. The Federal Government seems to be the major source of support for work of this type, other than that undertaken by industrial concerns, many of which have embarked on major programs to improve their intramural information services. In fiscal 1963, about $12 million were expended by Federal agencies for such research and development (3). The major sponsors were: Department of Commerce ($1.6 million), Department of Health, Education, and Welfare ($2.8 million), Department of Defense ($3.8 million), and National Science Foundation ($2.7 million). With the exception of the Council on Library Resources,[22] which was set up expressly to support the development of better information services, private foundations apparently provide relatively little support for communication research, at least in the area of scientist-to-scientist communication.

Trends in Support Patterns

The annual cost of operating the entire biomedical information complex has probably increased, in recent

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[18] Cost estimates for certain operations of the complex have been reported (5, 6, 7).

[19] Convened for a purpose that can be served by one meeting, or a short series of meetings.

[20] Only the costs to the performing organization (i.e., the organization arranging and conducting the meeting) are being considered here, not travel expenses borne by the participants.

[21] Current subscription rates for *Chemical Abstracts* are $500 for ACS members and educational institutions, and $1000 for all others; for *Biological Abstracts*, $260 for individuals and nonprofit educational institutions, and $325 for others.

[22] In fiscal 1963, the Council spent almost $1 million on such projects (1).

years, more rapidly than the number of biomedical scientists;[23] but any conclusions based on the inadequate data now available must be very tentative. Even the data on federal support are unreliable for assessing trends, since the methods used to obtain these data have been changing and the completeness with which agencies report expenditures for information activities has been increasing (3). However, trends in the over-all pattern of support are clear. As government sponsorship of biomedical research has grown to its present dominance, the operations of the biomedical information complex have become, in general, relatively more dependent on federal support and less dependent on user fees and academic institutions. All indications are that this shift is accelerating. If the system's users have, through direct payment of user fees, played an important role in managing the system, it would seem that a substitute for this control mechanism should be developed.

USES AND IMPLICATIONS OF MODEL

The model represented by the diagrams is crude and qualitative. It does, however, provide a framework for collecting data on volume of flow in the various channels, on time requirements for processing operations, and on manpower, money, etc. These data are required to develop the quantitative model that would seem to be one prerequisite for intelligent decisions on any long-term policies that may affect the operation of the entire system. Even in its present form, the model has a number of uses. Among those we have explored tentatively and found to be promising are:

1) To identify critical operations and activities where limited capacity may disrupt the functioning of whole components or of the entire system. When these points are identified, action can be directed toward overcoming the bottlenecks. For example, an analysis of document retrieval operations in biomedical libraries apparently indicates that the capacity of this chain is inadequate to handle the demands that will be generated by the rapid improvement in reference retrieval services now taking place (6).

2) To specify the type of processor required for different services. Once the operations are analyzed by processes, it is easier to determine which jobs are essentially clerical (hence potentially amenable to automation) and which require a high degree of subject-matter knowledge or other special qualifications (such as education in library techniques). Activities that cannot be delegated by biomedical scientists to others can also be identified. The model shows that, regardless of automation, any increase in information processing services will require additional scientific manpower. The anticipated returns must, therefore, be weighed against competing demands for this limited resource.

3) To determine where innovations may be advantageous and to predict their effects on other parts of the system. The model helps to predict the probable gross effects of an innovation on preceding or subsequent operations in the given processing sequence, or on operations in parallel chains. For example, the model calls attention to a major difficulty that arises when some, but not all, of the operations in the reference retrieval chain are automated. Greatly increased capacity for preparing reference search tools, such as printed indexes, will not result in commensurate improvement in the service provided by the entire chain unless the capacity for document analysis is correspondingly increased (see Figs. D-3 and D-4). The first operation has proved to be much more readily automated than the latter. Subject analysis of documents will remain, at least for the near future, an intellectual operation—one for which the present acute shortage of qualified personnel is unlikely to be remedied quickly unless new approaches are adopted, e.g., author indexing.

4) To assess mechanisms for coordinating components, operations, and activities. The performance of the system depends upon effective coordination of its parts. Certain formal mechanisms at present insure some degree of horizontal coordination among different organizations performing the same basic operations (e.g., for publication, the Conference of Biological Editors; for abstracting-indexing, the National Federation of Science Abstracting and Indexing Services). Mechanisms to effect coordination among the major functional components of the biomedical information complex, e.g., between generation-use and document processing, are largely nonexistent. However, the efforts of the Office of Science Information Service of the National Science Foundation to promote this type of vertical coordination in the larger science information complex are seen as an important influence on the biomedical system.

5) To provide a holistic perspective for examining the problems of biomedical communication. Only within the framework of the total complex can the relative importance of these problems be judged and sound decisions in allocating resources be made. Not until the quantitative aspects of the model are better developed can some of the major questions about the relative importance of various channels and operations be answered definitively; but from what is now known, it appears that the problems of reference retrieval have received a disproportionate share of attention and of the money and effort devoted to communication research and development.

Another use of the model, which does not lend itself to specific illustrative examples but could prove of major

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[23] Considering the annual cost of conducting hundreds of biomedical research meetings, of publishing some 1000 U.S. biomedical journals and several hundred books, of running scores of abstracting-indexing services that process biomedical literature, and of maintaining over 500 biomedical libraries and various other types of document or information processing services, an estimate of \$50 million for the cost of the biomedical information complex (about 6% of total U.S. expenditures for biomedical research) is obviously conservative. The total may well be twice this figure. Either estimate represents only operating expenses and not the capital investment. If the operating cost per research worker has not increased in recent years, it is an exception to the general trend of research costs.

importance for future improvement of the system, is to demonstrate to biomedical scientists how the biomedical information complex and each of its components are integral parts of their research effort; how they, as scientists, are now involved in all of the system's major operations; and why technologic advances, expanding budgets for information services, and larger numbers of highly trained "information specialists," will increase rather than decrease the system's dependence upon their active, informed participation in all of its basic processes.

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COMMUNICATION PROBLEMS IN BIOMEDICAL RESEARCH

Report of a Study

AD

31 October 1963

NATIONAL ACADEMY OF SCIENCES–
NATIONAL RESEARCH COUNCIL

COMMUNICATION PROBLEMS IN BIOMEDICAL RESEARCH

Report of a Study

by

The Division of Medical Sciences

National Academy of Sciences - National Research Council

in cooperation with

The Federation of American Societies for Experimental Biology

and with

The Institute for Advancement of Medical Communication

31 October 1963

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3. Information Output of Biomedical Research and Development.
4. Trends in Oral Communication.
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INTRODUCTION

R. Keith Cannan
Chairman, Division of Medical Sciences
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It has been aptly said that new scientific knowledge is increasing much more rapidly than any other product of society. Because this outpouring of information results directly from the great expansion of research that has been instigated and financially supported by society, it is not surprising that society has begun to be concerned with the fate of the information. Specifically, the question is being asked whether the new knowledge is being transferred as expeditiously as it might be to those in a position to exploit it in the public interest.

Pressures for action are developing in both the legislative and the executive arms of government. For some time, the Senate Committee on Government Operations has been probing and exhorting. Meanwhile, the Federal Council on Science and Technology has been working to improve the exchange of scientific information among the many government agencies involved in research, and the Office of Science Information Services of the National Science Foundation has been encouraging the systematic study of problems in communication and the search for more efficient methods of processing scientific information, as well as promoting cooperation among all activities, both private and governmental, that handle scientific information. The President's Science Advisory Committee instigated two broad studies that led to reports containing specific recommendations for action: the "Crawford Report," of April, 1962, "Scientific and Technological Communication in the Government"; and the "Weinberg Report," of January, 1963, "Science, Government, and Information." Although these studies attempted to cover science as a whole, their general recommendations were influenced primarily by conditions in the physical sciences and associated technological fields.

One report concerned directly with the biomedical sciences and the health professions has recently appeared: the proceedings of a Conference on Health Communications called by the Surgeon General, USPHS, in November, 1962. The recommendations contained in this document are pertinent to the present study.

The patterns of biomedical communication are in flux and profound changes are in prospect. In the places where policies are developed and decisions are made, it is recognized that the primary purpose of scientific information services is to meet the needs and speed the work of scientists. It follows that it is better for change to be fashioned from within the scientific community than to be imposed from without.

Certainly, scientists must be prepared to devote more thought to the problem, and then to take the steps necessary to ensure that their considered views are heard.

Scope

As an extension of these and other efforts to assess and strengthen the information resources of science, the Director of the National Institutes of Health, in October, 1962, invited the Chairman of the Division of Medical Sciences, National Academy of Sciences-National Research Council, to organize and conduct "a broad examination and assessment of the problem of communication among working scientists in the biomedical area." Subsequent conversations indicated that the Director was thinking of an intensive study that would develop, in the space of a few months, some basic considerations that would be helpful in shaping national policies with respect to improving the biomedical communication complex, i.e., the aggregate of all information activities serving biomedical research. It was therefore agreed that the proposed study should have limited objectives. First, it should be confined to "scientist-to-scientist" communication, recognizing that better communication between working scientists and professional practitioners and between scientists and the public are urgent social needs worthy of separate study. Second, the study should survey the broad potentialities and implications of modern information technology, rather than attempt to evaluate specific applications in information processing that are already being actively investigated by other competent groups. And third, the importance of encouraging the flow of biomedical information across national, linguistic, and cultural boundaries should be acknowledged, but emphasis should be placed on the problems and needs of the generators and users of biomedical information in the United States, and on actions relating to the American biomedical community.

Organization

If anything more than a superficial survey were to be made within the imposed time limit, it was evident that the Division would need the help of organizations already knowledgeable in the field of biomedical communication. Accordingly, the cooperation of the Federation of American Societies for Experimental Biology (FASEB) and the Institute for Advancement of Medical Communication (IAMC) was sought and has been given without reserve. The Office of Documentation of the Academy-Research Council has also been most helpful. Dr. Richard Orr, Director of IAMC, accepted responsibility for the design and conduct of the project and for the assembly of a small group of expert consultants to undertake special studies on a part-time basis. An outline of a program was quickly developed and the study was formally launched on January 1, 1963, with a target date of the end of October, 1963, for completion of the report.

Shortly after the staff work began, an Advisory Committee was appointed under the able chairmanship of Dr. Maurice Visscher. The members were selected to be broadly representative of the biomedical field and on the basis of an avowed interest in questions of scientific communication. The function of the Committee was to guide the staff studies, to review the results, and, on the basis of these and of the opinions and judgment of its members, to develop a statement of principles, conclusions, and recommendations.

Definitions

At the outset, the staff was faced with the task of finding an operational definition of the term "biomedical." The conclusion was soon reached that no categorical definition could be contrived that would be meaningful to the purpose of the study. It was therefore decided to sidestep the issue by agreeing (1) that "biomedical information" would be considered to comprise all information that NIH might be expected to regard as significant to its mission, and (2) that the "biomedical community" would be considered to include all scientists who might generate such information. Inasmuch as the objective of the study was to provide a report helpful to NIH, this may, perhaps, be accepted as a legitimate evasion.

Objectives

Within the limitations of time and of staff, the study was designed to achieve the following objectives:

(1) to survey the existing complex of information services, and to consider the degree to which it constituted a coherent, functional system (including not only such formal channels of communication as meetings, journals, indexes, abstracts, and reviews, but also informal, person-to-person communication);

(2) to analyze past and current studies of scientific communication in terms of their pertinence to the biomedical field;

(3) to collect data on the biomedical information services and the communication habits and prejudices of biomedical scientists, and to collate views on ways of improving the existing biomedical communication complex; and

(4) to identify basic principles and derive conclusions, as guidelines for private and governmental agencies responsible for promoting biomedical communication, distinguishing between

actions that may appropriately be taken forthwith and those that require further study or testing on a pilot scale.

Final Report

The studies of the staff were reported to the Committee as they proceeded. From August onwards, the Committee devoted itself to the preparation and refinement of statements of basic considerations and of conclusions and recommendations. Because the Committee's views are summarized in these statements and because the Committee was not asked to assume responsibility for the whole content of the staff studies, the latter will be issued as a supplement to this Report. The supplement, whose length and detail will delay its publication by several weeks and whose circulation will be more limited, will contain the full text of eight staff papers that summarize findings relating to some of the major aspects of biomedical communication.

The Report has been prepared for and is formally submitted to the Director of the National Institutes of Health. Those who have worked on the project hope that it will also be of interest to those actively engaged in biomedical research and to the specialists in communication who seek to serve biomedical research.

FOREWORD

Maurice B. Visscher
Chairman, Advisory Committee

The accompanying report by the Chairman of the Division of Medical Sciences of the National Academy of Sciences-National Research Council represents a comprehensive and, it is hoped, constructive synthesis of the contributions of the staff operating under the aegis of the Division of Medical Sciences, the Federation of American Societies for Experimental Biology, and the Institute for Advancement of Medical Communication, with the guidance of the Advisory Committee.

In as complex a matter as the subject of this report, it is inevitable that various individuals who have participated in determining its content and emphasis would have varying judgments as to the relative value and urgency of the several elements under consideration. The report reflects a middle ground of varying views and appears to us to have great merit in pointing out the continuing responsibilities of the biomedical science community in the communications field. By pointing out a large number of areas in which advancement in the effectiveness of communication could be accomplished by a combination of governmental and nongovernmental actions, it would appear to have immediate practical significance.

The Advisory Committee in its several two-day meetings has served to provide the Division of Medical Sciences and the staff with a group of scientific and professional experts whose criticism and suggestions have made possible a report with both balance and creativity.

STATEMENT OF BASIC CONSIDERATIONS

A. THE NATURE OF THE PROBLEM.

1. The problem is real and concerns both the public and the scientific community.

Communication in science, as in most human affairs, has always been and always will be a problem. The past two decades, however, have witnessed changes that aggravate this chronic problem of science. Not only has the output of new scientific information increased, but also the horizons of the traditional scientific disciplines and the ways in which research is conducted and administered have changed profoundly. These developments have combined to impose on the national resources for scientific communication severe stresses that are both quantitative and qualitative.

Most scientists today acknowledge that the communication problem is real and important, but relatively few feel that the situation is so critical as to call for crash programs or precipitate massive innovations. The general demand is for continuing intensive study and experimentation; and the scientific community has, accordingly, approached the problem conservatively by expanding established forms of communication and by evolving and testing new forms.

Today, however, scientific communication is no longer the concern of scientists alone. It is a problem in the public domain. Now that society has adopted research as an important instrument of national policy, the scientific community must accept the obligation to satisfy the public that the massive social investment in research is being soundly managed. Some of those responsible to the public for the nurture and surveillance of the research effort have become fearful that the social returns on the investment are being delayed by inadequate communication of the results of research to potential users. This concern has also been voiced by individual scientists in all fields.

The community of science must examine critically its ability to continue to manage and improve its own communications. Unless the scientific community shows more concern for this problem, it is likely to lose some of its traditional control over the forms of its communication.

2. The problem is international, but national and regional initiative will speed progress.

Because science is not constrained by national or cultural boundaries, scientific communication must be international in its scope, and free exchange across geographic and language barriers must be encouraged in all practicable ways. The promotion of cooperation and innovation at the international level, however, is a slow and deliberate process. Progress can be accelerated if functional national and regional scientific organizations will put their own houses in order and take the initiative for international action.

3. <u>The problem is science-wide, but the realities of the present organization of science and its communications by disciplinary groups need be considered for effective action toward improvement</u>.

An ideal system of communication would embrace all of science. Science is largely organized and managed, however, by disciplines and in disciplinary groupings, not only professionally and institutionally, but also with respect to sources of support. Inevitably, these disciplinary groups have developed channels of communication to meet their own particular needs. To make the most of the communication resources they have developed, and to prevent disruption of their communications, the disciplinary groups must play an active role in the development of the new and expanded services required to handle the growing volume of scientific information.

4. <u>The biomedical community is a functional disciplinary grouping appropriate for initiating action to increase the efficiency of its communication channels</u>.

The life sciences constitute a rational segment of science and, within the life sciences, the biomedical sciences are a coherent group identifiable by their own professional and institutional organizations, by common conceptual foundations, and by particular obligations to the health and medical services of society. Like other disciplinary groupings, the biomedical community has evolved its own communication channels. It is appropriate that this community assume the initiative in designing and implementing the changes required to serve its special communication needs. Although it seems best, for practical reasons, to approach the problems of scientific communication at the biomedical and national levels, it is of the utmost importance that means should be developed to improve interdisciplinary and international coordination of these partial efforts so that the intellectual unity of science may be sustained.

B. THE NATURE OF SCIENTIFIC COMMUNICATION.

1. <u>The functions of communication services are broader than mere transmission of the results of research</u>.

It is sometimes implied that the primary need for good communication services is to ensure that the final product of research shall be expeditiously incorporated into the body of current scientific knowledge. This is a narrow view. Scientific communication fertilizes research at all stages in its conception, development, and fulfillment.

The kinds of communication services that the scientist requires change with the progress of his investigation.

2. Scientific communication is an intellectual, not a mechanical, process.

The problem of improving scientific communication should not be conceived as chiefly one of finding more efficient means of switching "facts" from points of origin to points of use. The problem is much more complex and elusive than this. Intrinsically, scientific communication is an intellectual interaction between individual minds. It is personal and intimate. It has an evanescent quality and is loaded with value judgments. Conceptual scientific communication in particular requires a degree of resonance between sender and receiver that cannot be ensured by efficient switching devices. Any service that is to aid this process should be so designed as to accommodate these subjective attributes of the process.

3. The complex of activities contributing to scientific communication is only partly formalized.

Studies of the scientific communication complex and efforts toward its improvement have tended to concentrate on the formalized channels and tools of written communication, such as journals, bibliographies, abstracts, and reviews. Recently, the formalized oral communication represented by the structured part of meetings has received some attention. The working scientist, however, does not depend on these formal channels alone. Much of his essential communication, whether oral or written, is informal and is achieved through impromptu exchanges on a person-to-person basis by conversation and correspondence. In the operation of the communication complex and in the design of communication services or "systems," these informal means of exchanging information should be given due weight.

4. The need is for better rather than more information.

The power of science grows by the continuous reordering of knowledge in the light of new information and concepts, rather than by mere accretion of "facts." The mounting output of biomedical information calls for a more rigorous winnowing of the wheat from the chaff - a more severe control of quality - and for greater emphasis on viewing new information in the perspective of the old. Such control and critical evaluation should be exercised at all stages of the communication chain, from generator to user. Only biomedical scientists can perform these vital functions of science.

5. Communication requirements vary with the individual scientist, his role, his field, his project, and his environment; this variety must be accommodated by the complex of information services.

A scientist may play many roles in the biomedical scene. At one time or another, he may be investigator, practitioner, teacher, evaluator, administrator, or manager. What information he requires and how he wants it will vary with his role as well as with the field of his inquiry, the nature of his problem, the progress of his investigation, and the intellectual environment in which he is working. An effective biomedical information complex must be comprehensive and flexible enough to respond to the changing requirements of the individual scientist and to accommodate the wide variety of biomedical investigations and investigators without imposing on all the patterns peculiar to any one. An information service that attempts to be all things at all times to all scientists is likely to be satisfactory to none.

6. Modes of communication and types of information service useful in the physical sciences are not necessarily appropriate for biomedical research.

The range of functions that the biomedical communication complex is called upon to perform is much the same as that in any other area of science. The environment of biomedical research, however, is distinctive in many respects. The fact that biomedical investigation is focused on the nature of living processes imposes unique restraints upon experimental approaches and unique levels of complexity on the ways investigators organize their thoughts and vocabularies and pursue their studies. Large organized programs of research are the exception and the technical report, which plays so important a role in engineering and in areas of the physical sciences that are oriented toward technical development, is a relatively unimportant channel for biomedical communication. Biomedical research, moreover, is conducted mainly in academic institutions and is rooted in individual initiative. For these reasons, new forms of communication and new types of services that serve other scientific communities effectively will not necessarily be appropriate to, or of comparable usefulness in, the biomedical sciences.

C. DESIGN AND MANAGEMENT.

1. The biomedical community should retain responsibility for managing its communication complex.

In the past, the community of biomedical scientists has been largely responsible for evolving and managing its own information services. This is natural inasmuch as the biomedical investigator is the primary generator, evaluator, and user of the information generated by the biomedical research effort. The vast expansion and the professionalization of this effort in recent years has greatly magnified the task of processing documents and information but has not created any critically new situation that justifies relieving biomedical scientists of this responsibility.

2. Today's communication problem requires new relationships between biomedical scientists and professional information processors in their information services.

The traditional handlers of scientific information -- editors, librarians, and publishers -- have been recently reinforced by new types of information processors between generators and users -- documentalists, computer engineers, information system designers, audiovisual experts, document analysts, and other kinds of specialists. Despite the efforts of the most able processors of both the traditional and the newer types, however, the communication complex cannot function efficiently without the active and educated participation of the generators and consumers of the information. The mounting loads and demands on this complex can be met only by intimate cooperation among generators, processors, and consumers. Those who process biomedical information must be integrated into the biomedical fellowship.

3. Tomorrow's communication system should be developed from the present complex by judicious introduction of innovations.

It is sound policy to build upon the communication complex that now exists and has been proven by experience. Major innovations should be incorporated only after they have been tested for acceptability, efficiency, and compatibility with other components of the complex.

4. Effective coordination is necessary to transform the present complex into a system that can perform as required at reasonable cost.

An ideal system for biomedical communication would provide any scientist with the information he needs, when and where he needs it, and in the forms best suited for his use. The existing complex of services comprises many interdependent organizations, activities, media, and languages that must be integrated into a coherent system if these requirements are to be approximated. At present, mechanisms for effective coordination are poorly developed. Both the over-all performance of the complex and its efficiency in terms of returns for expenditure of manpower and money suffer. Better coordination is necessary to ensure complementarity and compatibility between journals, abstracting services, and libraries, as well as among libraries and among abstracting services. The argument for coordination is not, however, an argument for a monolithic master plan. There is need for flexibility and plurality in information services. There is a place for some redundancy and for some services that repackage information to serve particular groups and individuals.

5. A comprehensive communication system requires services for information processing as well as document processing.

A comprehensive biomedical communication system must include not only document processing--the systematic distribution, storing, and cataloguing of documents so that they reach those likely to be interested and may be retrieved readily on demand--but also the collection, evaluation, digestion, synthesis, dissemination, and retrieval of items of information selected from documents and other sources. This information processing begins where the processing of documents leaves off and requires a different type of processor. Compendia, critical tables, and review articles represent traditional types of information processing. These are and will continue to be of great value to science. These forms do not, however, completely meet today's needs for specific information on demand. Recently a number of services have been established that provide users, on a continuing or demand basis, with items of information in a narrowly defined field. These services have come to be known as Specialized Information Centers. Those services that also undertake to provide expert evaluation of the quality, validity, and significance of the information proffered qualify as Specialized Information Evaluation Centers of the type recommended in the Weinberg report.

6. Authors and editors must participate to make document and information processing more efficient.

Efficiency in processing documents and information for ready retrieval and use requires close cooperation between the generators of information and those who carry out the processing operations. Authors and editors must accept a responsibility for presenting new material in forms that facilitate indexing, abstracting, evaluation, and synthesis.

7. Modern technology should be exploited with full appreciation of its promise and problems.

Modern information technology, including intellectual techniques as well as mechanical and electronic equipment, by saving time and manpower, can contribute significantly to making better services possible. Mechanization of clerical operations can greatly expedite storage and retrieval of documents. Every effort should be made to exploit these new techniques in biomedical communication. Future technological developments hold the promise of automating completely some types of information services, including operations now considered to be intellectual as contrasted with ~~clinical~~ mechanical, but it should be recognized that the transition from partial mechanization to complete automation may carry the danger of reducing the flexibility previously provided by men in the processing chain. Efficient mechanization and automation will require a greater degree of coordination and compatibility of services than now exists.

8. Local biomedical libraries are the logical channels for access to the total resources for document and information processing.

Services are more readily adaptable to individual needs and are more fully used if they are in immediate contact with the scientist. A coordinated network of strong local libraries and information services, linked to the large national and regional libraries and to other centralized information services, will provide the channels through which a scientist can tap national resources yet retain the advantages of dealing by personal contact with a local service.

D. SUPPORT: FUNDS, RESEARCH, AND MANPOWER.

1. The biomedical community previously exercised control of its communication complex by holding the "purse strings"; ways must be found to preserve control as public subsidy increases.

In the past, biomedical information services have not, in the main, been a public charge. This is a healthy tradition that should be maintained as far as possible because it provides the best assurance that the biomedical community will continue to control its own communications. With the great expansion of scientific information in recent years, however, it has proved impossible to maintain some of the essential communication services and to meet some of the demands for new and improved services on the same basis as in the past. The sponsors of research have found it necessary to subsidize many services performed by private organizations and to establish and operate themselves a number of new services, some of which are intended primarily to serve their own managerial needs. The necessity for research sponsors to support communication services will probably increase as biomedical literature and the size and complexity of the biomedical research effort continue to grow. In this situation, it is essential that new mechanisms be developed to preserve control by scientists and ensure that elements of the complex do not become autonomous and poorly related to the community functions they are intended to serve.

2. Research on scientific communication can speed the total biomedical effort; it should be generously supported and recognized as a scientific endeavor in its own right.

Research on the means and processes of communication can make a very significant contribution to the national biomedical effort. Generous support is warranted, both for investigations and pilot projects that seek to exploit advanced information technology for biomedical communication services and for basic inquiry into the functions served by communication processes. Equally important for bringing the best talent to bear on the problems of biomedical communication is the recognition of communication research as an endeavor in the same scientific tradition as the more traditional lines of research.

3. <u>Mounting demands for trained personnel to provide services and conduct research in communication require recruiting and training programs best based in academic institutions</u>.

There presently exists a shortage of trained personnel to man existing biomedical communication services. Any large effort to improve and diversify these services will intensify the demand. A sustained effort in recruitment and in the provision of a variety of training programs is required. There is need to recruit personnel whose major experience has been in biomedical investigation or instruction and to train them in the techniques of handling documents and information. There is need, also, to acclimatize librarians, documentalists, and other types of specialists in information handling to the concepts and practices of biomedical investigation. Both types of training are best provided in an academic atmosphere where education is associated with research in communication. Graduate schools for the biomedical sciences, with their local communication services and their university environment, can supply this atmosphere but will probably need to be subsidized if they are to develop the needed facilities.

Although the required numbers of personnel are smaller, recruiting and training programs for research in communication are equally critical. The ideal atmosphere for these programs is also the biomedical graduate school.

CONCLUSIONS AND RECOMMENDATIONS

A. THE RESPONSIBILITIES OF THE BIOMEDICAL COMMUNITY.

1. In the catalogue of Basic Considerations that has been presented above, repeated emphasis is laid on the principle that the biomedical community must continue to play an active role in the conduct and management of its communications if the quality and usefulness of the scientific record is to be maintained. This responsibility should be accepted not only as an obligation to science and to society, but also as a challenge to scholarship.

A large segment of the biomedical community does accept this obligation and challenge. There are many others, however, who are reluctant to serve as teachers, editors, referees, critics, or evaluators of the literature in the fear that these responsibilities will be a burdensome distraction from their own investigations. The Committee recognizes a need to diffuse more widely amongst scientists an appreciation of the principle that the nurturing of good communications is an intrinsic and rewarding part of the advancement of knowledge, a hallmark of scholarship, and a stimulus to creativity. There is need, also, to extend greater academic recognition and prestige to those scientists who willingly contribute thought and effort to the improvement of scientific communication and to the members of those professional groups that operate information services for the benefit of scientists. Participation in the communication process should be more widely spread over the expanding biomedical community so that the burden on individual scientists will not be onerous and the fellowship of science will be enriched.

2. Much can be done by individual scientists to improve the existing channels of communication and prepare for the introduction of new types of information services.

In their role as <u>instructors</u>, scientists should place more emphasis on training their graduate students in oral communication and the use of visual aids, in the writing of original papers, in editing and abstracting, and in the preparation of critical reviews and bibliographies. There is need also to train students more adequately in the use of libraries and of other information retrieval services and to encourage them to explore the potentialities of modern information technology. All these activities should be introduced to students as intrinsic elements in the life of a mature investigator. Instructors should be alert to identify the occasional student who evinces an unusual interest in problems of communication and should encourage him to pursue these problems as worthy intellectual endeavors.

In their role as <u>investigators</u>, scientists should seek to cultivate a closer fellowship with the staffs of the institutional libraries that serve them so that a spirit of mutual participation in research by the generators, users, and processors of information may be cultivated. Libraries will be encouraged thereby to seek to improve and diversify their services in ways that will be most responsive to the needs of individual investigators.

As members of faculties, scientists can promote the importance of local scientific communication services at the administrative levels of their institutions and can press for more adequate support of institutional library services.

As members of national advisory groups, scientists have the opportunity to encourage sponsors of research to promote the study of problems in communication and to explore the potentialities of new proposals.

As members of editorial boards, scientists should also seek to improve coordination, to maintain high standards of quality, to accelerate publication, and to reduce costs. They should cooperate with the Conference of Biological Editors and with other private and governmental organizations in seeking these ends.

B. FACILITIES AND SERVICES.

1. Clearinghouse for Biomedical Meetings.

a. Open Meetings. The Library of Congress, the Department of Health, Education, and Welfare, and other governmental and private agencies provide information on forthcoming meetings of interest to biomedical scientists in addition to the meeting notices printed in many professional journals. Science and the Journal of the American Medical Association publish particularly extensive lists of future meetings. International meetings are covered by the Council for International Organizations of Medical Sciences (CIOMS). These services are steadily improving but do not cover all meetings. A national clearinghouse of information on biomedical meetings should be established in an appropriate institution such as the National Referral Center for Science and Technology of the Library of Congress. Those who sponsor or support meetings should ensure that the organizers of these meetings inform the clearinghouse of plans and programs. The clearinghouse would provide any announcement service with information on open meetings to supplement that from their own sources and would also, on request, provide organizers of prospective meetings with information on possible conflicts or duplication.

b. Closed Meetings. Attendance at many biomedical meetings is limited to invited participants. Support for many of these closed meetings is sought from funding agencies, which, if they are to program effectively and to avoid undesirable duplication, should have means of learning whether related meetings have recently been held or are under consideration. The proposed clearinghouse would provide this information.

2. National Translation Clearinghouse.

Although the past few years have seen the development of several private and governmental centers that maintain lists of existing translations of scientific documents and provide copies of translations on request or inform potential users about where these translations may be obtained, the completeness, speed, and ease of use of the service provided by these centers leave much to be desired. The PHS should assume leadership to ensure that an effective national clearinghouse is developed for the biomedical community by working with NSF to improve one of the existing clearinghouses. To avoid the expense of paying for translations that have already been made elsewhere, biomedical libraries and information services should be able to learn quickly from such a clearinghouse, by mail or faster means, whether a desired translation is available elsewhere.

3. Local Translation Coordination Centers.

All libraries of institutions conducting biomedical research should act as local translation "coordination" centers to which biomedical scientists could turn first when they need translations. Libraries should be organized to perform the following functions in response to a request: find a translated abstract; determine whether any of the institution's staff have the required language and subject-matter proficiencies; arrange for partial translations by local staff; search lists of translations that have been made elsewhere and, if the desired translation is available, obtain a copy; contract with commercial services for translations that cannot be accomplished by local staff, that are not listed as available, or that are urgently needed; and register any translations made or ordered locally with the national translation clearinghouse.

4. Audiovisual Materials.

For biomedical information recorded in audiovisual form, the National Audiovisual Facility of the Communicable Disease Center of the PHS should be developed to the point where it is analogous to the National Library of Medicine as a central resource for such records and a compiler of "tools" for their retrieval.

5. Specialized Information Evaluation Centers or Services.

The term "specialized information evaluation center" (SIEC), or "service" if decentralized, should be used to designate a service available to scientists on a national or international basis that performs one or both of the following functions for a designated field of research and development: evaluation of the quality, reliability, or validity of information; and synthesis of information extracted from a number of documents or other sources. Providing this type of service requires the participation of scientists who are themselves actively engaged in research in the given field.

By this definition a number of existing services qualify as specialized information evaluation centers (or services), for example, the Handbooks of Biological Data compiled under the auspices of the Federation of American Societies for Experimental Biology, the American Physiological Society's continuing series of Handbooks of Physiology and periodicals devoted to critical reviews, as well as less conventional services, such as the Psychopharmacology Service Center of the National Institute for Mental Health. Existing services of this nature should be supported and strengthened once their quality and utility have been established.

Currently there is considerable enthusiasm for establishing new centers to handle unpublished and published information in active biomedical research areas and to provide service that emphasizes currency, speed, and responsiveness to inquiries by individual scientists. The value of this type of SIEC, when properly conceived and organized, has been established for certain areas of engineering and the physical sciences. However, since such centers are expensive in terms of both money and research manpower, and since biomedical research has distinctive characteristics, this concept of service should be adopted with caution in the biomedical field pending the outcome of pilot projects. Agencies funding biomedical research should support by contract a limited number of carefully selected pilot projects for a 3- to 5- year period, with built-in provisions for objective evaluation. Special attention should be given to ensuring that such centers utilize to the optimum the services of existing document processing services, such as MEDLARS, rather than duplicate their work.

Although not designed specifically to evaluate this concept of information service, experience with the National Clearinghouse for Mental Health Information now being developed by NIMH, and the National Clearinghouse for Drug Information planned by the PHS, will also provide information useful in assessing the promise and problems of SIEC's in biomedicine.

6. Specialized Information Centers.

This term is currently used very loosely; at one extreme it is used as equivalent to SIEC, at the other it denotes a collection of documents specialized for a particular area of research and organized to provide rather conventional library services to scientists on a national or regional basis. Several hundred services in the U.S. have been identified, to which this term in the broad sense might be applied. Currently the National Science Foundation is encouraging the development of objective methods for evaluating the quality and utility of the variety of services offered by such centers. Although there are undoubtedly areas of biomedical research that could profit from the services of centers that attempt to collect all available information in a given area (published and unpublished) and that organize documents so that they may be retrieved in highly sophisticated ways, in general the greatest promise seems to be in centers that process information rather than documents and that make possible true information retrieval, by providing scientists with the specific items of information they want rather than referring to documents that may contain the desired information. This type of service may consist of publishing a "tool" that assists such information retrieval, e.g., the Index-Handbook of Cardiovascular Agents, or of answering specific inquiries, e.g., the Cancer Chemotherapy National Service Center.

Like SIEC's, this type of center is expensive in money and scientific manpower. Although scientists actively engaged in research may not be necessary for this type of information processing, a high level of scientific competence is required. Support for existing and new centers of this type should be governed by the same considerations as that for SIEC's.

7. The National Library of Medicine.

As the central resource for the network of biomedical libraries and information services, and as the major indexing service in the biomedical field, the National Library of Medicine is the hub of the entire document retrieval component of the biomedical communication complex. NLM is to be congratulated on the careful planning that has gone into the MEDLARS program and into increasing the coverage, currency, and quality of Index Medicus. The biomedical community and all agencies concerned with biomedical communication should give NLM full support in its efforts to improve its services, which are indispensable to the effectiveness of the present complex and to its future development.

NLM is at present considering many plans for new types of bibliographic services. The following represent endeavors worthy of special attention:

a. It is essential for the biomedical sciences to have a single, master bibliographic tool that is truly comprehensive and sensitively reflects the changing scope of biomedical research. NLM should be encouraged to broaden the coverage of Index Medicus and MEDLARS to encompass the total output of U.S. biomedical research, beginning with that supported by NIH and other governmental agencies, regardless of whether the form of publication is a journal article, book, technical report, or other type of document, and irrespective of whether the document is covered by another indexing service. Indexing performed by other services could be accepted if compatible with MEDLARS and suitable for the biomedical community.

b. NLM, in consultation with the National Federation of Abstracting and Indexing Services, should be encouraged to seek out gaps and deficiencies in the abstracting coverage of biomedical literature and to assume leadership in seeking to close these gaps and correct any deficiencies. Particular effort should be made to ensure that all substantive foreign literature is being abstracted with reasonable promptness. The current NLM program to improve abstracting coverage of Russian literature as well as that in other languages commanded by few American scientists is an excellent step in this direction. Eventually, it may be desirable to include for each biomedical document stored in the MEDLARS system either an abstract or information on where abstracts of the article may be found.

c. The current NLM program supports the publication in widely circulated journals of translations of Russian articles carefully selected by editorial referees. This program is an excellent way of introducing to the U.S. biomedical community relatively unfamiliar and neglected segments of the foreign literature. NLM should be encouraged to extend this concept to other foreign-language material that is also unfamiliar to American scientists.

d. NLM should utilize the full resources of the Federal Library System (Library of Congress, Library of the Department of Agriculture, etc.) and endeavor to fill any request by a library for a document.

e. While the MEDLARS program will utilize the terminology of requests for subject searches as a guide for revising and updating the subject headings for <u>Index Medicus</u>, NLM should be encouraged in its efforts to establish continuing mechanisms whereby the community of research workers can participate directly in developing new subject headings and revising outmoded terminology.

f. NLM should ensure that the biomedical community and its libraries are aware of recent changes in the policy of the Defense Documentation Center (formerly ASTIA) that make its services for searching the technical report literature and obtaining copies available to all grantees and contractors of the Public Health Service.

8. Support of Local Biomedical Libraries.

The libraries of academic institutions represent a vital component of the biomedical communication complex. This component has, however, deteriorated progressively from lack of support while the demands on it have steadily mounted. If institutional biomedical libraries are to function as local information service centers through which the scientist can tap the total national resources for document and information retrieval, and if scientists are to obtain the documents they learn about through the more efficient reference retrieval services that are being rapidly developed, strengthening this key component of the complex must have the highest priority.

An effective program to repair the damage resulting from years of neglect and to transform biomedical libraries into modern information service centers will require substantial financial support as well as efforts to train personnel, to develop new and improved types of services, to establish standards of service, and to elevate the status of libraries in the academic environment. For the short term, this support should be in the form of direct grants-in-aid to academic libraries in amounts sufficient to enable each to improve substantially and rapidly the quality and scope of its services and to enable all to meet certain minimal standards of service. This aid should supplement, not replace, regular institutional support. For the long term, means must be found to ensure that these libraries are adequately and continuously supported so that they may provide a high level of services to biomedical scientists. This may require the routine allocation to library services of a set percentage of research funds received by biomedical institutions.

9. Interlibrary Loan Network.

The load on the interlibrary loan network of the biomedical information complex has been increasing steadily and promises to mount sharply with the imminent advent of new and improved reference retrieval services. The capacity of this network is seriously strained at present and is grossly inadequate to meet the loads of the next few years. Pending the results of a special study (see Sec. C. 4. b) of ways to improve this network and the establishment of effective monitoring of the traffic in this network, immediate steps should be taken to provide short-term support for this network by subsidizing the interlibrary loan services of academic and other non-profit institutions.

10. Specialized Abstracting and Indexing Services.

Aside from the broad abstracting and indexing coverage recommended in connection with the National Library of Medicine, the most pressing need is for a special study aimed at developing standards for abstracting and indexing services and for a program for continuously monitoring abstracting and indexing. In the meantime, support of conventional types of abstracting and indexing services by agencies funding research should be limited to relatively narrow fields where a special need can be convincingly demonstrated. Any such specialized services should make maximal use of the output of the major broad services and should be supported by short-term contracts. Continuing support should be dependent upon objective and systematic evaluation of the quality and utility of the service.

11. Pilot-Trials of Miscellaneous Non-conventional Types of Services.

The evidence accumulated in other fields of science and from studies of scientists' information habits and requirements is adequate to justify carefully designed and selected pilot trials of several non-conventional types of information services. Agencies funding biomedical research should support by contract, for limited periods, such pilot trials to test their feasibility, value, and acceptability to the biomedical community, and their compatibility with existing conventional services. Such pilot trials might include services for:

a. making orally presented information available quickly in informal recorded forms upon request;

b. using telephone, radio, television, and motion pictures to bring the benefits of active or passive participation in meetings to a broader segment of the U.S. and international biomedical community;

c. publishing, by established journals, of abbreviated versions of papers, the full texts of which are abstracted and indexed by the regular services and supplied on demand in full-size or microform copy;

d. using advanced techniques in the publication of established biomedical journals, e.g., computer composition, "phototypesetting," microform editions, author composition, and methods for obtaining continuous "feedback" from readers;

e. screening computer tapes of current references to biomedical literature, such as those produced in the MEDLARS program, to provide individual biomedical scientists with a current-awareness service specially tailored to their interests, habits, and preferences; and

f. providing thesauri of current terminology in major areas of biomedical research suitable for use by authors and editors in choosing indexing terms to be published with the article or supplied to appropriate abstracting and indexing services. Such thesauri should be compatible with and complement those of the major, broad indexing services, such as Index Medicus and Chemical Abstracts.

C. SPECIAL STUDIES RELATED TO IMMEDIATE NEEDS.

It is recommended that further study of the areas outlined in this section be undertaken before policy decisions are made. Other investigations of a more general nature are recommended in Sec. D.

1. Prepublication Channels of Information.

a. Meetings, Conferences, and Symposia.

The contemporary biomedical scene is characterized by a heavy calendar of meetings varying widely in purpose, form, and size. Some follow traditional patterns of scientific assemblies while others take forms improvised to cope with the expanding population of biomedical scientists and the changing horizons of the disciplines. The sponsors of research are being increasingly called upon to support meetings of all sorts and varieties and are embarrassed by the lack of criteria by which wise decisions may be made. In the absence of an agreed set of principles, there is danger that choices may be made on the basis of the uncoordinated decisions of many independent advisory groups or simply on a policy of "first come, first served."

There is need for a deliberate study of the problem designed to lead to the development of an acceptable set of criteria for the guidance of those responsible for programming and funding the national biomedical research effort. The study should include a survey of current practices in the organization and conduct of meetings, of the extent to which duplication occurs and is justified, of the purposes served by different types of assemblies, and of the views of the biomedical community on the informational functions of various types of meetings. Consideration should also be given to the question of how the products of meetings should be placed in the printed record. The study should be under the direction of a representative group of biomedical scientists in consultation with the officers of organizations experienced in the planning of meetings and with representatives of the research funding agencies.

b. International Meetings.

The Committee recognizes that international congresses and international meetings of more limited scope provide unique channels for formal and informal oral communication between American scientists and those in foreign countries. Judicious support of these assemblies by funding agencies is fully justified by the substantial contribution that they make to the advancement of biomedical knowledge and to the encouragement of international cooperation in research. International biomedical meetings are, however, increasing rapidly in number and in variety of sponsorship and subject matter. Requests for the support of the organizational costs of the meetings and for travel funds for participants continue to mount. The investment of U.S. funds is already substantial and could become disproportionate to the scientific returns if wise discrimination is not exercised in the allotment of funds. The Committee, therefore, endorses the efforts of funding agencies to develop criteria for the administration of funds available for the support of international communications. The Committee suggests that such international bodies as WHO, ICSU, and CIOMS be encouraged to intensify their efforts to improve the quality of international meetings, to experiment in new forms, and to minimize undesirable duplication.

c. Directories and Registries of On-going Research.

Some agencies (e.g., NASA and AEC) make great efforts to inform individual participants in their programs of the existence of other contemporary work related to their own. Recently, NIH began publishing an annual subject index of all its extramural grants. A more comprehensive service is that offered by the Science Information Exchange. This organization seeks to maintain as complete a registry of all on-going research as possible and a file of summaries of all active research projects. SIE is prepared to make searches of this file for responsible scientific organizations and individual scientists. It is commended for the services it provides and should be encouraged to increase its coverage, particularly with respect to intramural research in government institutions and to projects that are not included in the program of major granting agencies.

These kinds of services are available to those responsible for the administration of funding programs and those who direct mission-oriented programs. They are also helpful to those who wish to explore current trends in the national research effort. There is, as yet, little evidence of the extent to which working scientists use services such as SIE or the NIH Research Grant Index, or of the potential value of these services for the conduct of research. A study of these questions would be helpful in guiding policy with respect to modifying or expanding these kinds of services.

2. Publications.

a. Page Charges.

The expanding output of original papers, coupled with the increasing costs of publication, has forced up subscription rates of many journals close to or beyond the point of diminishing returns. Journals that are unable to command large advertising revenues or do not receive some other form of subsidy are threatened with insolvency or restriction in volume of publication. A form of support that is coming into increasing use is the page charge. Insofar as funding agencies accept these charges as part of the costs of research, these agencies are obviously providing an indirect subsidy to the journals that use this device.

The problem is not simply an economic one. If the practice of page charges is not to be abused, the funding agencies must develop criteria for determining whether the charges of a particular journal will be accepted. The costs of an indiscriminate policy will be high and difficult to assess and such a policy will tend to encourage uneconomic practices and the perpetuation of journals that have outlived their usefulness. A policy of discrimination, on the other hand, will have the effect of withdrawing from the biomedical community a measure of control over its channels of primary communication.

The Committee believes that there is urgent need to study the question of page charges before this device becomes a generally accepted practice in the biomedical field. The study should examine in depth the anticipated effects on the standards of primary publication in the biomedical field of this and other forms of subsidy.

b. Economics of Publishing Separates in Place of Journals.

From time to time it is suggested that the user of biomedical information would be better served if he received only those original articles that interested him rather than bound issues containing all articles accepted by journals in his field. It has been proposed that the journal circulate to its subscribers a list of titles of accepted articles. Separates of all articles would be printed and distributed to libraries while other subscribers would be entitled to receive the particular articles that they selected from the list of titles.

As a preliminary to any pilot trial of this form of publication, it is recommended that a study of costs be undertaken. It should be possible from the unit costs of the various operations involved to derive a formula that would predict costs in defined situations to the user, the publisher, and those who would have to process the documents.

c. Depository for Unpublished Documents.

There is a growing need for a mechanism whereby voluminous tables and other details too lengthy to include in published papers can be made available to the relatively few who need this type of material. Pilot trials of new types of publication (see Sec. B. 11. c.), in which copies of documents are furnished on request, also require a similar mechanism. Therefore, NLM should examine the question of a proper depository for such "unpublished" documents that could deliver the documents rapidly and inexpensively, and should decide whether the biomedical field should use the present depository service provided by the Library of Congress or establish one elsewhere.

3. Abstracting and Indexing Services.

The development of consistent policies in the support of abstracting and indexing services is hampered by lack of approved standards and criteria. A careful study should be undertaken of duplication, promptness, accuracy, compatibility, and users' needs as a basis for the development of standards. Any proposed standards should be reviewed by representative groups of biomedical scientists and operators of abstracting and indexing services.

4. Library Services.

It is increasingly evident that institutional libraries will require additional public support if they are to meet the needs of the expanding research activities of their institutions. Subsidy is, however, justified only if acceptable standards of service are met.

a. Standards for Library Services.

The present standards for service by institutional libraries vary widely and are not defined in terms of the needs of the user. A study is needed to establish minimal standards and optimal goals for the operation of the various services that local libraries may undertake to offer. These standards will provide valuable guides in the development of a long-term program for the support of local libraries.

b. Interlibrary Loan System.

The present informal system of interlibrary loans is perilously close to breakdown. Short-term measures to preserve this vital function are recommended in Sec. B. 9. Several plans have been suggested for the long-term development of an efficient loan system: (1) a new central system might be developed at the National Library of Medicine that would undertake to meet all demands; (2) regional centers might be established to serve restricted areas; or (3) local libraries might be so strengthened as to become self-sufficient. Each of these proposals would involve large commitments in funds and extensive technological developments. A systematic study of present and future needs and of the relative advantages of these and other alternatives is required before irrevocable decisions are made.

D. RESEARCH AND DEVELOPMENT.

Systematic research and development in scientific communication is relatively new. Although activity in this new field has recently expanded rapidly, the promise that such research offers for increasing the effectiveness of the entire scientific effort has only begun to be realized. Concentration on the problems of storing and retrieving documents and information and on mechanical translation has obscured the fact that large areas for equally fruitful study have received little attention. The biomedical sciences can profit from the lessons in the physical sciences, where research and development in scientific communication first became a major endeavor. The Committee recommends a balanced, long-term program of research, including new conceptual approaches to communication and behavioral studies as well as the exploitation of mechanical, electronic, and automatic devices for the improvement of biomedical communication.

1. Specific Research Projects.

Many studies have been recommended in this Report. A few other problems for research to which the Committee would draw attention are set forth below:

a. meetings: the improvement of the design and conduct of meetings of all types;

b. journals: the assessment of quality control by refereeing or other means; the publication habits of authors; the foreign distribution of U.S. biomedical publications;

c. linguistic barriers: languages for facilitating man-machine exchanges; spoken languages to facilitate international communication;

d. microforms: applications to publishing and storing; studies of acceptability and economy;

e. media other than the printed word: the uses of film, videotape, computer tape, sound recordings, etc.;

f. behavioral studies: the habits and prejudices of biomedical scientists as generators, evaluators, and users of information; the relation of creativity to the use of information resources; and

g. biomedical potentialities of communication machines of the future: associative electronic memory banks; machine translation; high-speed character readers.

2. Centers for Research and Development.

SIC's and SIEC's, although established primarily as national and international services, must maintain active development programs if they are to maintain quality and efficiency and meet the demands of increasingly sophisticated scientist-users. Two other types of centers, however, are also needed in the biomedical community to provide appropriate environments for developing the entire spectrum of document and information processing services, to exploit the potential of audiovisual media, to improve methods of oral communication, and to conduct research on the fundamental processes of biomedical communication.

a. Centers for Development of Local Document and Information Processing Services.

Centers associated with enterprising biomedical libraries should be established to serve as "grass-roots laboratories" for assessing, with a local population of users, the utility of conventional types of library services and for testing new ways to supply scientists with the documents and items of information they need. This kind of practical development must be conducted in the realistic setting of an institution engaged in biomedical research, inasmuch as success can be determined only by continuous, intensive feedback from actual users of the services proffered. Academic institutions are particularly good settings for such centers, because the development program could be a cooperative endeavor of the library, the departments active in biomedical research, and other parts of the university, e.g., an engineering or library school.

Proposals for establishing these centers should be judged competitively, with no prior decision as to how many centers should be established. As particular centers prove outstandingly productive, they should be encouraged to expand their programs. Where the associated library provides regional as well as local services, a Regional Development Center can evolve.

b. Centers for Broad Research in Biomedical Communication.

In addition to the library-centered development programs described above, there is an urgent need for research centers where the processes of biomedical communication can be studied at a broader conceptual level and all communication media and techniques can be explored. This type of center should be established as a Department of Biomedical Communication within a graduate biomedical school. Its primary function would not be to act as the development arm of the school's library or of other communication service activities, such as photographic and illustration services, but rather to provide a combination of teaching and broad research, like any of the usual departments of biomedical schools.

Each of the three types of research and development programs described as appropriate for SIC's and SIEC's, for Local and Regional Development Centers, and for Departments of Biomedical Communication could, even if conducted separately, make a significant contribution. Some academic institutions, however, offer opportunities for establishing more than one type of program. A single school might have research and development programs associated with an SIC that serves an international population of scientists, with its local library, and with a Department of Biomedical Communication. Such a combination would be synergistic and constitute a major resource for research, for training specialists in information services, and for preparing scientists for careers in communication research.

E. TRAINING.

1. The Training of Personnel for Information Services.

The staffing of document and information services requires personnel with a variety of skills and experience and training programs that are correspondingly varied in content. Knowledge of the subject matter of the biomedical sciences, competence in foreign languages, understanding of the functions of the media of communication and the principles of processing documents and information--all these are required in greater or lesser degree for the different types of positions to be filled. The special needs of photographers, illustrators, manuscript editors, and experts in telecommunication should also be considered.

The various types of research centers proposed in Sec. D. offer favorable environments for training service personnel. Other settings in which valuable training can be secured are library and engineering schools, indexing and abstracting services, and SIC's and SIEC's. The establishment and conduct of training programs will require financial support for teachers and trainees and for other operating costs. The experience of the National Science Foundation in evaluating proposals for training programs should be drawn upon by other sponsors of programs.

2. Training for Research in Biomedical Communication.

Diversity in background of candidates for careers in communication research is desirable. The main qualifications would seem to be a strong motivation supported by graduate training in some scientific field or substantive experience in a scientific information service. A doctor's degree in medicine or in a biomedical science is desirable but not essential.

The National Institutes of Health are to be commended for their recognition of the importance of this type of training and for the pilot programs that they have sponsored.

For the graduate training of the quality required to prepare students for investigative careers in biomedical communication an academic environment is especially important. Only when the kinds of centers for research and development recommended in this Report have been established in universities and have begun to provide intellectual leadership will the true contribution of communication research be made to the biomedical effort.

F. COORDINATION OF THE BIOMEDICAL INFORMATION COMPLEX.

One of the main purposes of the study summarized in this Report was to delineate more clearly how each type of service in the biomedical communication complex contributes to the dissemination of information and the exchange of ideas and experience. In general, each service came into being because some group of biomedical scientists identified a need and sought to fill it. It is natural, therefore, that more thought and effort have gone into the nurturing of the individual services than into the task of integrating them into a functional, coherent system.

1. Journals.

The editorial boards of journals have a responsibility to monitor the efficiency with which their journals are fulfilling their intended purposes. This they do with varying degrees of diligence in respect of such ponderables as rejection rates, backlog, speed of publication, circulation, and costs. Less thought is given to coordinating the policies of a particular journal with those of others in respect of subject coverage, duplication, uniformity in terminology and citations, and possible savings in printing and publishing overhead that might result from group action.

The establishment of the Conference of Biological Editors in 1956 reflected a realization of the need for a larger measure of coordination in the management of the journal literature. This organization serves as a forum for the exchange of experience and proposals. The Committee commends the efforts of the Conference and of other professional associations, such as the American Medical Writers' Association and the Association of Dental Editors, in which biomedical editors also meet to share their experience and develop common approaches.

The National Science Foundation has pioneered in collecting data that may be used to monitor the general state of journal publication for science as a whole and to detect where serious problems exist. To promote coordination of effort among biomedical journals and of policies for supporting journal publication, objective data on trends and on adequacy of publication outlets for the various fields of research are essential. The PHS should encourage an appropriate organization to undertake the development and maintenance of a continuing monitoring program to collect data on journal backlogs, speed of publication, costs, circulation, numbers of articles and pages per issue, births and deaths of journals, and other objective indices.

2. Abstracting and Indexing.

Formation of the National Federation of Science Abstracting and Indexing Services was stimulated by the National Science Foundation to promote coordination of effort, to correct gaps in coverage, and to improve the general quality of the services. This organization now encompasses 20 of the major U.S. abstracting and indexing services, both governmental and private. A certain amount of work-sharing has been achieved, and a start has been made toward developing a "combine" with which a group desiring abstracting coverage for a narrow field can negotiate for a "package" service that draws upon the abstracts produced by two or more members of the Federation. The potential value of this organization has only begun to be realized.

The biomedical field is fortunate in having a single indexing service (Index Medicus) that provides relatively fast and uniform coverage for most of the substantive literature; however, in respect of abstracting coverage, the situation is less satisfactory. Although many services exist, their combined coverage has significant gaps and quality and promptness are uneven. To promote coordination of effort among abstracting services and of policies for supporting abstracting services, it is essential to have the same kind of over-all picture of trends and adequacy as for journal publication. The PHS should encourage an appropriate organization to undertake the development and maintenance of a similar monitoring program for the continuous collection of objective data on gaps and overlapping in the coverage of the biomedical literature and growth in the number of abstracts and of services. The efficiencies of individual services should also be monitored in terms of speed of publication, costs per abstract, and other objective indices.

3. Over-all Coordination.

The biomedical communication complex comprises a chain of processes in the reordering and refinement of information. There must be a continuous effort to fashion the operation of these phases so that they will be as complementary to and compatible with each other and the communication services of contiguous scientific disciplines as possible. This is a task that only the biomedical community can execute intelligently.

It is recommended that an appropriate scientific organization that commands the respect and support of biomedical scientists be encouraged to establish a representative deliberative body to maintain surveillance over the whole field of biomedical communication. A forum would thereby be provided in which the views of the academic, industrial, professional, and governmental contributors to the national biomedical effort in research could be ventilated and examined; resources, needs, and opportunities could be evaluated; and emergent problems could be identified and analyzed. Such a group should not have operational responsibilities, but should be available for advice on planning and programming.

The Weinberg report recommended that, for each area of mission-oriented research, a single agency within the Federal Government be made the "delegated agent" for information in that area, with responsibility for "supporting and otherwise carrying out information activities," and that "each agency should establish a highly placed focal point of responsibility for information activities that is part of the research and development arm, not of some administrative arm, of the agency." It will not be simple to implement these recommendations in the biomedical field, but some means must be developed to ensure that government policies regarding biomedical information services are coordinated effectively and are sensitive to the needs of the biomedical community.

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NATIONAL ACADEMY OF SCIENCES - NATIONAL RESEARCH COUNCIL
Division of Medical Sciences

ADVISORY COMMITTEE TO THE STUDY OF PROBLEMS IN BIOMEDICAL COMMUNICATION
FORMERLY
ADVISORY COMMITTEE TO THE STUDY ON SCIENTIST-TO-SCIENTIST COMMUNICATION IN THE BIOMEDICAL FIELD

Minutes of Third Meeting - 3-4 October 1963
Academy-Research Council Building
Washington, D. C.

ATTENDANCE

Advisory Committee to the Study of Problems in Biomedical Communication

Visscher, Dr. Maurice B., Department of Physiology, University of Minnesota, Chairman
Brayfield, Dr. Arthur H., Director, American Psychological Association, Washington, D. C.
Brosin, Dr. Henry W., Western Psychiatric Institute and Clinic, Pittsburgh
Hussey, Dr. Hugh H., Jr., Director, Division of Scientific Activities, American Medical Association, Chicago
Hyde, Dr. H. van Zile, Director, Division of International Medical Education, Association of American Medical Colleges, Evanston, Illinois
Jones, Dr. L. Meyer, Director of Scientific Activities, American Veterinary Medical Association, Chicago
Lazarow, Dr. Arnold, Department of Anatomy, University of Minnesota, Minneapolis
Leake, Dr. Chauncey D., Department of Pharmacology, University of California Medical Center, San Francisco
Remsen, Dr. Douglas, Director, Science Information Center, Squibb Institute, New Brunswick, New Jersey
Rhoads, Dr. Jonathan E., Department of Surgery, University of Pennsylvania School of Medicine, Philadelphia
Washburn, Dr. Donald, Director, Library and Indexing Service, American Dental Association, Chicago
Wilson, Dr. J. Walter, Department of Biology, Brown University, Providence, Rhode Island

Absent:

De Bakey, Dr. Michael E., Department of Surgery, Baylor University School of Medicine, Houston
Evans, Dr. Earl A., Jr., Department of Biochemistry, University of Chicago
Gerard, Dr. Ralph W., University of California, Irvine, California
Hirsch, Dr. James G., The Rockefeller Institute, New York City
Page, Dr. Irvine H., Director of Research, Cleveland Clinic, Cleveland, Ohio
Schreiner, Dr. George E., Georgetown University Hospital, Washington, D. C.
Wright, Dr. Irving S., New York Hospital, New York City

Guests

Abdian, Mr. Gregory, Washington, D. C.
Bourne, Mr. Charles, General Systems Department, Engineering Division, Stanford Research Institute, Menlo Park, California
Lee, Dr. Milton O., Federation of American Societies for Experimental Biology, Washington, D. C.
Leeds, Dr. Alice A., Institute for Advancement of Medical Communication, Washington, D. C.
Orr, Dr. Richard H., Institute for Advancement of Medical Communication, Washington, D. C.
Pings, Dr. Vern W., Medical Librarian and Associate Professor of Medicine, Wayne State University, Detroit, Michigan

Liaison Representatives

National Institutes of Health

Carson, Mr. Bruce F., Office of Director
Herman, Mr. William R., Office of Director
Kennedy, Dr. Thomas J., Jr., Office of Director

National Academy of Sciences - National Research Council

Office of Documentation

Werdel, Miss Judith A.

Division of Medical Sciences

Cannan, Dr. R. Keith, Chairman
Coyl, Dr. Edwin B.

Dr. Visscher, Chairman, called the meeting to order at 9:40 a.m. After welcoming those present he proceeded to the business of the two-day meeting. He suggested that the Committee devote itself primarily to the parts of the final report that deal with judgmental issues, i.e., the section on postulates and the section on conclusions and recommendations. The Committee would not hold itself responsible for the supporting and analytical material that will be printed as a supplement to the report. Dr. Visscher then called on Dr. Cannan to give his views on the matters to be considered.

Dr. Cannan called attention to the change of the Committee's name from "Advisory Committee to the Study on Scientist-to-Scientist Communication in the Biomedical Field" to "Advisory Committee to the Study of Problems in Biomedical Communication." He said that the present study was in the home stretch and a determined effort was being made to meet the deadline of 31 October 1963. The Committee members had been at a disadvantage in that they had been receiving material in separate sections, and had not had an opportunity to review the results of the study as an assembled whole. The Committee had reacted favorably, for the most part, to the first draft of "Postulates". A revised copy (from now on referred to as "basic considerations") had been prepared for their consideration. The revisions were based in part on suggestions received from the Committee members.

Dr. Orr reported that it had been concluded in discussions with Dr. Cannan and others that the final report might be in several parts: an introduction, a section on basic considerations, a section on conclusions and recommendations, a list of bibliographic sources, and a supplement that would contain the supporting papers. The report itself (i.e., excluding the bibliography and the supplement) would be about 30 pages long, whereas the supplement would be much longer and, of necessity, would be distributed separately at a later date.

Dr. Visscher asked for specific objections to the proposed plan; there were none. The Committee then proceeded to examine in detail the revised copy of the basic considerations (copy attached as Appendix A). This examination occupied the rest of the day and resulted in the suggestion of many minor changes and a few major changes. (These minutes will not reflect the various individual changes because they have already been incorporated into the finished report, published on 31 October 1963.)

Dr. Lazarow stated that he gained the impression from the original draft of the basic considerations that biomedical communication was going on pretty well at the present time, which, he considered questionable. An approach to the problem in terms of the capabilities of modern technics needs to be encouraged. One difficulty is that communication scientists and biomedical scientists often do not understand each other's language. Dr. Lazarow doubted that a real beginning had been made in improving the mechanical handling of information. For example, in preparing a scientific review, perhaps 80 per cent of the work involves simply getting material together. If this portion of the effort could be mechanized, the intellectual part of preparing a review would not be so time-consuming, and more qualified people would be willing to write reviews.

Dr. Rhoads was in favor of striking out in fresh fields. The attachment of new services to existing biomedical libraries may be a good idea, but the concept seems to be static. Libraries tend to be quite conservative, and it might be well to consider new facilities staffed by people with a demonstrated interest in information theory and in the development of new methods of handling information. Librarians, through no fault of their own, have had to exercise the strictest economy, and it might be difficult for them to conceive of spending their limited resources in a new and untried field. If additional services, experimental or otherwise, are attached to the library, they must be adequately financed and staffed and the end result must not be a lessening of support for the library itself.

Dr. Remsen said there was an urgent need for more experts educated or trained in a scientific discipline to move into the information area. The individual with a high degree of specialization in a particular field generally will know more about that field than the research administrator, who of necessity deals with many diverse specialties and specialists. The administrator will need to turn to such an informed specialist for advice. This can have important implications in the future for it may be only wishful thinking to believe that such a man will not be the one who determines which projects are acted upon favorably - a desk scientist, rather than a bench scientist.

The drug houses, at the present time, use a man intermediary between the information technologist and the bench scientist: an information evaluation specialist.

Dr. Brosin considers that there are two worlds of science: the world of facts, of which many are far removed from primary application but nevertheless exist, and the world of men. He believes that nothing will replace first-hand interchange, whether oral or written, between men.

Dr. Leake stressed that value judgments are all-important in the biomedical field. Documents that are considered classics in their field are so considered because scientists have made a judgment on their value. Also, one of the functions of science is to furnish information that can be verified.

In a general discussion about the scientist who becomes an information specialist, there seemed to be a question in the minds of some Committee members as to whether, in the actual day-by-day world, there was a real place for a scientist intermediary between the biomedical information technologist and the bench scientist, outside of limited special circumstances.

There was general support for an active program to increase the number of librarians and closely allied workers who are conversant with biomedical information problems.

A special international problem is the language barrier. With the accelerated growth of information, the problem of translation becomes increasingly important. Machine translation would be a solution, but this is at least a few years away. An international language of science would be a better solution. Although attempts to develop an international language for general use have never been popularly received, such a possibility should be kept in mind.

Dr. Rhoads suggested that the final report focus on an organization that for the government would have basic responsibility for biomedical information. His suggestion is that it be the National Institutes of Health; if that agency feels a need for outside help, it has the channels to request assistance. Some organization such as the National Research Council could relate the governmental and nongovernmental activities. In terms of recommendations for support that would strengthen biomedical communication, they could be offered in five areas: (1) support for existing libraries in their endeavor to handle the increase in the number of biomedical journals and the general increase in volume of material; (2) support of journals as is presently under way and may need to be further formalized; (3) some support, probably not very much yet, in the international field to assist in overcoming the language barrier and to study the basic problems that such barriers present; (4) support of research in communication technology at a limited number of regional units, whose purpose would be to develop new ideas in the field, not in parallel but using different approaches to cover a broad experience and broad areas of experimentation; and (5) support of training, including the traditional types of personnel, who are now scarce, as well as personnel in newer fields.

Mr. Abdian presented the following statement about biomedical communication:

> "While biomedical communication naturally encompasses the same wide range of functions as is involved in all scientific communication, its effective improvement cannot be viewed as a simple corollary to the uniform or standardized improvement of all scientific communication. The experimental environments of biomedical research and development are unique. This uniqueness stems from the essential fact of its concern and involvement with the life processes. In the normal pursuits of biomedical research and development, complex multivariable systems are the rule rather than the exception. As a result, the biomedical sciences are characterized by an entirely different order of uncertainty factors and correspondingly different philosophical, ethical, and operational climates. Under these circumstances, it is natural that the requirements for and uses of biomedical information involve different orders of complexity in its concepts, vocabularies, organization, and reordering.
>
> "It is also important to bear in mind that biomedical R & D, as contrasted with the physical sciences, is pursued very largely in the academic environment, by scientists with generally higher academic levels of professional education and experience. Their information requirements and uses are further affected by the kind and scope of the academic information resources and facilities upon which they are primarily dependent. The design of improved means for processing, communicating, and using biomedical information must be based accordingly on a clear recognition of such significant differences and must provide appropriately for them."

The chairman adjourned the meeting at 5:15 p.m. The Committee reconvened at 9:00 a.m. on 4 October 1963.

Dr. Visscher asked that the day's session be devoted, first, to the consideration of such projects as the Committee would like to see and felt should be accomplished, and second, to the discussion of mechanisms that might be recommended to accomplish these ends.

Dr. Cannan called attention to the fact that this was a study of the problems and needs in scientist-to-scientist communication. This study is the fundamental product that will emerge from these deliberations. It might be well to reach conclusions, rather than recommendations, which then could be placed in the public domain. In an introduction to the report it could be pointed out that in general the conclusions deliberately refrain from identifying sponsors.

Dr. Remsen expressed the opinion that the extent to which biomedical scientists lean on abstracting and indexing services in their daily work should be emphasized. Studies show that with added federal financial support in recent years the currency and inclusiveness of these services have increased. However, for many problem-oriented fields of medical research one must use three or four of these services and still may not obtain the coverage desired.

Several expressed a need to have a group take an over-all continuing look at the extent and quality of the abstracting and indexing services available to each biomedical discipline. Examples of wasteful duplication and void areas would be evident. Such a step might lead to significant work-sharing and more inclusive combined coverage, and may even speed up international cooperation.

The type of operation that Index Medicus and MEDLARS propose could be a general pattern for individual disciplines in developing methods to satisfy their own special needs. Special terminologies developed for disciplinary needs should be capable of integration into a broad indexing system.

The subject of compatibility between indexing services was mentioned by several as being most important. Compatibility was considered to be equally important in the field of abstracts. Dr. Lee felt that to obtain a desirable degree of agreement between systems there will have to be some financial considerations. One method would be to tie in a compatibility requirement with the approval of a grant request for financial assistance. Probably no two people will agree on what is perfect, so a compromise between perfection, practicality, and usability will be necessary.

Indexing and abstracting services are used for current-awareness and retrospective searches. It is now often a year after publication of an article when its abstract appears. Therefore, in general, abstracts cannot promote "current awareness". Abstracting services will need to be in the same time cycle as the indexing services if they are to be really useful as current-awareness tools.

Dr. Kennedy said he believed that the scientists working at the bench at NIH are more concerned with coordinating their communication with people working in the universities than in other government departments. It is at the managerial level that interdepartmental coordination needs to be stressed.

Dr. Jones, in reply to questions about the usage of abstracts, said that at least three categories of persons relied on them: the graduate student, the teacher, and the person working in interdisciplinary fields. The mature investigator may have less use or need for abstracts, as he reads certain core journals and may have his own channels for current awareness. Dr. Jones reported that while he was engaged in writing a textbook he made very extensive use of abstracts, as well as indexes.

Dr. Lazarow, speaking especially of problem-oriented literature retrieval (in his case in terms of diabetes and a specialized information center), said that he would like to have in his computer file a portion of a MEDLARS tape, some further documentation not included in MEDLARS, and a limited number of complete documents. Also, one should be able to add information from any new retrieval service as it becomes available; a basic requirement would be that they were all compatible, to the extent that they could be used in one computer file. In that connection, it is important to have compatible abstracts so that they could also be used in the system.

A group of biomedical scientists should specify their communication requirements with imagination and foresight, and without thinking of the constraints of existing methods and hardware. Once there are specific requirements, then specific solutions should be sought with the same critical, analytical, and experimental approach that is used by scientists in basic research. This would be a cooperative endeavor between the scientist and the documentalist. The hardware people should be challenged to produce hardware that is specifically appropriate for information retrieval.

The extent of biomedical literature coverage offered by <u>Index Medicus</u> was mentioned by several. In general there was a definite sentiment that the present coverage could and should be increased. Increases in both the coverage and the depth of indexing would remarkably increase the value of <u>Index Medicus</u>. The optimum would be to have complete coverage of the biomedical literature, but it was realized that to attempt that would raise many problems.

<u>Dr. Rhoads</u> believed that a reasonable number of regional centers for biomedical communication should be established. These would be libraries, training centers, and centers for research in methods of conducting biomedical information. He would envision them as having excellent collections of documents linked centrally with the National Library of Medicine and the Library of Congress, and linked locally with a substantial number of satellite libraries, medical schools, biological institutes, and other laboratories where biomedical scientists congregate. Each would have access to the advice of a committee of scientists and librarians in the area.

These centers, if they are really to advance the science of biomedical communication, would require personnel with a knowledge of present methods of information handling, knowledge of the technological possibilities in this field, knowledge of information theory, and competence in organizing and operating a strong educational and training program.

In the general discussion, it was brought out that such centers would operate in a broader field than medicine and therefore should be related to universities, rather than medical schools. These centers also are not visualized as substations of the National Library of Medicine. This autonomy in itself might lead to additional problems if a center does not constantly maintain in its program enough over-all coordination in methodology to permit its procedures and products to be integrated with and used by other national or regional information activities. The question to be constantly kept in mind is, "Are we of use to the scientist?"

The cost of such projects surely will be in millions of dollars per year.

In discussing information centers for research, it was pointed out that, in time, certain of them might be found to have only limited usefulness. Therefore, extreme care must be taken to consider the potential costs involved to prevent the creation of a hugh, expensive system with doubtful efficacy. How would one evaluate the effectiveness of a new or expanded service? Criteria would have to be established that would take into consideration the viewpoint of both the research scientist and the professional in the information field. If the clientele of a service or system used it increasingly, that would be a positive sign of its value. Lack of increased usage or even a lessening of patronage probably would indicate that the service or system was unsatisfactory.

Dr. Brayfield was of the opinion that the systematic investigation of scientific information processes should be supported and financial support provided from diverse sources. However, the behavior of scientists in the generation and use of scientific information is in itself an appropriate subject for investigation. The results of such systematic study would contribute importantly to the evaluation of an effective information exchange complex. A formal analysis of the structure and functioning of existing information exchange institutions, practices, and media also would provide a much-needed base line for the appraisal of subsequent developments. Provisions should be adequately trained personnel. One problem in relation to libraries is a lack of standards for a well-defined basic core library and optimum library service. The Medical Library Association has for years tried to improve standards of both libraries and librarians.

Another problem is that of microforms. There is no doubt of their value as a means of storage, but to get scientists to use the forms extensively will require a great deal of re-education aimed at changing habits and methods of obtaining information.

There was considerable discussion about the copyright law as it applies to photocopying. This seems to be a gray area and one that is not a problem at the present time; whether it will be in the future remains to be seen.

Dr. Wilson discussed the publication problem brought about by the increasing number of scientific articles. This problem has been met in two ways: by increasing the size of journals and by establishing new ones. The additional and rising costs of journals has resulted in two support mechanisms: subsidization of a journal and the imposition of page charges. A direct subsidy may be warranted until a new journal has become established.

How does one decide when a new journal is needed? Probably by the backlog of papers at established journals in a special field which tends to indicate that a new science has developed. Perhaps a better criterion is the quality of the articles published by a newly established journal. A journal may be said to be stable when it receives a continuous flow of good papers and has demonstrated editorial competence.

The imposition of page charges is now generally accepted. There have been many opinions expressed on the pros and cons of such charges. Should page charges be allowed by fund-sponsoring agencies to journals published for profit? Should there be a quality evaluation of the article before page charges are approved? An equitable policy needs to be established. A special study of the economics of page charges, to include their effect on the quality of journal articles, would be enlightening.

Dr. Hussey remarked briefly on the results of the Committee's meeting of the past two days. The basic considerations were developed in answer to the question, "Is there a problem?" They are, in greatest part, directed toward and applicable to the coordination of methods of communication. The basic considerations reject the thought that there is need for immediate crash programs or massive innovations without first having pilot studies. This is a reflection of the fact that scientists themselves are satisfied that progress is being made though perhaps not rapidly enough toward effective coordination. There has not been a clear definition of the extent to which coordination now exists or is being planned. A definition of extent must precede a decision for or against the establishment of any agency that would be intended to serve as an instrument for national or international coordination of communication methods or activities. The search for such a definition does not imply an unwarranted delay, but rather represents the attitude that careful diagnosis is a prerequisite for treatment.

A study of the present methods of coordination of communication within the scientific arena of the Federal Government is a logical responsibility of the scientists working in that arena. Dr. Hussey predicted that such a study would itself improve methods for coordination of communication. Such a study would also reveal plans for intragovernmental coordination and the government's intentions with regard to nongovernmental agencies, groups, or individuals.

There is an equal need for such a coordination study among nongovernmental biomedical scientists and organizations. Dr. Hussey feels that in this case also such a study in itself would result in better coordination. The NAS-NRC would be a good focus for a task force to perform the latter study.

In addition to and as a consequence of the two studies suggested, it would be advisable for the NAS-NRC to sponsor a committee to maintain a continuing interest in the coordination of biomedical communication.

Dr. Hussey pointed out that, in the various sections of the tentative report outlined during the past two days, there have been recommendations for several studies or task forces. It might be well to have some committee to coordinate the activities of these several groups as well as the two proposed in his remarks.

Dr. Visscher closed the meeting by telling Dr. Cannan and the Task Force that the report was now in their hands to refine and develop along the lines the Committee had advised. He expressed his appreciation to the Committee members for their assistance and interest in this important problem.

The meeting adjourned at 4:00 p.m.

<u>Note</u>:

1. The tentative recommendations originally submitted to the Committee for consideration are attached to the minutes of the Committee meeting held 19-20 August 1963.

2. The tentative Basic Postulates (now called Basic Considerations) submitted to the Committee for consideration at this meeting are attached.

3. The final revised set of Basic Considerations and the Conclusions and Recommendations were published in the final report on 31 October 1963.

4. The supplement to the report will be issued later.

2 October 1963

Communication Between Scientists

Some Basic Postulates

Synopsis of Postulates

A. Is there a problem?

1. There is a problem. Management finds it more urgent than most scientists do.

2. The problem is international but is more effectively approached nationally or regionally.

3. The problem is science-wide but is more effectively approached by functional disciplinary or interdisciplinary groups.

4. The biomedical sciences constitute a functional interdisciplinary group.

5. Better coordination of disciplinary and national approaches is needed.

B. The nature of scientific communication.

1. Communication is an intrinsic part of research. It is not merely its end-product.

2. Communication is an intellectual process, not a mechanical one.

3. The need is for better rather than more information.

4. Scientists depend upon informal as well as formal channels of communication.

5. The communication needs of a scientist vary with the role he is playing in the scientific scene.

C. Design and management.

1. The biomedical community should retain responsibility.

2. It should build upon the existing system.

3. The system is a complex of components. Better coordination is needed. Coordination should emphasize quality control, and flexibility. It should preseve a degree of redundancy.

4. The processing of documents and the processing of items of information are different kinds of operations.

5. Generators of original communications can facilitate processing by adopting agreed procedures for the presentation of their material.

6. Modern information technology has much to contribute. It also has its limitations.

7. The national network of biomedical libraries is a sound base to which to attach new services.

D. Support. Facilities and Manpower.

1. Agencies sponsoring biomedical research have a responsibility to support essential services that cannot sustain themselves.

2. Sponsoring agencies should encourage research on communications.

3. There is need to recruit and train various types of personnel to serve the communication system. Training and research in communications are best conducted in academic biomedical institutions.

Communication Between Scientists

Statement of Postulates

A. Is there a problem?

1. Communication in science, as in most human affairs, has always been a problem and always will be. The past two decades have witnessed not only a vast increase in the output of new scientific information but also some profound changes in the horizons of the established disciplines and in the ways in which research is conducted and administered. These developments have combined to impose on the national resources for scientific communication severe stresses that are both quantitative and qualitative.

   The scientific community has been coping with the situation reasonably well from its own point of view. It has been expanding established forms of communication and has been contriving and testing new forms. There is no widespread demand by scientists for crash programs or massive innovations. The demand is, rather, for continuing deliberate study and experimentation.

   However, now that society has adopted research as an important instrument of national policy, the days of laissez faire in science have passed. The scientific community faces an obligation to satisfy society that the massive public investment in research is being soundly managed. Scientific communication is no longer the private concern of the individual scientist. It is becoming evident that some of those who are responsible for promoting research in behalf of the public are somewhat fearful that the social returns on the investment are being delayed by inadequate communication of the results of research. In this situation, it behooves the community of science to demonstrate to the satisfaction of society its willingness and its power to continue to manage its own communications effectively. Otherwise, management is likely to be taken out of its hands. In the mind of the scientist, this is the root of the problem and the measure of its urgency.

2. Since science is not constrained by national or cultural boundaries, scientific communication must be international in its scope. The promotion of international activities and innovations is, however, a slow deliberate process. Progress will be more rapid if the initiative is taken by well-established national and regional organizations.

3. The ideal system of communication would be one that embraced all of science. Science is, however, organized and managed by disciplines and in disciplinary groupings, not only professionally and institutionally, but also in respect of sources of support. Inevitably, these disciplinary groups have developed their own channels of communication. It is appropriate that they should retain responsibility for extending information services in their own fields.

4. The life sciences constitute a rational segment of science and, within the life sciences, the biomedical sciences are a coherent group identifiable by their own professional and institutional organizations, by their common conceptual foundations and by their particular obligations to the health and medical services of society. It is appropriate that the biomedical community should take the initiative in putting its own communication system in order.

5. Although, for practical reasons, it seems best to approach the problems of biomedical communication by disciplines and at the national level, it is of the utmost importance that means should be developed to establish interdisciplinary and international coordination of these partial efforts.

B. The nature of scientific communication.

1. It is sometimes asserted that good communication services are needed in order to assure that the product of research shall be expeditiously incorporated into the body of current scientific knowledge. This is a narrow view. Scientific communication fertilizes research at all stages of its conception, development and fulfillment. The kinds of communication services that the scientist will call for change with the progress of his investigation. They vary also with the field of his inquiry, the nature of his problem and the intellectual environment in which he is working. In the engineering and in some areas of physical science the technical report is a very important channel of communication. In the biomedical field it plays an unimportant role.

2. The problem of scientific communication is sometimes conceived as one of finding more efficient means of switching "facts" from the point of origin to places at which they can be used. The problem is much more complex and elusive than this. Intrinsically, scientific communication is an intellectual interaction between individual minds. Ideally, it takes the form of dialogue. It is personal and intimate. It requires a degree of resonance between sender and receiver that cannot be assured by efficient switching devices. Scientific communication has a vagrant quality and is loaded with value judgments. This is particularly true in the biomedical field.

3. The power of science grows by the continuous reordering of information rather than by the passive accretion of "facts". The mounting output of biomedical information calls for a more rather than less rigorous winnowing of the wheat from the chaff; a more severe control of quality and of pertinence. This control can be imposed at all stages of the communication chain from generator to user. It is a control that can be exercised intelligently only by biomedical scientists, not only in the generation and use of information, but, also, in its continual critical evaluation.

4. Studies of the scientific communication complex have tended to place their emphasis on the improvement of the formalized channels for written communications such as journals, abstracts, reviews, etc. The working scientist, however, does not depend on these alone. Much of his communication is informal, oral, or written, either on a person-to-person basis or through seminars, conference and similar impromptu exchanges. In the design of communication systems these informal means of exchanging information should be given due weight.

5. A scientist may be called upon to play many roles in the biomedical scene. At one time or another, he may be investigator, practitioner, expositor, administrator or manager. His needs for information will vary with the role that he is cast to play. An effective biomedical information system should be comprehensive and flexible enough to respond to the habits and needs of all of these groups without necessarily imposing on all the patterns peculiar to any one. Services that attempt to be all things to all men are unlikely to be satisfactory to many.

C. Design and management.

1. In the past, the biomedical community has been largely responsible for the evolution and management of its information services and for securing the means for their support. It is natural that this should have been so, since the biomedical investigator is the primary generator, evaluator and user of new knowledge. The vast expansion and the professionalization of the biomedical research effort have not created any new situation that would justify transfer of this responsibility from the biomedical scientists to some, as yet, undefined group of information specialists. The traditional dealers in information - editors and librarians and publishers - have been recently reinforced by new "middlemen" - documentalists, computing engineers, and information systems designers. Without the educated participation of the generators and consumers of the information, not merely their passive cooperation, the communication system cannot function efficiently despite the ablest middlemen. The situation, therefore, calls for a more intimate integration of the experts in information technology into the biomedical fellowship.

2. It is sound policy to build upon the communication system that now exists and that has been proven by experience rather than to seek to supplant it by major innovations that have not been tested for acceptability, efficiency and compatibility.

3. The biomedical communication system is a complex of many component facilities and services. The existing system may be criticized for inadequate coordination of its components with respect to complementarity and compatibility. In the further development of the system one of the most difficult tasks will be to devise improved means of coordination. There is need to diffuse a greater sense of this responsibility more widely amongst biomedical scientists. Efforts at coordination should emphasize the need for quality, flexibility and plurality in information services. There should be a place for redundancy and for services that repackage information to serve particular groups and individuals. Coordination does not imply the ruthless elimination of duplication.

4. The task of systematically storing and cataloguing documents so that they may readily be retrieved on demand involves operations that differ fundamentally from those of storing and cataloguing related items of information. Both types of service are needed in a comprehensive communication system.

5. The processing of documents and of items of information for ready retrieval requires the cooperation of the generators of new information with those responsible for processing it. Authors and editors must accept a responsibility for presenting new material in such forms as may be devised to facilitate indexing, abstracting and repackaging.

6. Modern information technology, including the use of electronic equipment, microforms and other mechanical devices, has much to contribute to the development of a more coherent system that will save time and manpower by expediting storage and retrieval of information. The danger of premature automation is that it may reduce the flexibility of the system by imposing rigid patterns of communication and by substituting form for substance, remoteness for intimacy and ritual for understanding.

7. Services are more adaptable to individual needs if they are locally accessible to the scientist. A coordinated network of strong local libraries linked to the large national libraries will provide a solid core to which may be attached new resources for the service of scientists.

D. Support, facilities and manpower.

1. In the past, information services have not, in the main, been a public charge. This is a healthy tradition that should be maintained as far as possible since it provides the best assurance that the biomedical community will continue to manage its own communications. The great expansion of scientific information in recent years is, however, largely a result of the growth of research sponsored by public funds. In this situation, sponsoring agencies will accept the principle that communication is a vital element in research and will be prepared to subsidize essential elements of the communication system when it has been demonstrated that it is not possible to maintain them on a self-sustaining basis. Such specialized services as are specifically called for to meet managerial needs of the sponsors of research should obviously be underwritten by management.

2. Research on means of communication can make a very significant contribution to the national biomedical effort. Generous support is warranted, in particular, for studies that seek to exploit modern information technology and to adapt it to the habits and needs of biomedical investigation.

3. There presently exists a shortage of trained personnel to man existing biomedical communication services. Any large effort to improve and diversify these services will intensify the need. There is need for a sustained effort in recruitment and in the provision of a variety of training programs. There is need to recruit personnel whose major experience has been in biomedical investigation or instruction and to train them in the techniques of handling documents and information. There is need, also, to acclimatize librarians, documentalists and other information specialists to the concepts and practices of biomedical investigation. This training should be provided in an academic atmosphere in which education and research in communication are associated together. Graduate schools provided this atmosphere but will probably need to be subsidized if they are to develop the needed facilities.

TELEPHONE: EXecutive 3-8100

CABLE ADDRESS: NARECO
WASHINGTON, D. C.

NATIONAL ACADEMY OF SCIENCES
NATIONAL RESEARCH COUNCIL
2101 CONSTITUTION AVENUE, WASHINGTON ~~25,~~ D. C. 20418

DIVISION OF MEDICAL SCIENCES

14 November 1963

Mr. Charles Bourne
Research Engineer
General Systems Department
Engineering Division
Stanford Research Institute
Menlo Park, California

Dear Charlie,

Enclosed is a copy of the report, "Communication Problems in Biomedical Research". The report has today been sent to Dr. James A. Shannon, Director, National Institutes of Health.

In addition to the report, a supplement will be published and distributed in a few weeks. It will consist of the eight papers listed in the contents page of the report.

Dr. Maurice Visscher, in his foreword, delineates the responsibility assumed by the Advisory Committee. The report reflects the best obtainable consensus of the views of the Advisory Committee members.

This project has been an intense and sometimes confused one. Each one has done his best and it is hoped a product has been produced that will be helpful to the National Institutes of Health.

On behalf of Dr. Cannan and myself I wish to thank you for your loyal support and diligent efforts.

Sincerely,

Edwin B. Coyl, M.D.
Professional Associate

Enclosure

TELEPHONE: EXECUTIVE 3-8100

CABLE ADDRESS: NARECO
WASHINGTON, D. C.

RCA Pen.
proj 4398

NATIONAL ACADEMY OF SCIENCES
NATIONAL RESEARCH COUNCIL
2101 CONSTITUTION AVENUE, WASHINGTON, D. C. 20418

DIVISION OF MEDICAL SCIENCES

2 December 1963

Mr. Charles Bourne
Research Engineer
General Systems Department
Eingineering Division
Stanford Research Institute
Menlo Park, California

Dear Mr. Bourne,

Immediately after the submission to the Director, National Institutes of Health, of the report on "Communication Problems", I disappeared on a trip to Europe. Now that I am back at my desk I want to record the indebtedness of the Division to you for your devotion to the project and your enlightened contributions to the development of facts and argument. I greatly enjoyed working with you.

Ventures of this character in which an informed staff must seek to interact with an advisory group having widely ranging interests and background are difficult and often frustrating. The product, in this case a report, can not be fully satisfactory to anyone because it must be a compromise between conservative and radical opinion, enthusiasm for particular projects and reluctance to face change. Nevertheless, I am convinced that your service contributed more than helping in the drafting of a report. The debate that we were able to stimulate will radiate outward and will have its real influence in helping to persuade the biomedical community to take its communication problems more seriously.

I found the undertaking enlightening and rewarding and hope that you did so also.

Thanks and good luck in your more permanent enterprises.

Seasonal greetings.

Sincerely yours,

R. Keith Cannan

R. Keith Cannan
Chairman of Division

xc: J. Noe

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
BETHESDA 14, MD.

NATIONAL INSTITUTES OF HEALTH
Area Code 301 Tel: 656-4000

December 4, 1963

DEC 5 1963

Dear Dr. Cannan:

This is to acknowledge receipt of the NAS-NRC report on its study of "Communications Problems In Biomedical Research". The report has been widely circulated within the Institutes and Divisions of the National Institutes of Health and is currently under study both there and in my own immediate office. As soon as the staff has had an opportunity to react to the document, I think it would be profitable for us to sit down and discuss the matter in some detail. We are also anxious to see the supplement to the report.

My own personal first impression is that the analysis, as well as the conclusions of recommendations, are sober, sound and solidly grounded in reality. While I anticipate some specific disagreements within the NIH staff on a number of points, I am confident that this document will provide the basis for our continuing evolution towards evermore effective action programs in the field of scientific and technical information and biomedical communications.

I would like to take this occasion to express my deep appreciation to you and to your staff in the Division of Medical Sciences for your splendid cooperation in mobilizing the resources of the Division on short notice to assist us in our efforts to deal with the issues which fall into this category of "communications". I hope you will extend my thanks to the members of the Advisory Committee who must obviously have devoted much thought and effort to the problem with which they were confronted, and also to members of the staff.

I shall try to set up an appointment to discuss the report upon my return from Europe.

Sincerely yours,

JAShannon

James A. Shannon, M. D.
Director

Dr. R. Keith Cannan
Chairman, Division of Medical Sciences
National Academy of Sciences-National Research Council
2101 Constitution Avenue, N. W.
Washington 25, D. C.

Telephone: EXecutive 3-8100

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NATIONAL ACADEMY OF SCIENCES
NATIONAL RESEARCH COUNCIL
2101 CONSTITUTION AVENUE, WASHINGTON 25, D. C.

DIVISION OF MEDICAL SCIENCES

6 December 1963

MEMORANDUM

TO: Members of Advisory Committee to the Study of Problems in Biomedical Communication

FROM: R. Keith Cannan, Chairman of Division of Medical Sciences

Enclosed is a copy of a letter from the Director, National Institutes of Health, acknowledging receipt of the report of our study.

I am sure that you will be happy, as I am, to learn that we have been able to provide a document that NIH will find helpful in the development of its policies and programs.

For your personal contribution to this effort, may I again express the deep appreciation of the officers of the Academy-Research Council.

Enclosure

IAMC

2/7/64

Dear Charlie,

Here is my draft of the Foreword to the Supplement (8 Staff Papers) of the NAS--NRC Report. Of course, Cannan may modify it before publication.

Best regards,

Dick

R.H.O.

Looks OK to me.
[illegible]

FOREWORD

This volume of Staff papers is a supplement to the Report of the Advisory Committee to the NAS--NRC Study of Communication Problems in Biomedical Research.* The Report represents a synthesis of the Staff findings and proposals and of the experience and views of the members of the Advisory Committee. These Staff papers, with their greater length and detail, are being issued separately to exemplify one type of raw material that went into the making of the Report. The Advisory Committee bears no responsibility for the content of these papers, which summarize some of the work of the Staff and its consultants.

Staff and consultants were selected to provide a wide spectrum of backgrounds, knowledge, and viewpoints. Dr. Leeds, who managed the office set up as headquarters for the study, had worked in the field of optical instrumentation after her medical education in Germany and more recently was in charge of the technical information service of an electronics research group. Dr. Coyl's background included participation in many Academy activities with biomedical scientists, and medical practice as a military surgeon.

The consultants rounded out the competencies of the study group. Mr. Abdian worked for many years in governmental activities concerned with scientific information--first as Assistant Chief of the Technical Information Service of the Atomic Energy Commission, and later as Program Director of Research Data and Information Services of the Office of Scientific Information Service, National Science Foundation. He was a member of a task force established by Dr. Jerome B. Wiesner, Special Assistant to the President for Science and

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*National Academy of Sciences--National Research Council: "Communication Problems in Biomedical Research, Report of a Study." 31 October 1963.

Technology, that studied scientific information activities within the Federal Government and prepared the "Crawford" Report in early 1962. Mr. Bourne, the engineering consultant, conducted numerous studies on information retrieval systems. Dr. Lee, whose early experience encompassed teaching and research in physiology, worked on the problems of scientific communication for many years. He served as President of the American Documentation Institute and as Chairman of the Conference of Biological Editors, as well as a member of the President's Panel on Scientific Information, which produced the report, "Science, Government, and Information, commonly known as the "Weinberg" Report. Dr. Ping's experience included teaching; providing information services for a wide range of academic, scientific, and biomedical personnel; and research on library problems.

These consultants were "borrowed" from their respective institutions and spent varying proportions of their time on the study. The Staff and consultants worked on the study at their home institutions.

As rapidly as Staff findings developed, they were presented to the Advisory Committee, either orally or as memoranda and working papers. In addition to the intensive exchange between Staff and consultants and the members of the Advisory Committee at the latter's meetings, there was considerable informal communication between the two groups at all stages of the study.

Many others contributed to the study. A number of organizations, institutions, and governmental agencies provided information and data. Most of these sources are identified in the Staff papers. In addition, many individuals at the several institutional bases of Staff members and consultants provided extra hands and heads at critical times.

Despite the impressive manpower and resources available, the broad scope of the study presented so many challenges, all demanding collection of data and information, analysis, and synthesis, that decisions had to be made early on the priority of various problem areas. Staff and consultants accepted assignments of a score of major and minor projects. A large number of compilations, data sheets and progress reports resulted. For the major projects, and a few of the minor ones, these were distilled by joint effort into memoranda and drafts for working papers. As soon as these acquired enough form and substance to be of some help, they were given to the Advisory Committee. Even then the process of revision continued and as additional material developed, addenda were prepared.

The versions of the working papers that are included here reflect the way they developed and were presented to the Advisory Committee. After the Report was completed, they were revised only to incorporate findings which may have been given to the Advisory Committee orally but not distributed in written form. The process of revision is not yet finished. The Staff and consultants, as individuals, are preparing to publish in appropriate journals a number of articles reporting such of the findings as may interest scientists, editors, librarians and other information service personnel, and those engaged in research and development in the field of scientific information.

With the exception of the first two, each paper in this volume concentrates on a single aspect of biomedical communication. The first paper sets forth Staff suggestions for implementing some of the Committee's recommendations that appear in the Report. The second considers the entire complex of activities serving communication among those engaged in biomedical research and attempts to analyze its characteristics and functions.

The other papers are more typical of scholarly reports in that they are simple presentations of the results of data collection and analysis in the traditional format. The only common thread is that each concentrates on one facet or component of the biomedical communication "system." Paper number 3 assesses the quantity of information generated by the biomedical research community--a factor that has received most of the blame for the information "crisis"--and relates the size of this output of documents and words to the increases in manpower and funds. Paper number 2 examines oral communication, particularly its formal aspects, i.e., meetings. Two types of documents produced and circulated by the system--biomedical serials and technical reports--are the subjects of papers 5 and 7, respectively. Paper number 6 deals with the mechanisms that have developed to enable biomedical scientists to obtain these documents from storage. The last paper analyzes the abstracting and indexing services that enable scientists to find out which documents may contain information they need.

Taken together these papers present a sketchy picture of the biomedical communication complex and its problems--detailed in some spots and merely outlined in others of equal or greater importance. The most glaring defect in the picture is that the whole area relating to the use of information is almost blank. Actually the Staff made a major attempt to find and analyze the facts concerning the wants, needs, and habits of scientists in using information and information services. Most of this effort was expended in learning how few facts and how many opinions there were. Lacking facts, rather than to prepare either a distillation of more or less informed opinions, or a consensus of Staff views, we elected to leave it blank in the hope that it would be filled in as the Advisory Committee discussed this critical area and resolved the value conflicts that always become evident during such discussions. In retrospect, we believe this decision was wise, and we see more clearly than ever that the biomedical community itself must make the many value judgments critical for any real effort to improve biomedical communication.

COMMUNICATION PROBLEMS
IN
BIOMEDICAL RESEARCH

SUPPLEMENT
to

A REPORT SUBMITTED ON 31 OCTOBER 1963
to the
DIRECTOR, NATIONAL INSTITUTES OF HEALTH

10 March 1964

NATIONAL ACADEMY OF SCIENCES–
NATIONAL RESEARCH COUNCIL

COMMUNICATION PROBLEMS IN BIOMEDICAL RESEARCH

SUPPLEMENT

to a

Report of a Study

by

The Division of Medical Sciences

National Academy of Sciences - National Research Council

in cooperation with

The Federation of American Societies for Experimental Biology

and with

The Institute for Advancement of Medical Communication

10 March 1964

With the Support of

The National Institutes of Health, Public Health Service
Contract No. PH43-72-167

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STAFF PAPER NO. VIII: ABSTRACTING AND INDEXING SERVICES IN BIOMEDICINE

FOREWORD

Richard H. Orr, M. D.
Director, Institute for Advancement of
Medical Communication

The Division of Medical Sciences of the National Academy of Sciences-National Research Council has recently prepared and issued a Report on communication problems in biomedical research.* The Report represented a synthesis of the views and experiences of the members of an Advisory Committee of the Division and the results of a series of studies and proposals by a Staff assembled specifically for this project.

The present volume constitutes a Supplement to the above Report and comprises a group of papers prepared by the Staff for consideration by the Committee. These papers are published separately because of their bulk and because the members of the Staff, rather than the members of the Committee, assume responsibility for their content.

The design and conduct of the Staff studies were under the immediate direction of the writer of this Foreword. Headquarters for the studies were established at the Federation of American Societies for Experimental Biology in Bethesda, Maryland, and were organized and managed by Dr. Alice A. Leeds. Intimate liaison with the Academy-Research Council was maintained by assignment to the study of Dr. Edwin B. Coyl from the staff of the Division of Medical Sciences.

Dr. Leeds, after completion of her medical education in Germany, became engaged in the field of optical instrumentation and, more recently, was in charge of the technical information service of an electronics research group. Dr. Coyl had an extended career as a military surgeon before joining the staff of the Academy-Research Council.

The competences of the study group were extended by the part-time services of several consultants, who conducted their studies at their own institutions but made frequent visits to Washington for joint consultation. Mr. Gregory Abdian worked for many years in government activities concerned with scientific information: first as Assistant Chief of the Technical Information Service of the Atomic Energy Commission, and later as Program Director of Research Data and Information Services of the Office of Scientific Information Service, National Science Foundation. He was a member of a task force established by

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* National Academy of Sciences-National Research Council: "Communication Problems in Biomedical Research: Report of a Study," 31 October 1963. This study was carried out under contract with the National Institutes of Health.

Dr. Jerome B. Wiesner, Special Assistant to the President for Science and Technology, that studied scientific information activities within the Federal government and prepared the "Crawford Report" in early 1962. Mr. Charles Bourne, the engineering consultant, has conducted numerous studies on information retrieval systems. Dr. Milton O. Lee, whose early experience encompassed teaching and research in physiology, has worked on the problems of scientific communication for many years. He has served as President of the American Documentation Institute, as Chairman of the Conference of Biological Editors, and as a member of the President's Panel on Scientific Information, which produced the report, "Science, Government, and Information," commonly known as the "Weinberg Report." Dr. Vernon M. Pings's experience has included teaching; providing information services for a wide range of academic, scientific, and biomedical personnel; and research on library problems.

Many others contributed to the study. A number of organizations, institutions, and government agencies provided information and data; most of these sources are identified in the staff papers. In addition, many individuals at the several institutional bases of Staff members and consultants provided extra hands and heads at critical times.

Despite the impressive manpower and resources available, the broad scope of the study presented so many challenges, all demanding collection of data, analysis, and synthesis, that decisions had to be made early on the priority of various problem areas. Staff and consultants accepted assignments of a score of major and minor projects. A large number of compilations, data sheets, and progress reports resulted. For the major projects, and a few of the minor ones, these were distilled by joint effort into memoranda and drafts for working papers. As soon as these acquired enough form and substance to be of some help, they were submitted to the Advisory Committee. Even then, the process of revision continued and as additional material developed, addenda were prepared.

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With the exception of the first two, each paper in this volume concentrates on a single aspect of biomedical communication. The first paper sets forth Staff suggestions for implementing some of the Committee's recommendations that appear in the Report. The second considers the entire complex of activities serving communication among those engaged in biomedical research, and attempts to analyze its characteristics and functions.

The other papers are more typical of scholarly reports in that they are simple presentations of the results of data collection and analysis in the traditional format. The only common thread is that each concentrates on one facet or component of the biomedical communication "system." Paper No. III assesses the quantity of information generated by the biomedical research community (a factor that has received most of the blame for the information "crisis") and relates the size of this output of documents and words to the increases in manpower and funds. Paper No. IV examines oral communication, particularly its formal aspects, i.e., meetings. The production and circulation of serials and of technical reports are the subjects of papers V and VII, respectively. Paper No. VI deals with the mechanisms by which biomedical scientists may obtain these documents from storage. The last paper analyzes the abstracting and indexing services that enable scientists to find out which documents may contain information they need.

Taken together, these papers present a sketchy picture of the biomedical communication complex and its problems, detailed in some spots and merely outlined in others of equal or greater importance. The most serious omission is the whole area relating to the use of information. The Staff made a major attempt to find and analyze the facts concerning the wants, needs, and habits of scientists in using information and information services. Most of this effort was expended in learning how few facts there were, and how many opinions. We finally elected to make no attempt to develop a consensus, in the hope that this would emerge as the Advisory Committee discussed this critical area and resolved the value conflicts that always become evident during such discussions. In retrospect, we believe this decision was wise, and we see more clearly than ever that the biomedical community itself must make the many value judgments critical for any real effort to improve biomedical communication.

SYNOPSES OF THE SUPPLEMENTAL STAFF PAPERS

SYNOPSIS - STAFF PAPER NO. I. SUGGESTIONS FOR IMPLEMENTING CERTAIN OF THE CONCLUSIONS AND RECOMMENDATIONS IN THE REPORT OF THE STUDY

The Staff, in the course of preparing background material for the Advisory Committee, developed certain ideas as to ways to carry out some of the conclusions and recommendations made in the Report. This paper contains an outline of these ideas.

SYNOPSIS - STAFF PAPER NO. II. THE BIOMEDICAL COMMUNICATION COMPLEX EXAMINED AS A SYSTEM

The biomedical communication complex is analyzed as a system from the functional viewpoint. A qualitative model is developed in which the major functional components are (1) generation-use, (2) oral communication, (3) primary record processing, (4) document processing, (5) information processing, and (6) research and development aimed at improving these functions. Between generation and use, the flow of information through components 2, 3, 4, and 5 depends on chains of processing operations. The rate of flow through a given component is governed by the rate of its slowest operation except where alternative paths exist. In addition, the operations of each component depend, in general, on the accomplishment of the operations of a preceding component. This crude model can serve as a framework for collecting the data required to develop a quantitative model and can be useful in considering the problems of biomedical communication and their possible solutions. The financial support of this complex of operations comes from government, private foundations, industry, academic institutions, and use fees for services (e.g., subscription fees). The present trend is increasingly toward dependence on government support.

SYNOPSIS - STAFF PAPER NO. III. INFORMATION OUTPUT OF BIOMEDICAL RESEARCH AND DEVELOPMENT

This staff paper presents an analysis of the hypothesis that the quantity of printed information generated by the biomedical research and development effort is directly related to manpower and less directly to expenditures. Available data on publications directly attributable to the biomedical R & D effort in the past decade are supplemented by data collected from annual bibliographies of NIH staff, NIH Research Grants Indexes, Index Medicus, the Mayo Clinic, and the Medical College of Virginia. The number of publications by NIH grantees is compared with the number of extramural research projects supported by NIH and with the expenditures for such support. An excellent correlation exists between growth in number of projects during the period 1956-1959 and number of publications by grantees in the years 1958-1961. The ratio of publications in a given year to active projects two years previously is relatively constant at around 1.4. The incidence of multiple authorship has been increasing rapidly in the past 20 years; and for some author populations, the average number of authors per "paper" now exceeds 2. The "publication productivity" (i.e., the ratio of total number of publications by a given population to the number of individuals in that population) of different types of research communities varies widely. The data suggest a possible decrease in publication productivity over the past two decades, but further analyses are required to establish whether a significant trend exists. The total volume of literature directly attributable to U.S. biomedical R & D is estimated at 32,000 papers in 1957 (60 percent of the total U.S. biomedical literature) and 54,000 papers in 1961.

SYNOPSIS - STAFF PAPER NO. IV. TRENDS IN ORAL COMMUNICATION

The Staff collected data on selected aspects of oral communication from published materials and records of professional societies and government agencies. This paper summarizes the findings and indicates areas for future study. In 1961, there were about 500 scientific biomedical societies in the United States. These societies held some 1,600 regular meetings during the year. The number of regular society meetings has tripled in the past three decades. This increase is secondary to the proliferation of societies in this period. State and local societies accounted for four-fifths of the total number of regular meetings. Publication of lists of forthcoming meetings constitutes an announcement service that is provided by journals and specialized activities. All such services depend ultimately on the initiative of sponsors of meetings in sending out notices. Comparing 1956 with 1962, the over-all increase in meetings announced by a combination of the major services was 48 percent, but international meetings increased by 117 percent and ad hoc meetings (as contrasted with regularly scheduled meetings) increased by 206 percent. Meetings serving large segments of the biomedical research community have grown annually by some 10 to 20 percent since 1957. This growth rate is close to that for biomedical research manpower. Available data on expenditures by NIH grantees can be interpreted as indicating that they are traveling more. In the past 10 years, the number of U.S. personnel working abroad in biomedical fields has increased by 50 percent, but in other fields the increase is much larger. The same phenomenon is seen with foreign scientific and technical personnel working in the U.S. Data on Federal expenditures for direct support of scientific meetings are conflicting, but indicate that over one-fourth of the extramural funds NIH devotes to the support of all types of information activities goes to the support of meetings. In 1960, about $6.5 million (3.2 percent) of NIH extramural research funds went for oral communication activities. We conclude that there are insufficient data to test the important hypotheses offered by observers of the current scientific scene: that the written record is being bypassed and relegated to a largely archival function, that scientists are spending relatively more of their time in oral communication, and that meetings are becoming a less effective means of communication. The importance of the unanswered questions and the large amount of scientist-time used for oral communication warrant more study than oral communication has previously received and systematic development efforts to improve both meetings and informal oral communication.

SYNOPSIS - STAFF PAPER NO. V: CHARACTERISTICS OF THE BIOMEDICAL SERIAL LITERATURE

This staff paper describes quantitatively some of the aspects of the biomedical literature that affect current and future information problems. Previous studies and standard reference compilations were critically reviewed for substantiated data. Additional data were collected on samples of the document output of the U.S. biomedical research community that were developed from the Annual Bibliography of NIH Staff for 1961 and the NIH Research Grants Index, Fiscal Year 1962. Data on the number, growth, and languages of biomedical serials and papers, and on the distribution and character of papers resulting from U.S. biomedical research, were analyzed. Around 5,800 substantive biomedical serials were alive in 1960--an increase of less than 20 percent over 1950. Of the serials born after 1950 about one-third died before 1960. During the same decade, the number of biomedical articles increased by not more than 30 percent. Shelf space required for the average biomedical serial increased by 10 percent. Review papers constituted only 3 percent of all contributions to the biomedical literature. The literature resulting from U.S. biomedical research increased more rapidly than biomedical literature as a whole. In particularly active fields of research, growth spurts occurred; e.g., the literature of psychopharmacology increased from 900 papers in 1955 to almost 2,600 papers in 1959. Of the different publications ("titles") in which NIH staff papers appeared, 10 percent contained more than half of all the papers. For NIH grantee papers, 10 percent of the titles carried almost three-fourths of all the papers. Of the papers generated by both populations, over four-fifths appeared in journals, compared with around 5 percent in proceedings volumes. Up to 20 percent of the publications of NIH grantees are abstracts of reports given at meetings or brief, preliminary accounts of research. The general conclusion is that the growth rate of biomedical literature may have decreased at some time before 1950 and that an increasing proportion of the output of U.S. biomedical research is finding its way into publications that would not be considered biomedical in the conventional sense.

SYNOPSIS - STAFF PAPER NO. VI: SECONDARY DISTRIBUTION OF DOCUMENTS

By 1965 improved reference-retrieval services, such as those to be provided in the MEDLARS program of the National Library of Medicine (NLM), will enable the biomedical scientist to obtain references to relevant documents more easily and from a broader segment of the world's scientific literature than at present. References to relevant material are, however, of no value to the scientist unless he can obtain the documents referred to. This staff paper will explore the likely impact of improved reference-retrieval services upon the present library system that supplies the biomedical scientist with documents. Past studies are reviewed and analyzed, and some new data are assembled. We find that the cost of maintaining U.S. biomedical libraries probably exceeds $12,000,000 annually. From their own collections, these libraries supply locally an unknown proportion of the total documents needed by the biomedical community, and meet the residual demands by an extensive interlibrary loan network. The flow of documents in this network has been increasing by about 10 percent a year since 1958, and presently amounts to over 600,000 documents. With an average cost to the lending and borrowing libraries of $4.00 per completed "loan" of an original document or a photocopy, the annual cost of interlibrary transactions now exceeds $2,000,000 annually. Current signs of strain indicate that the network, as presently operated and financed, has reached its maximal capacity and is critically unstable. The demand for interlibrary loans may well reach 1,000,000 documents annually in 1965; to meet this demand, the network must be radically strengthened if the biomedical scientist is to benefit from the improved reference-retrieval services that will become available to him.

SYNOPSIS - STAFF PAPER NO. VII: TECHNICAL REPORT LITERATURE IN BIOMEDICINE

This paper reviews briefly the generation, processing, and use of technical reports; summarizes Staff findings relating to the volume, origin, and distribution of biomedical technical reports; and assesses the current and potential importance of technical reports to the biomedical community. In addition to reviewing published information, the Staff examined the announcement periodicals of the major technical report services: the Defense Documentation Center (DDC) of the Department of Defense (DOD), the Division of Technical Information of the Atomic Energy Commission (AEC), the Office of Scientific and Technical Information of the National Aeronautics and Space Administration (NASA), and the Office of Technical Services (OTS) of the Department of Commerce. All scientists may purchase reports from OTS. Only those engaged in Federally supported work are eligible to use the first three services. U.S. Public Health Service grantees' eligibility for DDC services was clarified recently. Technical reports differ in general from journal articles in that they are longer, the criteria for review are different, distribution is more restricted, and abstracting-indexing is performed mainly by services that do not handle the bulk of journal literature. A relatively small proportion of technical reports later appear as journal articles. Most academic biomedical libraries do not possess the bibliographic tools and techniques to handle this form of literature. For 1962, 1,615 biomedical technical reports were identified, of which over half were sponsored by DOD. Prices of biomedical reports available from OTS averaged $5.21. Of 916 non-classified DOD reports, 609 were available from OTS. It is concluded (1) that the technical report literature is at present relatively unimportant to biomedical scientists, but will assume greater importance in the future; (2) that the use of technical reports by most U.S. biomedical scientists has, in the past, been characterized by practical difficulties, some of which have been recently remedied; and (3) that if this literature is to be exploited fully, the biomedical community must become better acquainted with this resource and acquire the tools and techniques for handling it.

SYNOPSIS - STAFF PAPER NO. VIII: ABSTRACTING AND INDEXING SERVICES IN BIOMEDICINE

This paper outlines the functions, requirements, and economics of

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ices. It presents data on the number, perform-
ervices that are useful to biomedical scientists.
ices are considered to include those which list
act, and those which only index. The basic
indexing services are (1) to alert scientists
ocuments, (2) to provide an efficient tool for
record, and (3) to supply a ready reference of
ormation. Performance requirements depend on
ized by a service, and compromises are dictated
nts and economics. "Discipline-oriented" serv-
he long-term function of facilitating retrieval
rd, whereas, "mission-oriented" services gener-
alerting function. Three hundred twenty-six
vices process biomedical literature. All together,
0,000 documents a year, not all biomedical, and
y a document processed by more than one service.
that provide either abstracts or indexes processes
nts a year. The output of these large services
verage, by 190 percent over the past 10 years.
in 1962 for abstracting and indexing biomedical
d at $4 million. Each of the 882 journals repre-
.S. biomedical research output (14,334 journal
rantees as resulting from their work) was covered
than three of the 13 major services, and almost
ere covered by at least one of the services. Two of these services, <u>Index Medicus</u> and <u>Bibliography of Agriculture</u>, covered 94 percent of the articles in the sample. Coverage of a random sample of the literature generated by world-wide biomedical research would probably not be as complete. It is concluded that abstracting and indexing services useful to biomedical scientists have improved significantly in the past 10 years as regards completeness of coverage and currency; but that, with rising unit costs and demands for better services, closer cooperation among the various services is imperative if we are to maintain our pluralistic system. The greatest problem is seen to lie in stimulating the necessary cooperation.

abstracting-indexing services. It presents data on the number, performance and costs of those services that are useful to biomedical scientists. Abstracting-indexing services are considered to include those which list titles, those which abstract, and those which only index. The basic functions of abstracting-indexing services are (1) to alert scientists to the existence of new documents, (2) to provide an efficient tool for searching the scientific record, and (3) to supply a ready reference of condensed or digested information. Performance requirements depend on which function is emphasized by a service, and compromises are dictated by conflicting requirements and economics. "Discipline-oriented" services tend to emphasize the long-term function of facilitating retrieval from the scientific record, whereas, "mission-oriented" services generally concentrate on the alerting function. Three hundred twenty-six foreign and 142 U.S. services process biomedical literature. All together, they process almost 2,000,000 documents a year, not all biomedical, and this figure includes many a document processed by more than one service. Each of 12 U.S. services that provide either abstracts or indexes processes more than 10,000 documents a year. The output of these large services has increased, on the average, by 190 percent over the past 10 years. Total U.S. expenditures in 1962 for abstracting and indexing biomedical literature are estimated at $4 million. Each of the 882 journals represented in a sample of U.S. biomedical research output (14,334 journal articles cited by NIH grantees as resulting from their work) was covered by an average of more than three of the 13 major services, and almost all sample journals were covered by at least one of the services. Two of these services, <u>Index Medicus</u> and <u>Bibliography of Agriculture</u>, covered 94 percent of the articles in the sample. Coverage of a random sample of the literature generated by world-wide biomedical research would probably not be as complete. It is concluded that abstracting and indexing services useful to biomedical scientists have improved significantly in the past 10 years as regards completeness of coverage and currency; but that, with rising unit costs and demands for better services, closer cooperation among the various services is imperative if we are to maintain our pluralistic system. The greatest problem is seen to lie in stimulating the necessary cooperation.

NAS-NRC Study on Communication Problems in Biomedical Research

Staff Paper No. I

SUGGESTIONS FOR IMPLEMENTING CERTAIN OF THE CONCLUSIONS AND RECOMMENDATIONS IN THE REPORT OF THE STUDY*

The NAS-NRC Report of a study on Communication Problems in Biomedical Research, dated 31 October 1963, contains, on pp. 14 through 31, a series of conclusions and recommendations. The staff that prepared the background material for the Advisory Committee developed some suggestions for ways to carry out certain of the conclusions and recommendations. The section headings, designations, and page numbers that follow correspond to those of the original report and should be considered in that context.

B. FACILITIES AND SERVICES.

5. Specialized Information Evaluation Centers or Services (pp. 16-17).

The most promising subject-matter fields for SIEC's would appear to be those characterized by rapid expansion, large quantities of unevaluated and often conflicting data, convergence of disciplines or sciences, and widely scattered sources of relevant information.

The criteria used to select institutions in which to establish SIEC's might include:

(1) the existence of an outstanding research program in the subject-matter field at the institution;
(2) enthusiasm of the members of the research staff in supporting the establishment of an SIEC, and
(3) access to a local, excellent information service, such as an adequate biomedical library.

It is desirable that pilot projects emphasize flexibility and variety in the information services they offer, and that they be sensitive to the needs of all potential users. A concentration of effort on intellectual, rather than mechanical, processing of information would seem desirable. A record of data on the operation of each pilot project should be maintained that would be sufficient to enable an outside group to evaluate its effectiveness.

6. Specialized Information Centers (pp. 17-18).

Centers established to provide true information retrieval would be most useful in fields where there is a special need to exploit new

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* Not for publication or publication reference.

information rapidly; where the types of answers needed are relatively few and predictable; where agreement on terminology facilitates indexing; and where sources of relevant information are widely scattered.

The same general requirements or criteria as are listed above for an SIEC should be used to select an institution in which to establish an SIC. The SIC should also maintain an adequate record of its activities so that it can be evaluated by an independent group.

8. Support of Local Biomedical Libraries (p. 20).

The following steps are considered as appropriate for implementing this recommendation:

(1) Libraries applying for federal aid would submit detailed plans to the appropriate agency for improving their services and could request a first-year grant of up to one-third of their expenditures in the base year. The size of grants in subsequent years might be governed by the library's ability to utilize additional funds efficiently. All grants would be conditional on evidence that the institution's contribution to its library's budget is maintained at least at the level of the base year.

(2) As standards for library services are established (see Sec. C.4.a of the Report and of this paper), these could be used to judge progress and to guide the program.

This grant program, which should be independent of any programs for establishing new libraries or constructing physical facilities, might be continued for 3 years, or until a better long-term support mechanism has been developed.

Local information services could be improved by the use of biomedical literature specialists who would work directly with the institution's research teams but would be assigned administratively to the library. The salaries of these specialists could appropriately be charged to the direct costs of research.

9. Interlibrary Loan Network (p. 20).

For short-term support of the interlibrary loan network, any non-profit, non-federal library might, upon application to the appropriate federal agency, be granted $4.00 for each lending transaction to a biomedical library up to 1,000 such transactions per year, and $2.00 for each transaction above 1,000. Grant payments to the library might be on an annual or semiannual basis, rather than by individual transaction billing. Furnishing a photocopy would be considered "loaning." The conditions under which a lending institution would receive such aid might be:

(1) that the lender not charge the borrower for reasonable amounts of material or photocopying;

(2) that the lender, during the last three calendar years, loaned an average of at least 250 items per year to biomedical institutions;

(3) that the lender be able to answer 90 percent of the requests it receives within 3 working days (a request would be considered to be answered by shipment of the requested document or by a statement that, because the document is not available in its collection, the request has been forwarded to a specified institution; the latter implies that each lender would have the resources necessary to locate material not in its own collection);

(4) that the lender accept requests by telephone as well as by mail and dispatch requested material by the fastest means;

(5) that funds available from this program be used not to support the lender's general operation, but only for interlibrary loan service; and

(6) that the lender maintain and make available specified minimum statistical and management records.

This program is not proposed as a permanent means for subsidizing libraries. A limit of 5 years should be placed on the program, which would allow time to complete a study of the long-term support needed to maintain satisfactory interlibrary loan services.

11. Pilot-Trials of Miscellaneous Non-Conventional Types of Services (pp. 21-22).

a. Making orally presented information available quickly upon request.

In dynamic, mission-oriented fields of biomedical research and development, the interval between the presentation of results at meetings and publication assumes importance. Various mechanisms are being used in physics and chemistry to decrease this "unavailability" gap. In general, these do not appear particularly well suited for biomedical research. Several other mechanisms, however, seem appropriate for pilot trials.

The Psychopharmacology Service Center of the National Institute of Mental Health has, in recent years, written to meeting participants requesting copies of the texts of their oral reports. Such material has been used only by the staff of the Center unless the author gave the Center express permission to supply a copy to a specific investigator who had requested it. On this basis, the Center has obtained excellent cooperation from authors. An independent survey, in which investigators in psychopharmacology were interviewed regarding their publishing and information-acquiring habits, indicated that the majority would use and cooperate with a service that would make informal records of oral reports freely available to qualified investigators on request. In view of the precedent that has been established in psychopharmacology and the demonstrated acceptance of the idea in this field, the

Psychopharmacology Service Center might undertake a pilot trial of a service to be known as RIB (Research Information Bank). The following general approach is suggested:

(1) invite each NIH grantee in this field to provide RIB with a copy of the text of his oral reports, positive prints of his slides, and any additional data or details of methodology that he would have presented at the meeting if time had permitted;
(2) extend the same invitation to others giving relevant papers at meetings;
(3) ascertain the author's action or plans regarding publication;
(4) publish an announcement periodical consisting of indexed abstracts of these oral reports, noting those already published (or accepted for publication), and distribute this periodical to NIH grantees in the field and to other responsible investigators;
(5) supply to responsible investigators, on request, a replica of the full manuscript, slides, and additional material;
(6) extend the same services to the editors of scientific journals, who may wish to solicit publication of selected reports;
(7) periodically ask contributors to RIB about plans for publication of their oral reports;
(8) announce publication, when it occurs, in the announcement periodical and answer future requests for that report by referring to the published article; and
(9) study the economics of this type of service, its acceptance by contributors, its utilization, its value in establishing personal contacts, its influence on the research of users, and the effects of feedback stimulated by this mechanism on the publication that ultimately results from an oral report.

Another mechanism that might be tried, to answer requests, is the use of tape recordings made at meetings, and copies of the slides projected. This service could be tested by a professional organization.

A third possible mechanism involves voluntary deposition of the text and visual material of an oral report with the society sponsoring the meeting. Pending publication, the society would, on request, make copies of this material available.

C. SPECIAL STUDIES RELATED TO IMMEDIATE NEEDS.

2. Publications (pp. 24-25).

a. Page charges.

In conjunction with studying the implication of page charges in the biomedical field and exploring alternative methods of subsidizing publication, tentative minimal standards to qualify for subsidy, and other appropriate conditions for support, might be assessed for their acceptability to the biomedical community.

<u>Suggested minimal standards for publication of original work:</u>

(1) Except for special cases, each manuscript should be reviewed by at least two scientists qualified to judge the merit of the work reported.

(2) The title of a paper should be specific and informative, and should contain a high proportion of words useful for mechanical or human indexing.

(3) A carefully edited, author-prepared abstract meeting certain standards should be printed with each paper and made freely available for reprinting by any abstracting service.

(4) When a suitable thesaurus for the given field becomes available, indexing terms selected by the author and the editor should be printed with the paper and made freely available for use by indexing services.

(5) The most widely accepted editorial conventions should be followed.

(6) While high standards of editorial processing and refereeing are maintained, efforts should continue to reduce the average time between receipt of a manuscript and its publication.

<u>Suggested conditions for support (in addition to meeting minimal standards):</u>

(1) Publication subsidies (including page charges) should be used to supplement, not to replace, funds previously committed to publication, or should be used to lower subscription prices and thereby encourage wider circulation.

(2) Publication subsidies should not be so high that the publishing organization is relieved from the necessity of striving continuously for economy.

(3) Publications receiving subsidies should submit annual financial reports as evidence that conditions (1) and (2) are being met.

4. <u>Library Services (pp. 25-26).</u>

a. <u>Standards for library services.</u>

The proposed study might be undertaken by a Commission with a membership representing the key biomedical research disciplines, medical librarians, special librarians, operations research specialists, and documentalists. This Commission could assess the information services presently offered to biomedical scientists in academic, non-profit research, industrial, and governmental institutions and define tentatively both minimal and optimal standards for each major type of local biomedical information service. These definitions would be made in terms of operational measurements of functions performed, rather than of statistics on "volumes" held, on expenditures, or on number of staff. For example, the standards for document delivery might be stated in terms of minimal percentage of a random sample of literature that can be delivered within an hour, a day, or a week. The standards for reference services might be in terms of the time required to answer a selection of typical reference questions. These standards could be reviewed annually and revised as user demands changed.

This Commission might also determine the kinds of data required to assess the cost of each type of service. These data could be collected systematically by the Medical Library Association and the National Library of Medicine. When combined with data on the use of services, they would provide a basis for meaningful estimates of minimal and optimal levels of library expenditures.

D. RESEARCH AND DEVELOPMENT.

1. Specific Research Projects (pp. 26-27).

d. Microforms.

Inasmuch as microforms are now used chiefly for storage and preservation, and librarians generally consider the preservation of the scientific record part of their function, the Medical Library Association (MLA) would be an appropriate organization to undertake a program to review systematically the biomedical literature and establish priorities for reducing parts of this "record" to microform. The general policies of this program might be as follows:

(1) the initial selection of titles (books and journals) for microreproduction should be based on use, age, and bulk;
(2) generally, titles should be selected only if held by enough libraries for the prorated cost of microreproduction to represent significant savings over the cost of storing the original documents;
(3) before final action is taken, the titles selected should be made public so that commercial firms could decide whether they wished to market the titles in microform;
(4) responsibility should be assigned to specific institutions for preserving the original documents in good condition;
(5) funds should be sought for microreproduction of unique or rare documents; and
(6) NLM should obtain a copy of each microreproduction

resulting from this program and assume responsibility for preserving it in this form or, when microreproduction technology advances, in a more advantageous form.

f. Behavioral studies.

Citation indexes have great potential as a tool for these studies.

2. Centers for Research and Development (pp. 27-28).

a. Centers for development of local document and information processing services.

Appropriate areas for development at these centers might include (but not be limited to) the following:

(1) selective dissemination of documents to individuals on the basis of their interest;
(2) education of the local biomedical community on information resources;
(3) mechanization of "housekeeping" functions;
(4) training of biomedical information service specialists;
(5) integration of the center's staff with research teams;
(6) adaptation of services provided in industrial research establishments to academic and non-profit institutions;
(7) increasing the efficiency and effectiveness of standard library services;
(8) testing systems for microform storage and retrieval;
(9) collecting data on the interactions between local and regional information centers and between biomedical libraries and specialized information centers of various types, and designing and testing new types of relationships;
(10) new techniques of document analysis, announcement, search, retrieval, and delivery; and
(11) expansion of library services to include audiovisual services, editorial services, and clinical record processing.

Proposals for such programs could be judged by:

(1) the degree to which the total needs of the local biomedical community are considered;
(2) evidence of a systematic, objective approach to evaluation of services;
(3) qualifications of the project director and staff;
(4) evidence of support, enthusiasm, and participation on the part of the local research community;
(5) exploitation of the full resources of the parent institution; and
(6) originality, tempered by realism.

E. TRAINING.

1. The Training of Personnel for Information Services (pp. 28-29).

Agencies sponsoring biomedical research might consider supporting the following types of programs:

(1) training programs, for biomedical literature specialists, conducted jointly by a library school and a medical school, and similar to those currently sponsored by NSF for the physical sciences and engineering;
(2) expansion of existing "internship" programs as a means of upgrading present biomedical librarians; and
(3) on-the-job, intensive, short-term training of biomedical information service specialists by biomedical libraries, information centers, and abstracting-indexing services.

A candidate for the third type of program in academic biomedical libraries should have at least a bachelor's degree with a major in science, preferably a biological science. As soon as possible, he would start working directly with scientists to serve their individual needs and thereby, in effect, extend library services into the laboratory. Part-time training for graduate students could also be considered.

Recruitment by academic biomedical libraries might be facilitated as follows:

(1) Libraries could create an image that is attractive to qualified personnel by becoming, in fact, centers through which biomedical scientists can use all local, regional, national, and international information services; by upgrading promising members of their present staffs through outside training; by freeing trained staff members to work directly with the library's users; by streamlining housekeeping functions and using clerical help to perform those tasks for which trained staff members are not required; and by initiating continuing research to improve the libraries' services.

(2) Medical schools could assist biomedical libraries to develop this new image by rapidly increasing library salaries to levels competitive with those in industrial information services; by giving faculty status to appropriate members of the library staff; by revitalizing the faculty library committee; and by appointing as the committee's chairman a scientist who is engaged in research. This chairman should take an active role in facilitating the integration of the library and its personnel into the mainstream of academic research and teaching.

(3) The Medical Library Association and the Special Library

Association could jointly urge, initiate, and sponsor a curriculum revision study for library schools similar to the program for basic science curricula revision supported by NSF.

June 1963
(Revised December 1963)

NAS-NRC Study on Communication Problems in Biomedical Research

Staff Paper No. II

THE BIOMEDICAL COMMUNICATION COMPLEX EXAMINED AS A SYSTEM*

INTRODUCTION

Rationale of Approach

The complex of all the activities, services, and processes that deal with the information generated and used by the community of biomedical scientists can be considered to represent a "system," in the same sense in which an organism constitutes a system. Both have evolved in response to needs, both are self-organizing, and neither was "designed," in the usual sense. The advantages of a systems approach are: that it facilitates analysis of the functions served by this heterogeneous and seemingly amorphous complex, and that it aids in visualizing abstract processes and their interactions. Study of the biomedical communication complex as a system is similar to physiological research, in that it attempts to correlate structure with function and to gain an understanding of the processes occurring in a dynamic system.

In this paper, the results of our analysis are presented in the form of block diagrams. Gray recently emphasized the value of such diagrams in a discussion of engineering's contribution to physiology:

> "The engineer has developed one device for enforcing an elementary rigorousness that is refreshingly simple and general. This is the block diagram, a qualitative mathematical model which conveniently displays, without distracting detail, all the components and variables of a system together with their circuitry....
>
> "On several occasions I have had the opportunity to watch a fellow physiologist attempt to represent in this simple form, and at this elementary level, the system on which he is expert. He is usually flabbergasted to discover that his ready knowledge is unequal to the task. He finds he is uncertain about numerous items suddenly revealed for the first time to be of key importance. The usual result is a period of cerebration more intense, novel, and cogent than any he had previously accorded the system, punctuated by trips to the library to find answers to questions never before asked. If a workable diagram is eventually formulated, the light it sheds may be truly exciting. One can suddenly see physiological flesh and blood as a coherent, determinate, functioning system...." (1)

His description of the physiologist's experience fits ours exactly.

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* Not for publication or publication reference.

Nature of the System

A system may be broadly defined as a bounded complex of elements--men, machines, or objects--interrelated by processes and responding to events to achieve an objective. In the case of the biomedical information complex, the generators and users of information must be included, as well as the men and machines handling the information between generation and use. The objects in this system are "documents," in the general sense, i.e., all types of manipulatable records, including films and magnetic tapes, as well as written records. The objective of this system is to facilitate the accumulation and application of scientific knowledge. The immediate objective has been aptly stated by Shaw, one of the pioneers in the field of information science: "the end product of this system of communication must be the information needed by and usable to each scientist, wherever he may be and whatever his needs may be at the moment."

The biomedical information complex is not self-sufficient. Although considered separately here, it is only one part of a larger system serving all of science.

Analytic Viewpoint

Any system must be oversimplified if it is to be analyzed in a way that emphasizes the similarities among its elements rather than the differences. In our analysis, we have chosen to follow the flow of information from generation to use. Because the terminology used to describe organizations, activities, services, and people engaged in handling information often obscures their common functions, the sequence of major operations involved in this flow has been described in terms of the functions performed rather than of the names of the performers. Other viewpoints would yield different pictures, all equally valid but not necessarily equally useful for our purpose. The ideal visualization would encompass all major viewpoints, looking both forward in time from the generator, and backward from the user.

If the information resulting from scientific observation, experimentation, and reasoning is called "scientific" information, then the information about research, i.e., news about scientists, money, equipment, and supplies or messages related to the administration of research, may be termed "parascientific" information. This analysis pertains primarily to scientific information.

Conventions Used in Diagrams

Certain conventions have been adopted for all diagrams:

(1) a parenthetical letter-number combination in a box refers to a diagram that provides a further breakdown of the operation;

(2) boxes with broken outlines and broken-line arrows represent processes and flow channels outside the concern of the diagram;

(3) a small square containing a single letter indicates that processes have been omitted to simplify the diagram and refers to another diagram that shows these processes;

(4) a star (★) indicates an important point at which quality control is commonly exercised; and

(5) the symbol, ⊕ , indicates an important point at which the message is improved in form or content by feedback from the generator's colleagues or from specialists in form of presentation (e.g., non-scientists, editorial specialists).

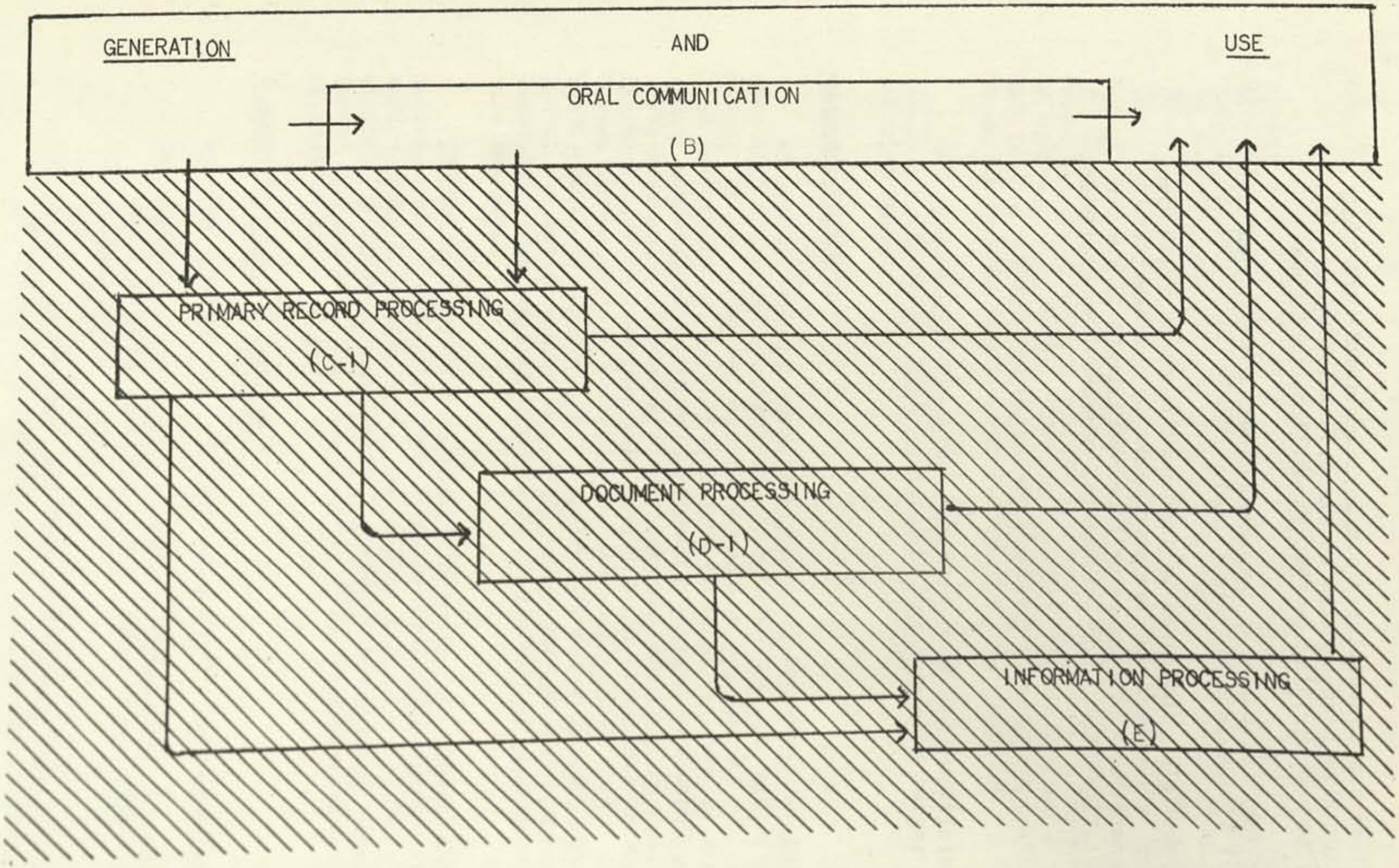

FIGURE A. OVER-ALL VIEW OF BIOMEDICAL INFORMATION COMPLEX

▨ PROCESSES FOR HANDLING <u>RECORDED</u> INFORMATION

ANALYSIS

Over-all View of Biomedical Information Complex (Fig. A)

In Fig. A, five major functional components are distinguished. The terms used for these components were chosen for generality:

(1) Generation - Use: depicted as a two-phase function;

(2) Oral Communication;

(3) Primary Record Processing: all activities associated with recording scientific information and with the initial distribution of the records produced;

(4) Document Processing: collection, analysis, storage, and retrieval of information records (documents) after recording and initial distribution; and

(5) Information Processing: operations in which information is extracted from documents, evaluated, modified, and synthesized into new records.

If the system and its elements are to operate most efficiently in promoting the objective of the complex, a sixth component must be added, namely, research and development aimed at improving efficiency. This component, however, cannot be depicted in the same scheme. Another function of the system not depicted separately in this diagram is quality control. This function, which is vital for the ultimate purpose of the system, is performed at a number of places in the scheme we have selected.

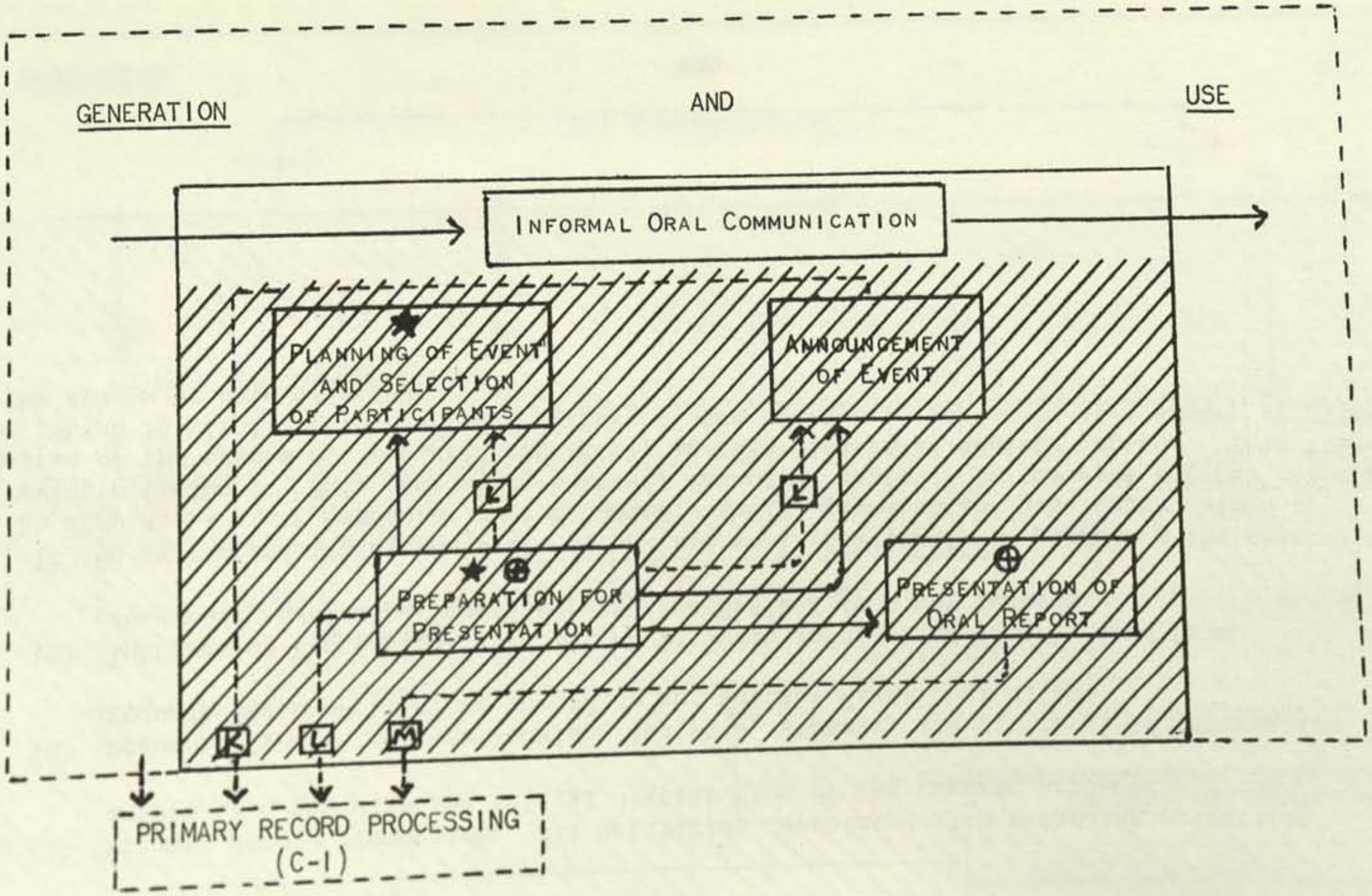

Figure B. Oral Communication

▨ Processes associated with FORMAL oral communication

----→ Pathways requiring that the information be recorded

K L M See corresponding symbols in Figure C-2A

Oral Communication (Fig. B)

Informal oral communication includes all face-to-face or telephone exchanges other than those structured by the formalities of such planned events as scientific meetings, lectures, and seminars. The processes of formal oral communication include the planning and announcement of the events, as well as the activities of the generators in preparing for and presenting oral reports. Quality control may be exercised by selecting the active participants (generators) on the basis of their past work or of abstracts of the reports they wish to present. In all cases, there is either oral or written exchange between the active participants and the planners. In preparing to present a paper, a scientist may have to obtain a decision from his institution as to whether a given piece of work is ready to be reported and his presentation may be modified as a result of feedback from his institutional associates. The titles or abstracts of papers to be presented at an event are included in its announcement, which is usually transmitted in recorded form as well as orally. Preparation for an oral report entails either making notes or writing out the full text. At the event, the presentations may be recorded verbatim or summarized by listeners who intend to give an account of the event later. Thus the information transmitted orally is committed in whole,or in part, to records by several routes, which will be covered under "primary record processing."

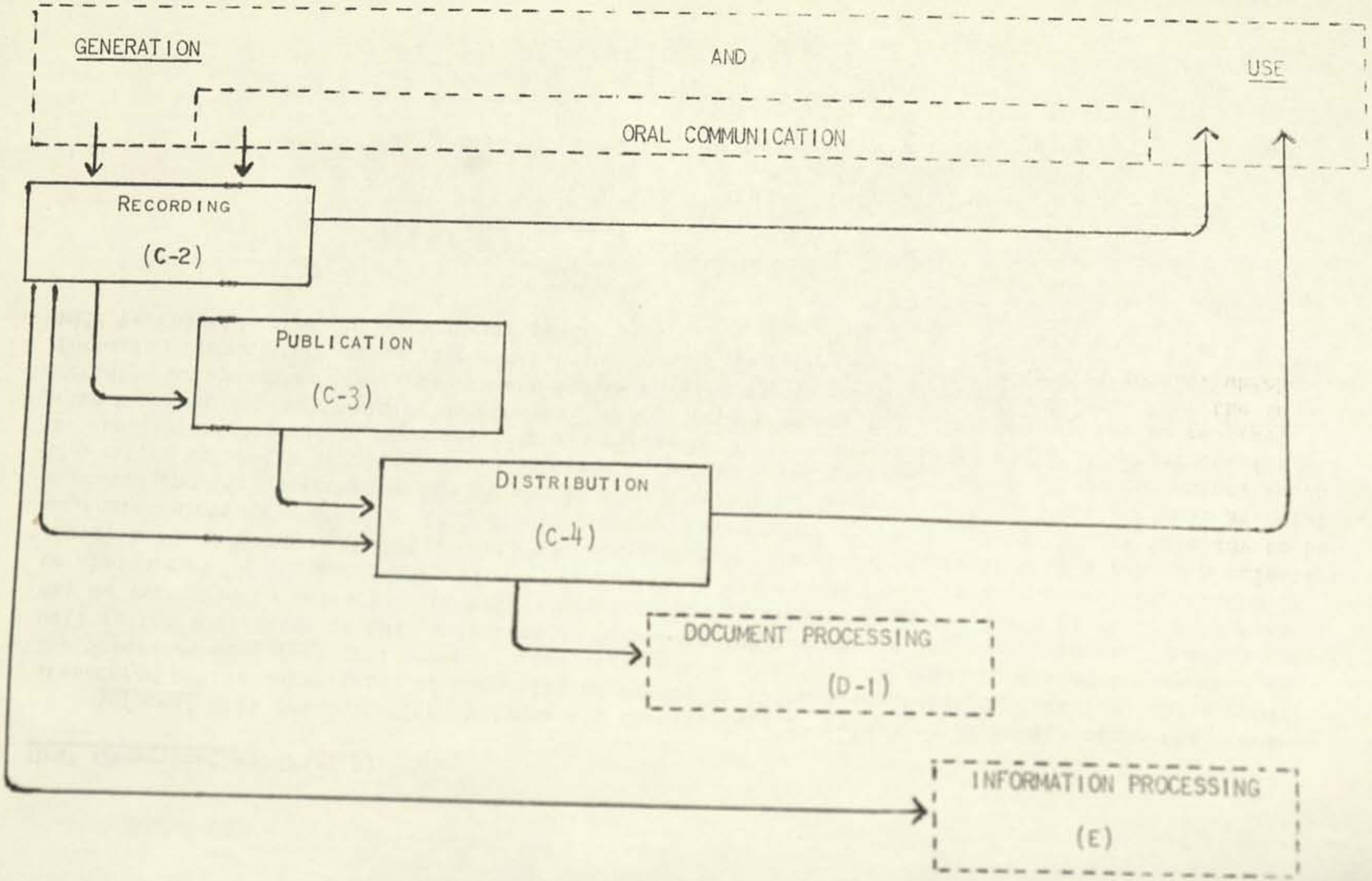

FIGURE C-1 GENERAL SCHEME OF PRIMARY RECORD PROCESSING COMPONENT

General Scheme of Primary Record Processing Component (Fig. C-1)

Figure C-1 shows the complete sequence of major operations entailed in primary record processing. Figures C-2, C-3, and C-4 dissect the operations of recording, publication, and distribution, respectively.

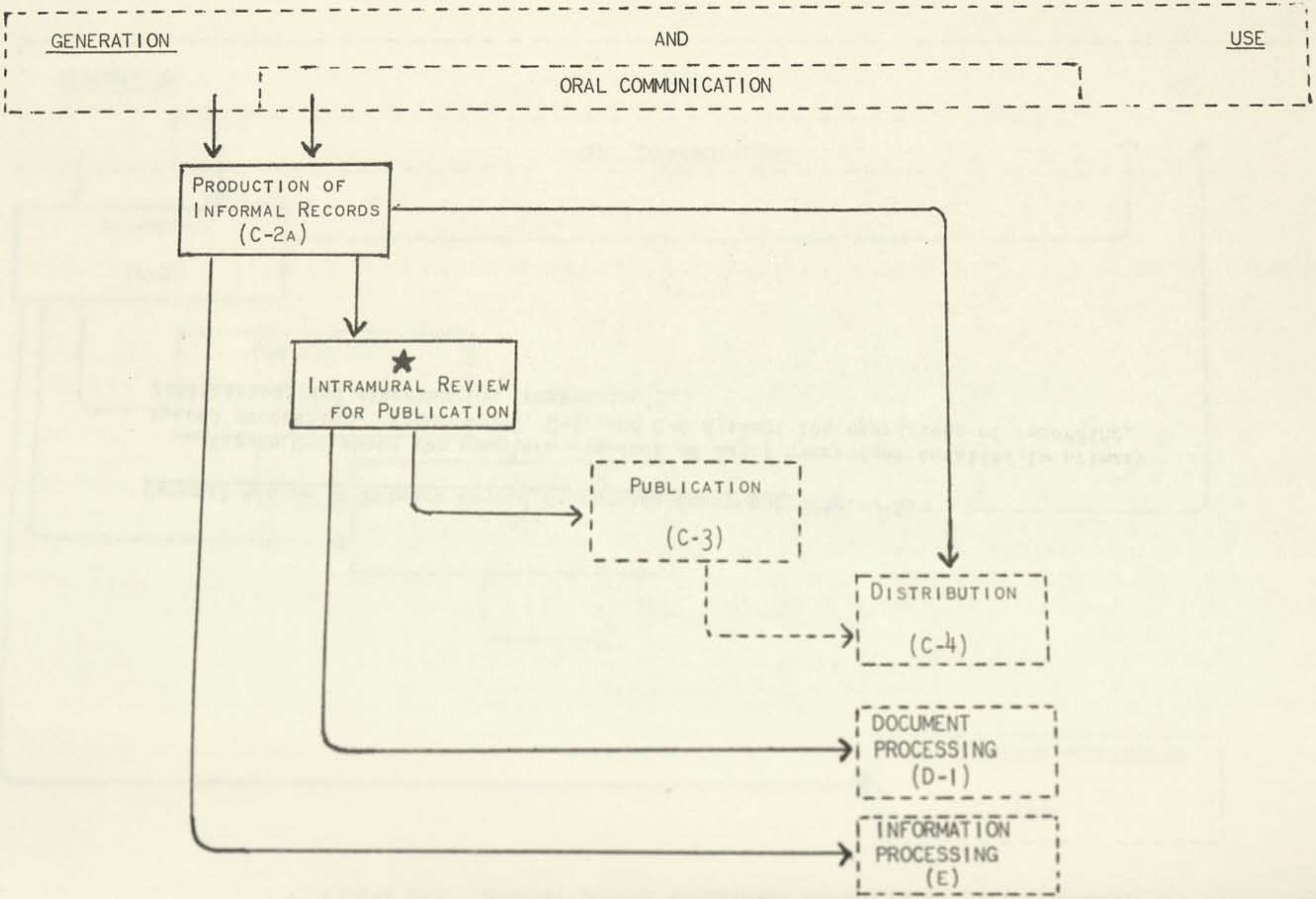

Figure C-2. Recording

Recording (Fig. C-2)

The focus in Fig. C-2 is on the processes involved in the operation of recording. Informal records include manuscripts, data and work sheets, notes, correspondence, and other forms of recorded scientific information not intended for distribution outside administrative or personal channels. Production of informal records is shown in more detail in Fig. C-2a. Some informal records are distributed as such or are reviewed by the generator and his institution for publication as formal records. This review may include a quality-control decision as well as other considerations, including protection of proprietary interests in industrial institutions and selection of the appropriate form for publication (e.g., journal article, book, or technical report).

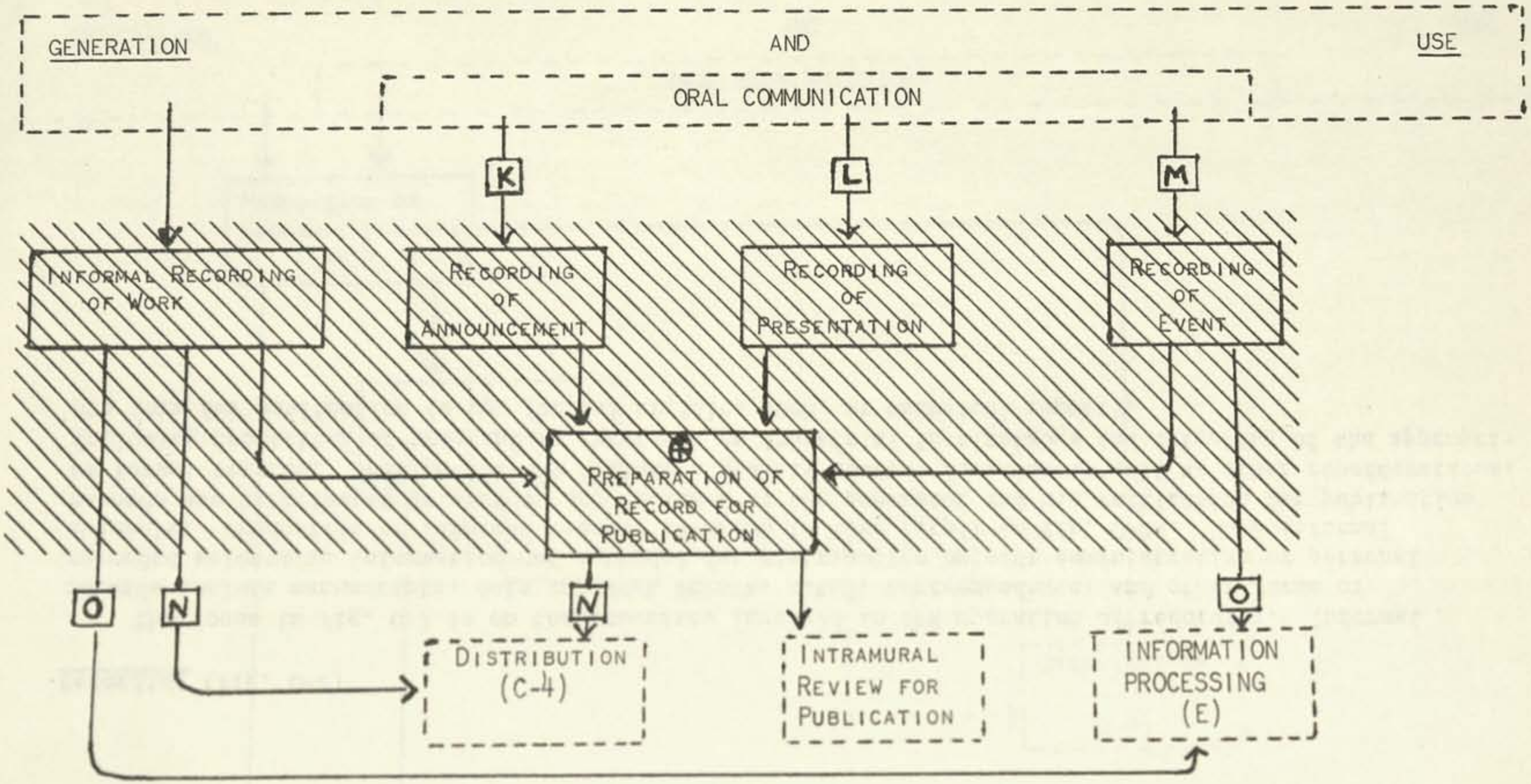

Figure C-2a. Production of Informal Records

▨ Processes resulting in production of informal records

K L M See corresponding symbols in Figure B

N See corresponding symbol in Figure C-4

O See corresponding symbol in Figure E

Production of Informal Records (Fig. C-2a)

The different kinds of informal records produced as byproducts of formal oral communication are depicted in Fig. C-2a, with those produced for other purposes. Any of these informal records may receive limited distribution. If publication is contemplated, a certain amount of preparation is usual before committing the record to a definitive intramural review. Drafts may be distributed to obtain informal opinions, and feedback may modify successive drafts.

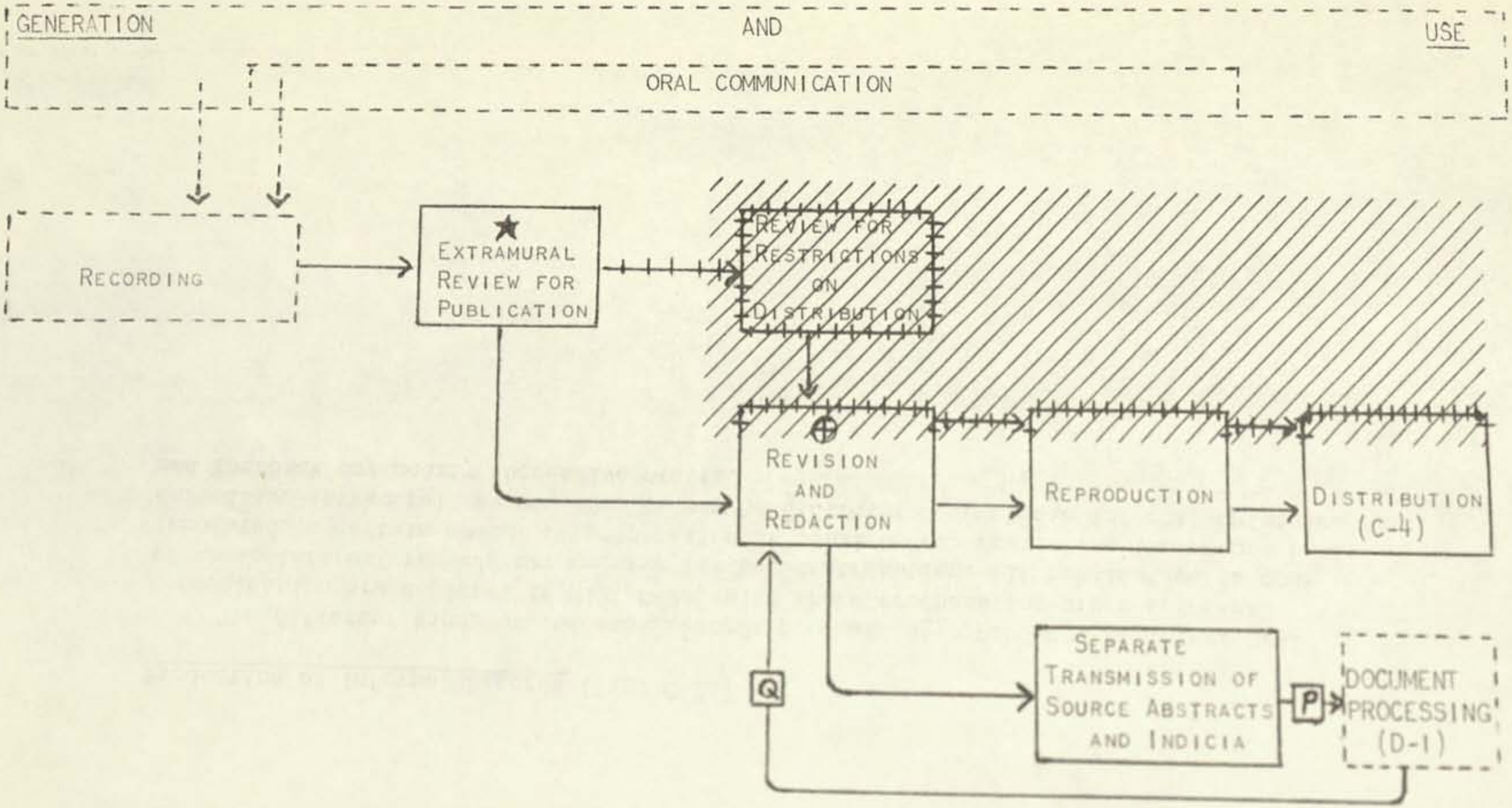

FIGURE C-3. PUBLICATION

▨ PUBLICATION OF DOCUMENTS FOR RESTRICTED DISTRIBUTION

┼┼┼→ PATHWAYS FOR RECORDS WITH RESTRICTIONS ON DISTRIBUTION

[P] SEE CORRESPONDING SYMBOL IN FIGURE D-3

[Q] SEE CORRESPONDING SYMBOL IN FIGURES D-3, D-4, AND D-4A

Publication (Fig. C-3)

The informal record is submitted for extramural review to a publisher (book), editorial board (journal article), or the sponsoring agency (technical report). For the technical report this review includes a consideration of indications for limiting distribution in accordance with security or other restrictions. If the report is classified for security reasons, all subsequent processes entail special precautions and often special channels parallel to those for non-classified reports. During revision and redaction, the form and content of the record are modified by feedback to the generator before copies are reproduced (printed, photocopied, etc.) for distribution.

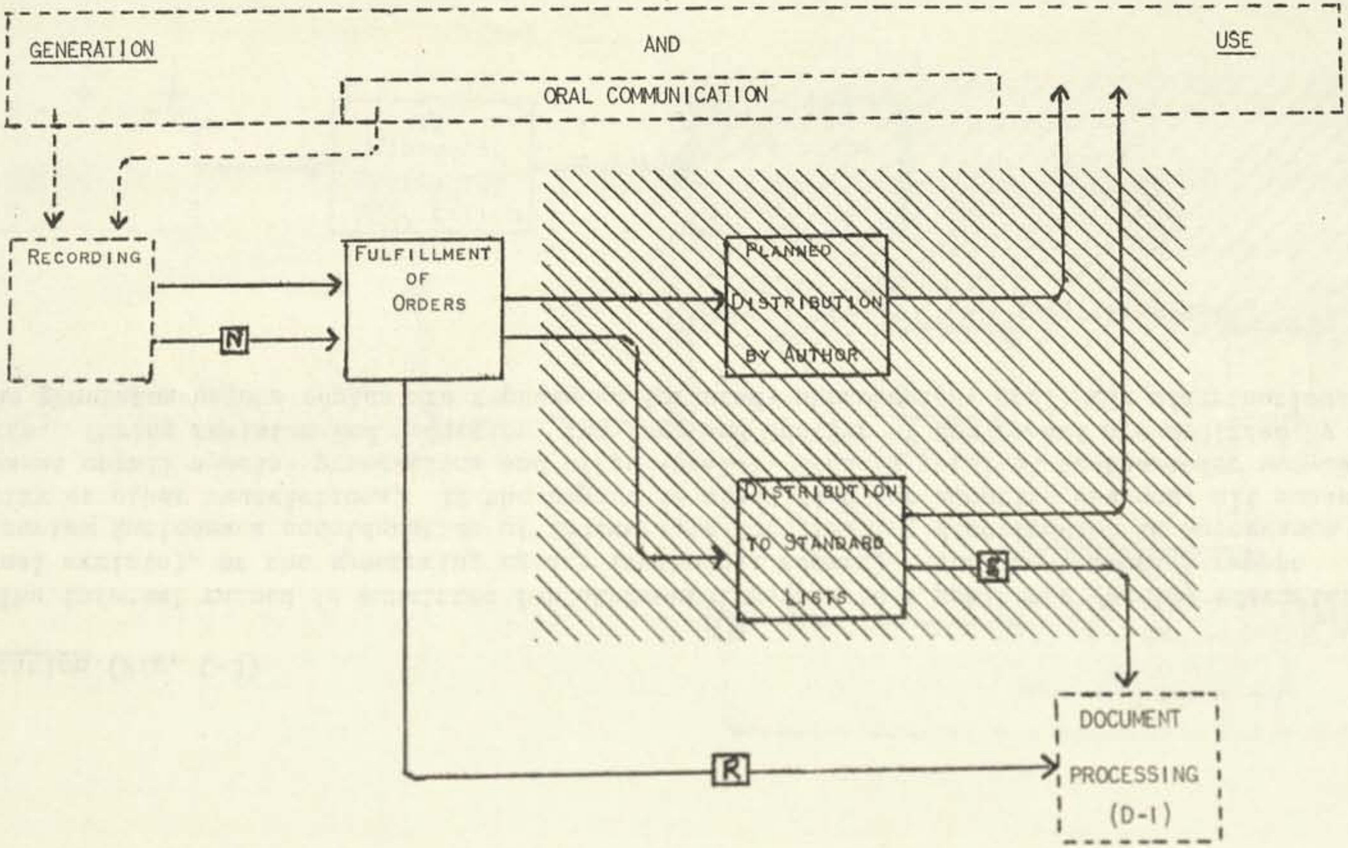

Figure C-4. Distribution

▨ Primary distribution of documents

N See corresponding symbol in Figure C-2a

R See corresponding symbol in Figures D-2 and D-4a

S See corresponding symbol in Figure D-2

Distribution (Fig. C-4)

For formal records, the issuing organization fills prepublication orders for copies that the author (or his institution) will distribute automatically and for copies to be sent to standard lists of recipients (e.g., subscribers). All automatic distribution according to set plans is termed "primary" distribution to distinguish it from "secondary" distribution. The latter occurs in response to postpublication orders (requests) for a specific document (e.g., a reprint of a journal article). Secondary distribution is covered later (Fig. D-2) as part of the document processing component. Informal documents, though often distributed to only one recipient (e.g., letters), may receive a wider primary distribution and some secondary distribution to meet requests from those who have heard of the document in some way, often by word of mouth.

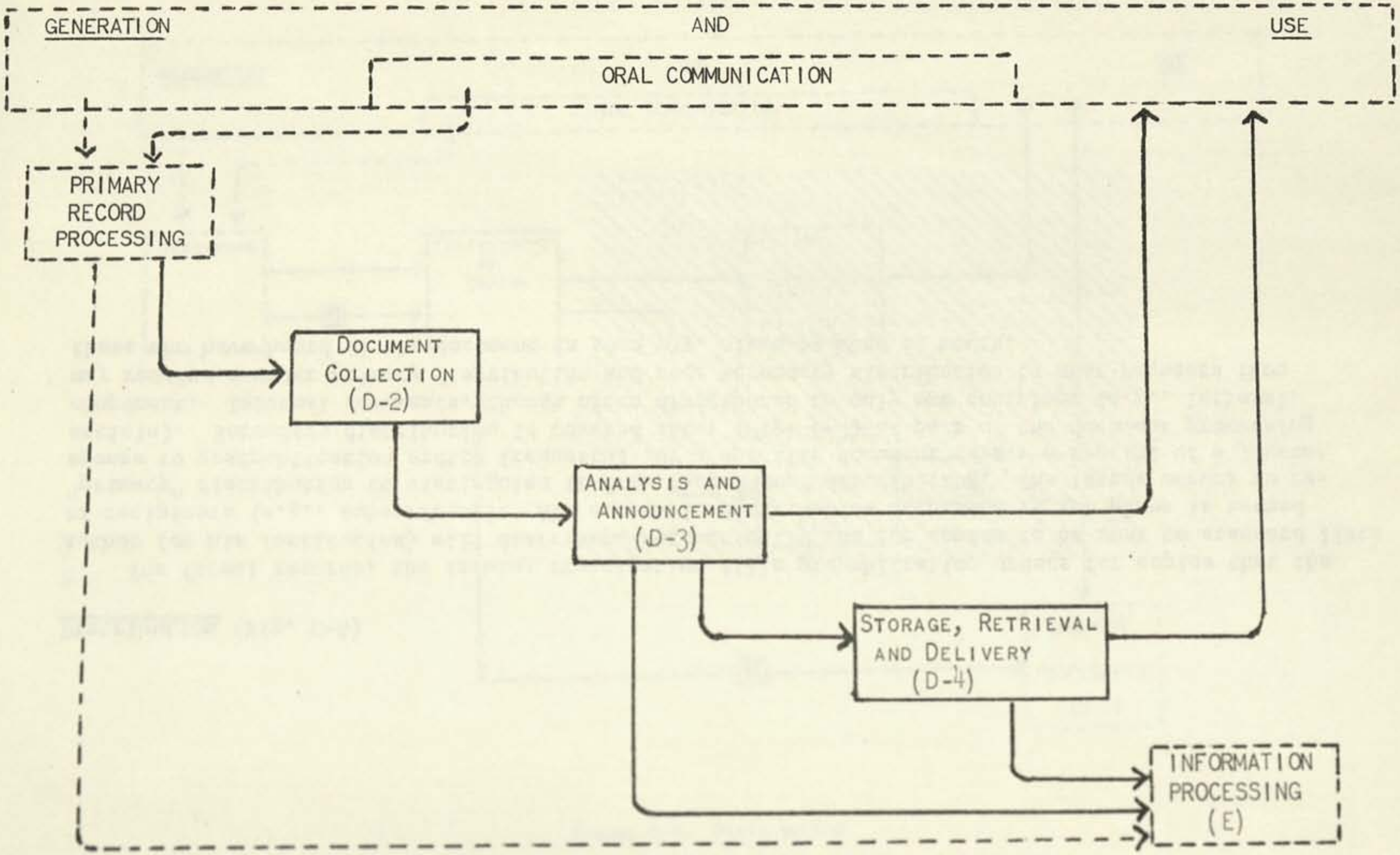

FIGURE D-1. GENERAL SCHEME OF DOCUMENT PROCESSING COMPONENT

General Scheme of Document Processing Component (Fig. D-1)

The major operations included in document processing are summarized in Fig. D-1 and analyzed in detail in Figs. D-2, D-3, and D-4. The documents processed may be either formal or informal records; however, the latter are usually considered to be "ephemera" by conventional document processing services (e.g., libraries and abstracting-indexing services) and are either discarded during collection or stored without the processing that formal records receive. For example, they are seldom announced.

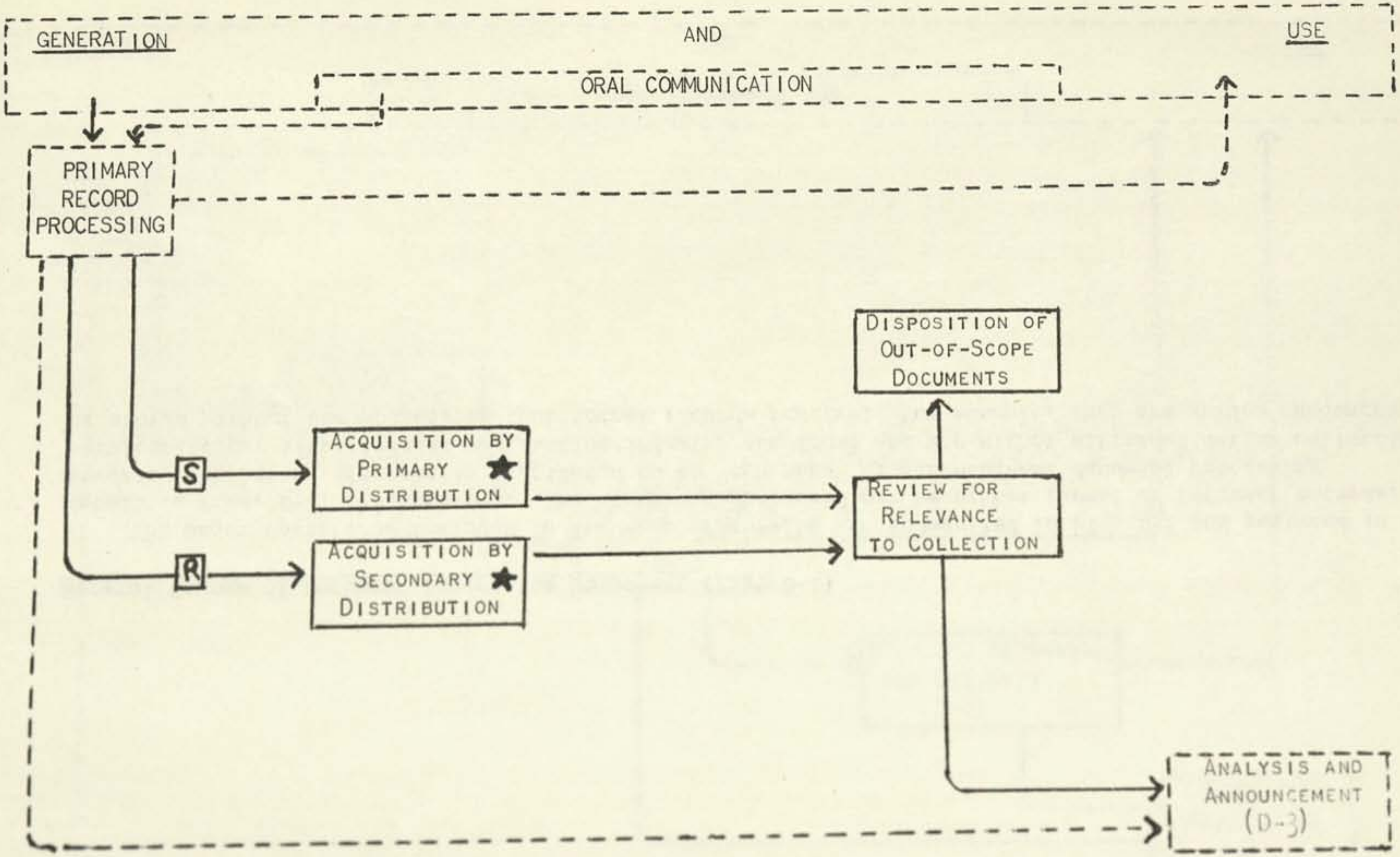

FIGURE D-2. DOCUMENT COLLECTION

$\boxed{R}$ $\boxed{S}$ SEE CORRESPONDING SYMBOLS IN FIGURE C-4

Document Collection (Fig. D-2)

The processes depicted in Fig. D-2 apply to the building of small, personal collections by scientists as well as to the acquisition of extensive collections by great libraries. In acquiring documents by either primary or secondary distribution, quality-control decisions are usually made. After receipt, a scientist collecting for his own use may discard a document if he finds that the information contained, although relevant to his interests, is of questionable quality. In collections intended for the use of many, however, documents that have been ordered are usually retained unless obviously irrelevant or in a form not suitable for subsequent processing.

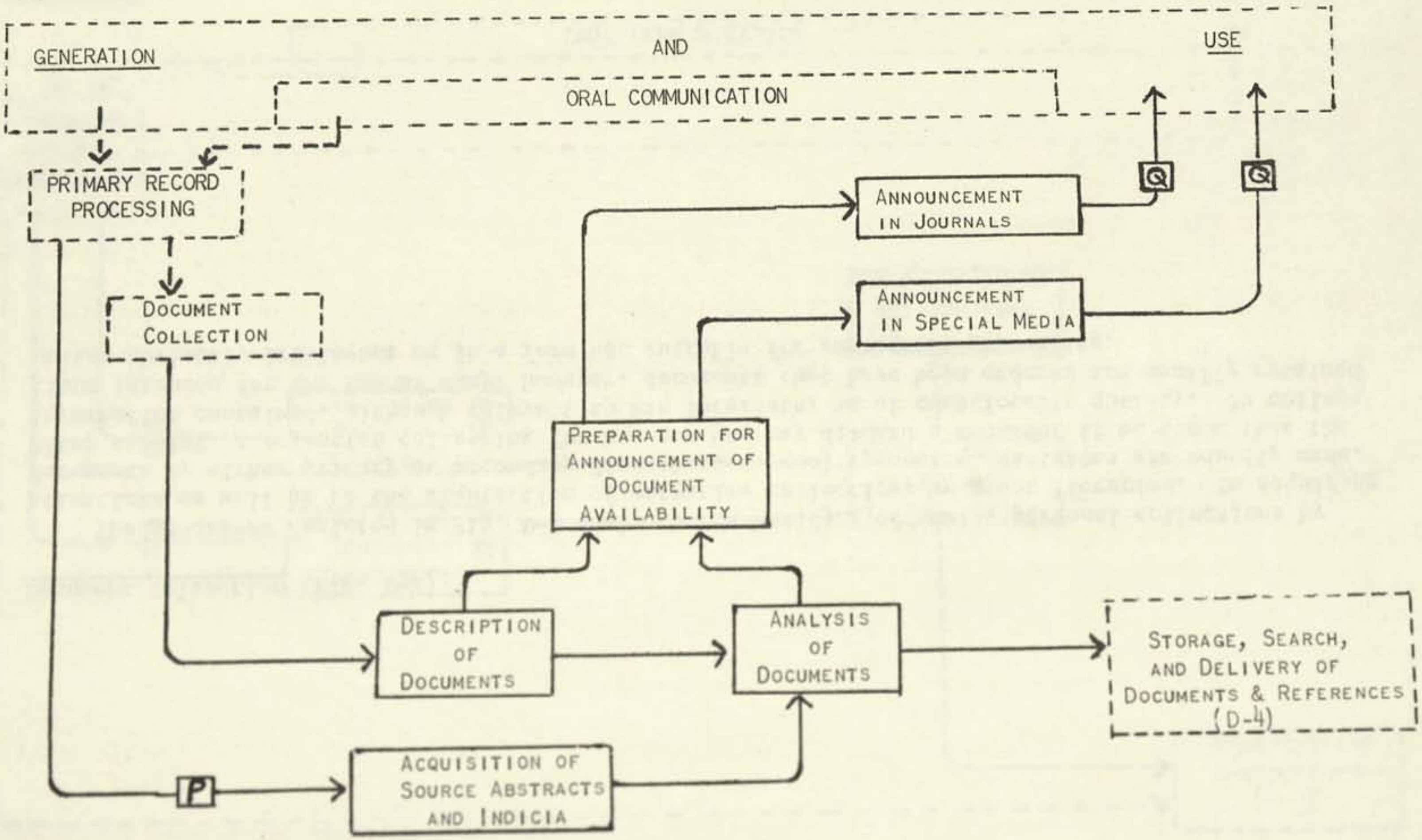

FIGURE D-3. DOCUMENT ANALYSIS AND ANNOUNCEMENT

P SEE CORRESPONDING SYMBOL IN FIGURE C-3

Q SEE CORRESPONDING SYMBOL IN FIGURE C-3

Document Analysis and Announcement (Fig. D-3)

Documents for collections of any size are usually characterized by physical form, issuing source, titles, dates, authors, etc., before storage. In libraries this process is called "descriptive cataloging." It is essentially a clerical operation, in that it requires no knowledge of the subject matter of the documents. Documents are then analyzed by subject content and classified or indexed to facilitate later retrieval. The results of this analysis are index terms (indicia), annotations, or abstracts for each document. Some libraries, and all abstracting-indexing services, then announce their acquisitions. The announcement function may be served by special media, such as a simple list of document titles issued to the clientele of the document processing services, or by a periodical containing abstracts of each document and detailed author and subject indexes. Acquisitions can also be announced in a special section of a journal devoted primarily to publishing original records. The products of either descriptive cataloging or subject analysis may be used in announcement. Lists prepared by permuting the words in document titles using a computer are an example of announcement by purely clerical processes. Index Medicus is an announcement periodical that uses the products of both descriptive cataloging and subject analysis. Regardless of the announcement medium, the same processes described for primary record processing, from redaction and revision on, must be accomplished. Some documents are received with abstracts and indicia prepared either by the author or by the publishing organization. "Ready-made" abstracts and indicia are, in some cases, also obtained separately by arrangement with the publishing organization (e.g., Biological Abstracts receives author abstracts on forms supplied to authors by cooperating journals).

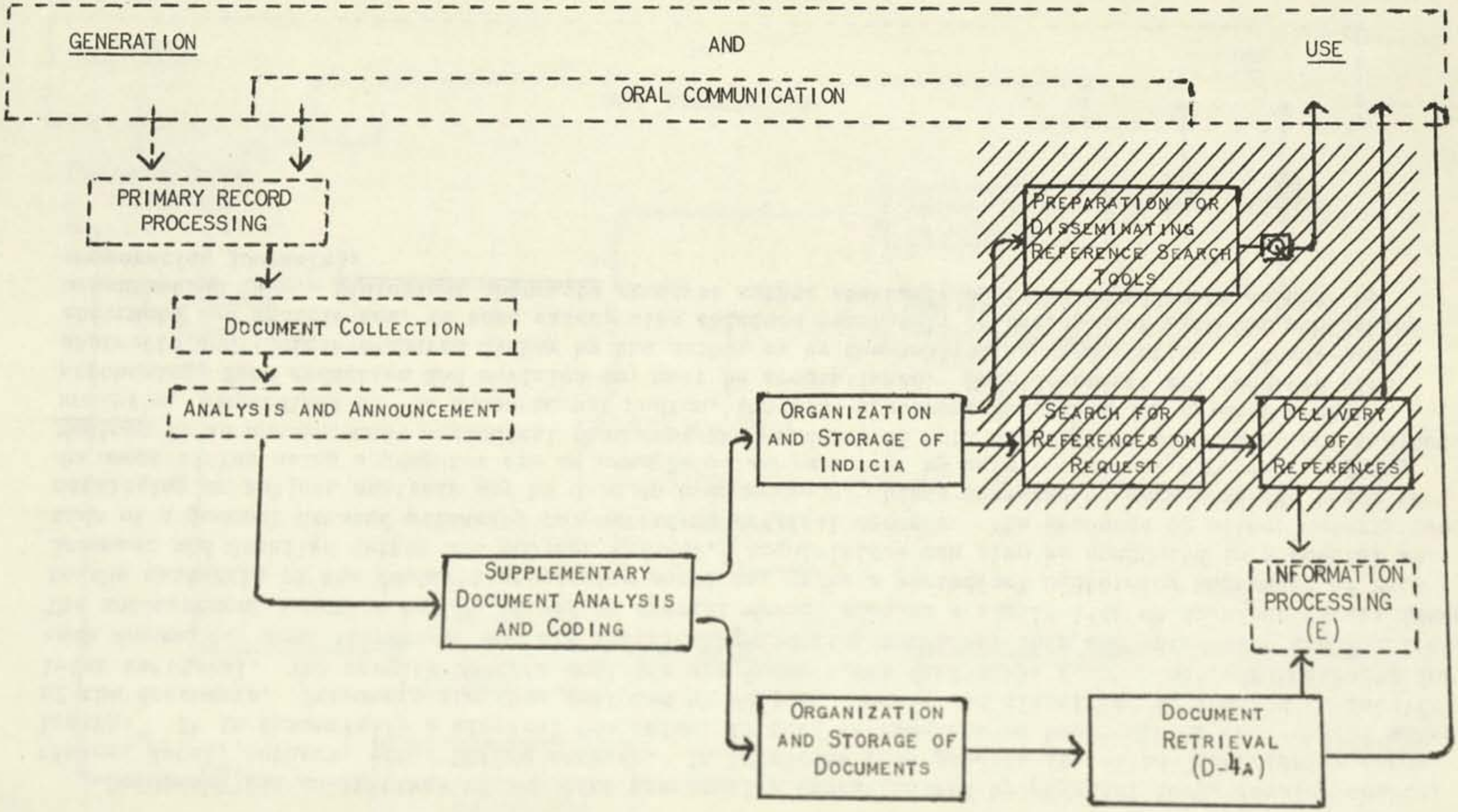

Figure D-4. Storage, Search, and Delivery of Documents and References

▨ Processes associated with reference retrieval

Q See corresponding symbol in Figure C-3

Storage, Search, and Delivery of Documents and References (Fig. D-4)

Before storage, additional subject analysis and coding of the indicia may be required to ensure efficient retrieval, i.e., search and delivery. From here on the indicia are usually processed separately from the documents they describe, and two parallel processing chains exist, one storing the indicia and retrieving from this store references or "addresses" to documents that may contain desired information, the other storing the documents themselves and retrieving them once their addresses are known. Any document-processing service must develop both chains to some degree, but one or the other is usually emphasized. Abstracting-indexing services concentrate on the reference processing chain and produce reference search tools (e.g., Chemical Abstracts); typically these services do not themselves maintain extensive document stores. Some specialized libraries, particularly those of industrial concerns engaged in research, develop their reference retrieval capabilities in narrow subject fields to a high degree by supplementing the reference search tools they can purchase from abstracting-indexing services with their own more exhaustive analysis of formal records. Such libraries also cover informal records (e.g., internal reports) that are not processed by standard abstracting-indexing services. Their document collections are highly specialized and relatively small, and they must augment their document retrieval capabilities by calling on major conventional libraries for loans or photocopies of documents. When a library specializes in a narrow field and in providing excellent reference retrieval services for research workers, it is often referred to as a "specialized information center" if these services are available to other than intramural scientists.

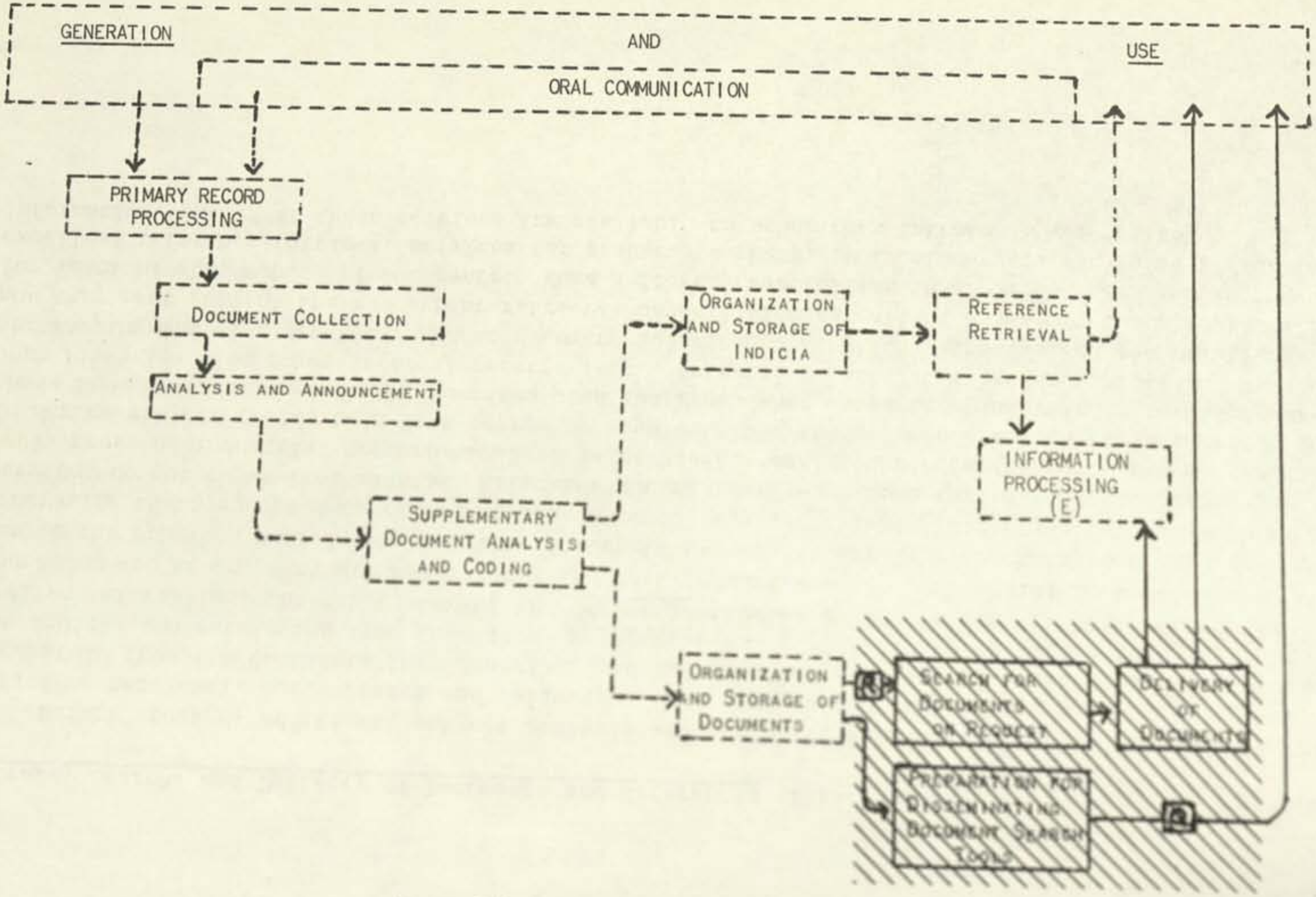

FIGURE D-4A. DOCUMENT RETRIEVAL

▨ PROCESSES ASSOCIATED WITH <u>DOCUMENT</u> RETRIEVAL OR <u>SECONDARY</u> DISTRIBUTION

Q SEE CORRESPONDING SYMBOL IN FIGURE C-3

R SEE CORRESPONDING SYMBOL IN FIGURE C-4

Document Retrieval (Fig. D-4a)

Conventional libraries, which serve a heterogeneous clientele and handle relatively broad subject areas, e.g., academic biomedical libraries, typically allot most of their resources to building large stores of documents with the goal of becoming largely self-sufficient as regards document retrieval. They purchase reference search tools for journal literature from abstracting-indexing services rather than undertaking their own subject analysis of this type of literature. Although most do some descriptive cataloging and subject analysis of books they also depend on the "ready-made" reference search tools for books that are produced by the large government libraries and by commercial services, such as the Library of Congress catalog cards, the National Library of Medicine catalog, and Books in Print (Bowker Co.). Document retrieval employs search tools analogous to those for reference retrieval. "Union lists" are produced and published as regional or national efforts of libraries. These lists indicate which libraries have given documents and are used when a library wishes to borrow a document it does not have itself.

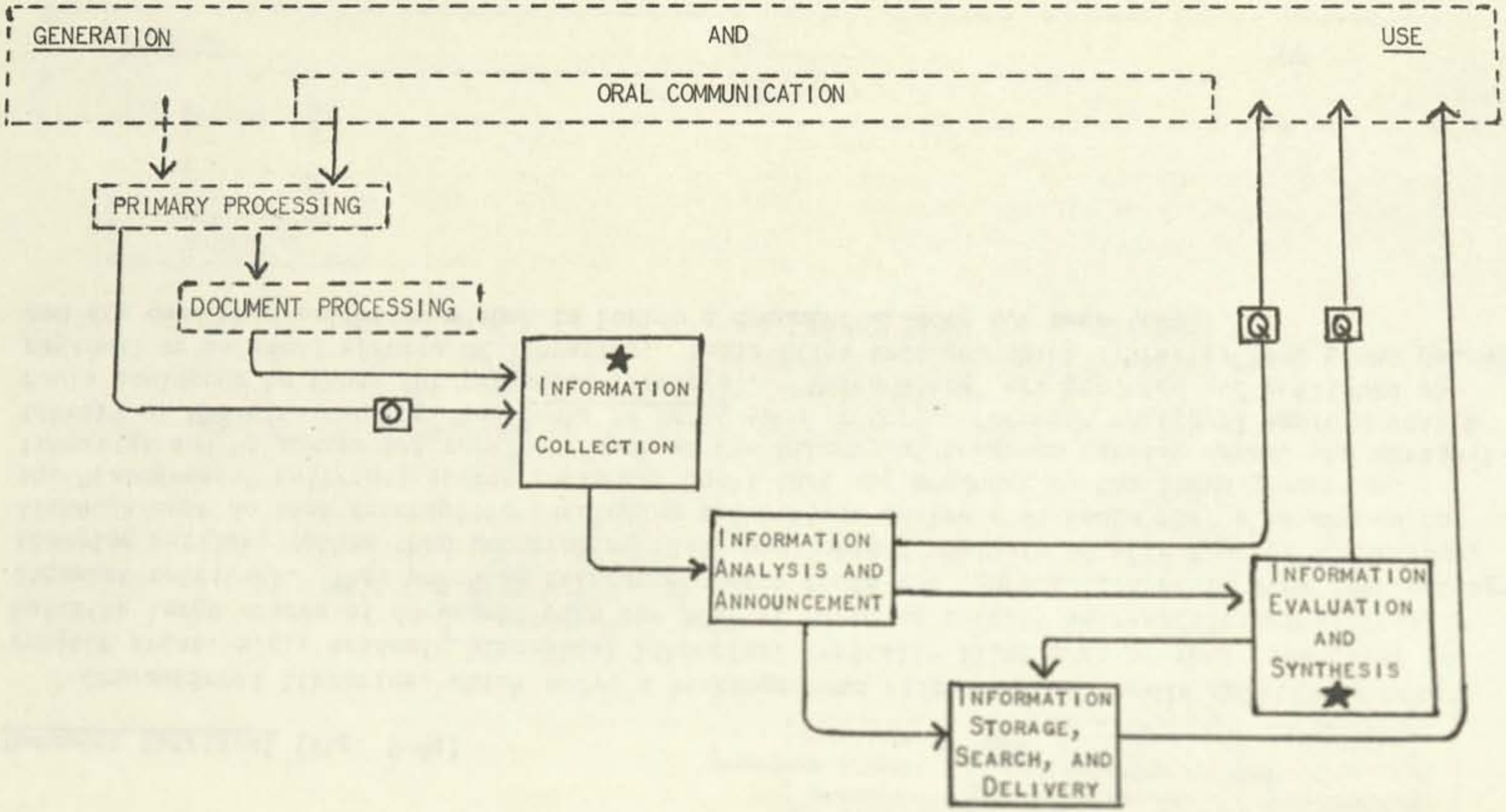

Figure E. General Scheme of Information Processing Component

O See corresponding symbol in Figure C-2a

Q See corresponding symbol in Figure C-3

General Scheme of Information Processing Component (Fig. E)

Information processing is distinct from document processing in that the unit processed is an item of information, rather than a document; in a general sense, it starts where document processing leaves off and it depends largely on prior accomplishment of the operations of document processing. A scientist is primarily an information processor. He uses his information processing abilities to provide general service to the scientific community when he reviews the information generated by others, evaluates it, reassembles the information items (synthesis), and produces a new record. A critical review that evaluates existing information and achieves a synthesis is the best example of one of the two major types of traditional information processing services. The other does much the same thing with data to produce critical tables and handbooks of standard values. Another information processing activity involves providing a factual answer to a question, as opposed to referring the inquirer to one or more documents that may contain the answer, or several different answers. Scientists have always answered colleagues' questions, using their experience to sift available information and arrive at the "best" answer; but until fairly recently this activity has not commonly been formalized or "institutionalized" as a service, at least for research workers. Currently the trend is toward increasing numbers of institutionalized services to produce critical reviews, critical data compilations, and authoritative answers. These may be called specialized information <u>evaluation</u> centers to distinguish them from document processing services.

Figure E depicts the basic operations of such information processing activities. Most of the operations are analogous to those of document processing. Several differences, however, exist: (1) An information processing service may itself record new scientific information, rather than waiting for scientists to produce and distribute their own records; e.g., the service may use an observer to record oral presentations at scientific meetings or may obtain data directly from the generators. (2) Documents can be judged by the quality and value of the information they contain, rather than by form; information processing services, therefore, handle more informal records and are less handicapped by the time-lag inherent in publication. (3) The step of critical evaluation and synthesis is added to those shared with document processing.

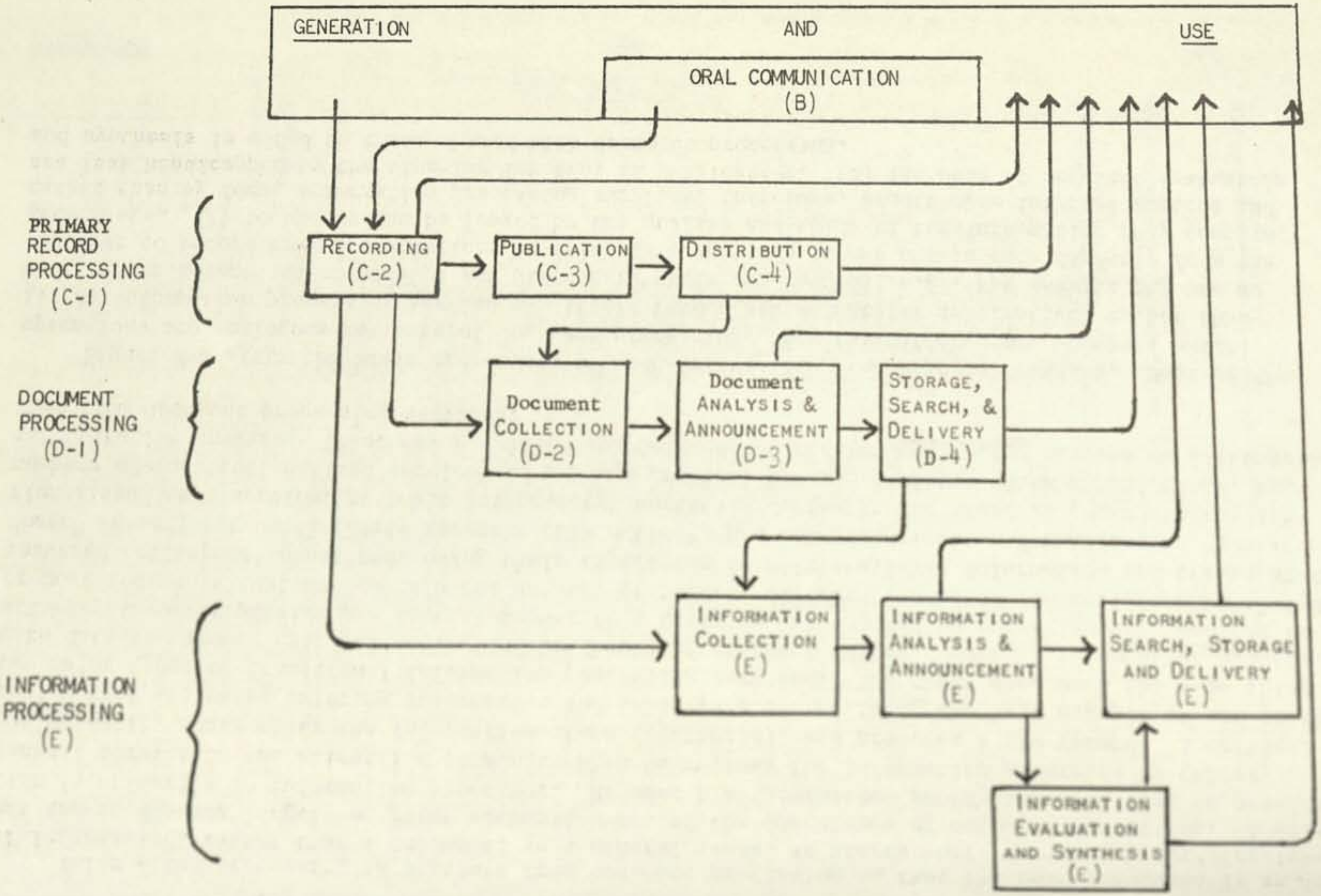

FIGURE F. RECAPITULATION OF MAJOR COMPONENTS AND SUB-COMPONENTS OF BIOMEDICAL INFORMATION COMPLEX

Summary of Major Components and Operations of Biomedical Information Complex (Fig. F)

The major operations of the entire system are recapitulated in Fig. F. Thus far the channels in the model have been considered only from the generation end. At this stage it is interesting to reverse the viewpoint and look at the system briefly from the use end.

The information processing component is seen as a user of scientific information. Information processing, as we have defined it, requires that the processors have substantive knowledge of the scientific field in which they work. For many services, the processors must be the peers of the clientele served in scientific judgment. Such scientists, who spend varying portions of their time in processing information for others, are the scientific "middlemen" described as the "backbone" of the type of information center* on which the Weinberg Report (2) placed great emphasis. The functions of information processing are central to the growth of science in that information is metabolized to produce knowledge (3). That part of the information processing component that has been institutionalized actually represents a specialized segment of the biomedical research community (the generation-use component).

The model also illustrates the rich variety of the channels available to the user. To obtain the information he desires, he may use any or all of the four components and may choose the channel best suited to his needs and habits. The information carried by the different channels varies in currency, strictness of quality control, condensation, specificity, etc. His freedom of choice is limited, however, in that the channels are not true alternatives, and no one component can fill all his needs. For example, if he wants to know what a colleague has done in the previous few months, he must usually rely on oral communication or informal records (correspondence), because a time-lag is inherent in the production of formal records. If he wants only a simple answer to a specific, but unusual, question, such as "What is the LD_{50} dose of morphine for salamanders?", it is unlikely that he will find an information processing service that can readily meet his need. He will probably have to try his luck with document processing services and attempt to find the answer somewhere in the documents they will supply.

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* These would be called "information evaluation centers" (or "services") in our terminology.

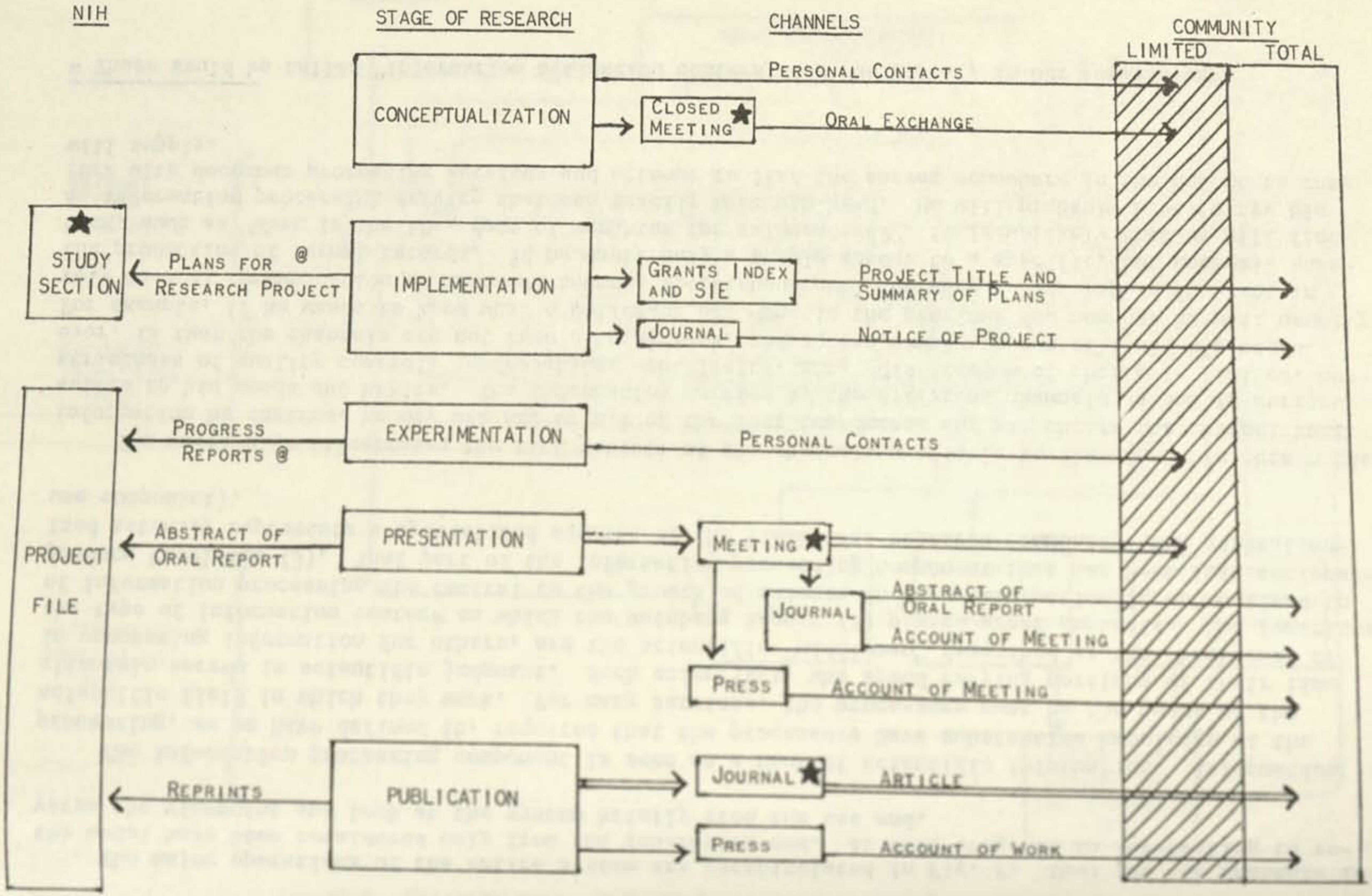

FIGURE G. INFORMATION OUTPUT OF NIH PROJECTS

@ PRIVILEGED CHANNELS

Quality Control Over Information Channels (Fig. G)

The major points at which the "yes-or-no" type of quality control may be exercised over output channels are summarized in Fig. G, using a typical NIH project at various stages as an example. Administrative channels are shown on the left side. An NIH study section exercises quality control over the dissemination of information on a scientist's plans through the NIH Grants Index and the Science Information Exchange, in that only approved projects are processed by these services. The major output channels to the scientific community are shown on the right. Double-walled arrows designate the more important channels for substantive reports of research results. Quality control over output is exercised by the scientific community at three major points. When the investigator is formulating a project and wants to discuss his ideas, he may not have the advantage of the forum provided by small, closed meetings of leaders in his field unless he qualifies for inclusion in the group. His paper may not be accepted for presentation at a meeting unless certain quality standards are met by the "preview"* he submits to the meeting planners. Finally, a journal may not publish his manuscript if it fails to meet the editorial board's standards for quality. Although quality control of some kind is exercised by most meeting planners and journals, a persistent scientist can almost always find some meeting at which he may give his paper or some journal that will publish his manuscript. Therefore, although quality control is exercised over individual elements of the two main output channels, there is no effective quality control for the channels as a whole.

All the channels carrying oral information or informal records reach only a limited segment of the research community, whereas the audience for a published document is potentially unlimited. This means that journal publication of "previews" of oral reports is often the first channel by which information resulting from research becomes widely available to the biomedical community.

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* This is usually referred to inexactly as an "abstract" and represents a summary of what he thinks he will say.

TABLE II-1. PERFORMANCE AND SUPPORT OF FUNCTIONS OF BIOMEDICAL INFORMATION COMPLEX

FUNCTION SERVED	GENERATION (AND RECORDING)			ORAL COMMUN. (FORMAL)		1° RECORD PROCESSING (LESS RECORDING)		DOCUMENT PROCESSING* LOCAL SERVICES			DOCUMENT PROCESSING* GENERAL SERVICES			INFORMATION PROCESSING (EXTRAMURAL, FORMAL SERVICES**)			COMMUNICATION RESEARCH & DEVELOPMENT				
PERFORMING ORGANIZATION / SOURCE OF SUPPORT	A	I	G	A	P	P	C	A	I	G	P	C	G	G	A P	C	A	I	G	P	C
GOVERNMENT (G)	●	+	●	●	+	+	?	?		●	+		●	●	+	?	●	+	●	●	●
FOUNDATIONS	+			+	+	?		?									+			?	?
INDUSTRY (I)	+	●		+	+				●									●			+
ACADEMIC (A)	+			+				●							+						
USE FEES†	☒	☒	☒	+	●	●	●				●	●			●	●	☒	☒	☒	☒	☒

A = ACADEMIC AND NON-PROFIT RESEARCH INSTITUTIONS
I = BIOMEDICAL INDUSTRIAL ORGANIZATIONS, PRINCIPALLY PHARMACEUTICAL COMPANIES
F = FOUNDATIONS, INCLUDING VOLUNTARY HEALTH ASSOCIATIONS
G = FEDERAL GOVERNMENT
P = PROFESSIONAL SOCIETIES
C = COMMERCIAL ORGANIZATIONS -- PUBLISHERS, INFORMATION SERVICES, AND COMPANIES PERFORMING CONTRACT RESEARCH AND DEVELOPMENT IN SCIENTIFIC INFORMATION
* "LOCAL" SERVICES ARE THOSE INTENDED PRIMARILY FOR LOCAL BIOMEDICAL COMMUNITIES, E.G., INSTITUTIONAL LIBRARIES; WHEREAS, "GENERAL" SERVICES ARE FOR THE ENTIRE BIOMEDICAL COMMUNITY, E.G., ABSTRACTING-INDEXING SERVICES, NATIONAL LIBRARY OF MEDICINE, ETC.
** E.G., PSYCHOPHARMACOLOGY SERVICE CENTER OF NIMH, REVIEW PUBLICATIONS, HANDBOOKS OF BIOLOGICAL DATA, ETC.
† SUBSCRIPTIONS, MEETING REGISTRATION FEES, MEMBERSHIP DUES, AND OTHER DIRECT CHARGES ON USERS OF INFORMATION
● PRIMARY SOURCE OF SUPPORT FOR GIVEN TYPE OF PERFORMING ORGANIZATION
\+ SECONDARY SOURCE (PROBABLY > 10% OF TOTAL SUPPORT)
? POSSIBLY QUALIFIES AS SECONDARY SOURCE

DISCUSSION

Financial Support of the System

Table II-1 presents a rough assessment of the relative importance of the different sources from which the system draws support. This analysis is in terms of immediate, rather than ultimate, sources of funds; thus, although scientists may use Federal grant funds to pay for journal subscriptions, the immediate source is "use fees."

Federal Support. In recent years, data on Federal expenditures for scientific communication have improved. For fiscal 1963, total Federal obligations for scientific and technical information activities amounted to some $125 million (4). About $40 million went to private organizations in the form of grants or contracts with the primary purpose of supporting information activities. This figure for "extramural" support does not include research grant or contract funds used for information services (e.g., to attend meetings or purchase journals). Thus, it represents the Federal government's contribution to the entire scientific information complex as an immediate source of support only. Of this $40 million, the Public Health Service spent almost $7 million. (Its expenditures for "intramural" information activities were around $15 million.) Of the $7 million, approximately 15 percent went for activities that we have grouped under formal oral communication, 12 percent for primary record processing, 46 percent to document and information processing, and 28 percent to research and development in scientific communication. An unknown proportion of other Federal agencies'* intramural and extramural expenditures on scientific information activities also represents support for the biomedical information complex. Their contribution as sources of support is probably of greatest relative importance in the area of research in scientific communication, where many of the findings apply generally to all fields of science.

Other Sources of Support. Data on sources of support other than government cannot be obtained so directly, and the various published estimates of total U.S. expenditures (private and governmental) for scientific communication are difficult to relate to the biomedical information complex. We have undertaken to develop cost estimates for some of the activities of the complex, but numerous gaps remain. Although the total cost of each or all of the system components is not known precisely, it is possible to rank in a rough order of importance the different sources of support for the major types of organizations that perform the system's functions.

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*Primarily other agencies sponsoring biomedical research, such as the Atomic Energy Commission, the National Science Foundation, Office of Vocational Rehabilitation, Department of Agriculture, and Department of Defense.

Generation-Use and Oral Communication. The pattern of support for biomedical research itself is identical with that for the generation-use component.* The support pattern for oral communication can be assessed only for its formal aspects, i.e., for planned events. For the ad hoc type of research meetings held under the auspices of academic or professional organizations, it seems probable that currently the major source of support is Federal funds, whereas, for the regularly scheduled meetings of professional organizations, registration fees are still the major source.**

Primary Record Processing. The Federal government contributes directly to the publication and distribution operations of primary record processing by subsidies and page charges. Industry contributes primarily by paying for advertising space. Although commercial publishers are not eligible for government payment of page charges, they receive an unknown amount of support in the form of subsidies for publication of proceedings and charges for excess illustrations, tables, etc.

Document Processing. The operations of "local" document processing services (primarily libraries) are not generally eligible for direct Federal support, but an unknown amount of overhead funds on grants and contracts goes to support these services. The overhead funds allotted by institutions to their libraries may be small, but the total contribution from this source could well amount to more than 10 percent of the total operating budgets of academic libraries. Industrial and academic institutions contribute importantly to supporting "general" document processing services, such as abstracting-indexing services; but this support is mediated through the payment of subscription fees. Institutional subscriptions account for almost the total subscription revenue of the more expensive services.† Although not depicted in the system diagrams, translation activities may be considered a special type of document processing. Currently, both the Federal government and industry spend large sums for translations performed by professional societies and commercial services.

Information Processing. A recent compilation (5) lists some 50 U.S. services that would appear to qualify as generally available biomedical information processing services (or specialized information evaluation centers) by our definition. About half of these are associated with academic or professional organizations. From the descriptions of the latter, it is obvious that most are actually byproducts of an intramural research program and are not supported primarily to provide extramural information services. Not included in this compilation are the numerous

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* The first operation (recording) of primary record processing is also directly supported by biomedical research funds.

** Only the costs of the performing organization (i.e., the organization arranging and conducting the meeting) are being considered here, not travel expenses borne by the participants.

† Current subscription rates for Chemical Abstracts are $500 for educational institutions and $1,000 for all others; for Biological Abstracts, the rate is $225 for all subscribers.

biomedical review publications issued by professional societies and commercial publishers. Certain of the information processing operations of some government services, e.g., the Psychopharmacology Service Center of NIMH, are performed by commercial contractors.

Communication Research and Development. The Federal government seems to be the major supporter of research and development aimed at improving scientific communication other than that performed by industrial concerns, many of which have undertaken major programs to improve their intramural information services. With the exception of the Council on Library Resources, which was set up expressly to support the development of better information services,* private foundations have provided relatively little support for communication research, at least in the area of scientist-to-scientist communication.

Trends in Support Patterns. The annual cost of operating the biomedical information complex has, in recent years, probably increased more rapidly than the number of scientists; but projections on the basis of existing data must be very rough.** Even data on Federal expenditures, which are best developed, are unreliable for assessing trends, because the methods used to obtain these data have been changing and the completeness of agencies' reporting has been increasing. However, changes in the over-all pattern of support are clear. In the past 20 years, as government sponsorship of biomedical research has grown to its present dominance, the operations of the biomedical information complex have, in general, become less dependent on use fees and academic institutions. All indications are that this shift is accelerating.

Usefulness of Model

The model of the system represented by the diagrams is crude and qualitative only. It does, however, provide a framework for collecting the data on the volume of flow in the various channels, time requirements for processing operations, manpower, money, etc., required to develop a quantitative model. Such a model would seem to be essential for intelligent decisions on policies that may affect the operation of the entire system.

Even in the present form, the model can be useful in a number of ways. Some of the more important are:

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* In fiscal 1963, the Council spent almost $1 million on such projects (6).

** See other staff papers for estimated trends for some operations, such as local and general document processing services. When the annual cost of publishing some 1,000 U.S. biomedical journals and several hundred books, of running scores of abstracting-indexing services, of maintaining some 500 biomedical libraries and various types of information centers, and of conducting hundreds of meetings is considered, an estimate of $50 million (about 6 percent of the total U.S. expenditures for biomedical research) is obviously conservative. This represents only operating expenses; the capital investment is much larger.

(1) The model permits analysis of the existing mechanisms for coordination of components, operations, and activities, on which the performance of the system depends. At present, mechanisms exist for ensuring at least some degree of coordination among the organizations performing certain operations (e.g., for publication, the Conference of Biological Editors; and for abstracting-indexing, the National Federation of Science Abstracting and Indexing Services). However, continuing mechanisms to effect coordination among the major functional components of the system, e.g., between primary record processing and document processing, are largely nonexistent. The efforts of the Office of Science Information Service of the National Science Foundation to promote coordination among performing organizations within the larger science information complex are a noteworthy exception.

(2) The model facilitates identification of critical operations and activities where limited capacity may disrupt the functioning of whole components or of the entire system. When these points are identified, action can be taken to overcome the bottlenecks. For example, our analysis of document retrieval operations indicates that the capacity of this chain is inadequate to handle the demands that will be generated by improvements in reference retrieval services (See Staff Paper No. VI).

(3) The model provides a perspective for viewing the problems of biomedical communication in terms of their relative importance and for allotting available resources accordingly. Not until the quantitative aspects of the model are better developed can some of the questions about the relative importance of various channels and operations be answered definitively; but from what is now known, it would seem that the problems of searching for references have received a disproportionate share of attention and of the effort devoted to communication research and development.

(4) The model aids in determining where innovations might be advantageous and in predicting their effects on other parts of the system. For example, in considering for possible automation those activities that have been identified as essentially clerical, the effect of such a change upon the capacity of the given channel can be seen, as well as the changes that may be required in operations that depend on the given activities.

(5) The model indicates clearly the type of personnel required for different information activities--where a high degree of subject matter knowledge is essential, and where other qualifications are more important. For example, it can be seen that, regardless of automation, any increase in information processing services will require scientific manpower and the anticipated returns must, therefore, be weighed against competing demands for this limited resource.

(6) The model demonstrates that the biomedical information complex and each of its components are integral and essential parts of the biomedical community and identifies the activities that cannot be delegated by research scientists to others.

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6. [illegible]

June 11, 1963
(Revised November, 1963)

NAS-NRC Study of Communication Problems in Biomedical Research

Staff Paper No. III

THE INFORMATION OUTPUT OF BIOMEDICAL RESEARCH AND DEVELOPMENT *

INTRODUCTION

The study described in this paper was undertaken to develop relationships between the magnitude of the national biomedical research and development (R & D) effort and the quantity of information generated thereby. Specifically, the study was directed to the hypothesis that the volume of output of information is related directly to the number of research workers, rather than to the funds expended on R & D. The conclusions reached illuminate one factor contributing to current communication problems and provide a useful basis for the prediction of future trends.

The general objective was translated into the following specific aims: (1) to obtain a comprehensive picture of past, present, and anticipated biomedical R & D, in terms of funds, manpower, and organization; (2) to identify the information output that can be attributed directly to this effort; and (3) to establish general correlations between effort and output. These aims could be achieved only by restricting our study to R & D communities for which adequate data were available on manpower and expenditures, and to units of information output that could be readily recognized and counted. For these reasons, the exploration of quantitative relationships was necessarily limited to the U. S. biomedical community and to printed information.

In addition to the "primary records" of R & D, as we define original reports of systematic scientific investigation, the "literature" contains many "secondary records" of various types (e.g., reviews, teaching articles, texts, and handbooks), as well as a sizable miscellany of case reports, descriptions of clinical experience, editorial matter, essays, organizational reports, etc. Although the volume of secondary records is undoubtedly related to that of primary records any quantitative correlations between R & D effort and the number of biomedical papers or documents should be most obvious from the direct output of R & D, i.e., the primary records. We therefore concentrated on that portion of the literature.

This paper relates some of the findings to date, describes our plans for additional collection and analysis of data, and points out areas that warrant more intensive study in the future.

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* Not for publication or publication reference.

METHODS AND SOURCES

There were many practical obstacles to this apparently simple approach. Although the measurement and analysis of the resources of U.S. science and technology have improved in recent years, accurate and reliable data on important aspects of biomedical R & D are still largely lacking. As might be expected, the most complete data pertain to financial support. Next to dollars, professional manpower has received the most attention; but private practitioners engaged in R & D without outside support and physicians engaged in research but employed in hospitals, federal and state research installations, industry, and group practice, are not well covered (1). Useful compilations of data on research projects and the organizations conducting them are only beginning to be available. In addition to the existing large gaps, there are troublesome inconsistencies in the terminology and definitions of what is being measured and analyzed. Even in the case of some serial data issued from a single source, the bases and methods of measurement change so often that it becomes precarious to attempt to assess trends over a span of as little as 10 to 20 years.

We encountered even more serious practical difficulties in trying to identify quantitatively the information output from biomedical R & D. Although there are a few estimates of undetermined accuracy, essentially no solid data exist on the information generated by all U.S. biomedical R & D. Admittedly, it is not as easy to couple biomedical information output directly with R & D activities, as it is for the information generated by defense, space, and nuclear R & D. In these fields, the major emphasis is on development; and the major instrument of support is a contract requiring the delivery of a report. In contrast, most of the funds in the biomedical field are allocated for research rather than development, the grant is the primary instrument of support, and the major source of funds (NIH) requires only administrative reports, allowing the investigator freedom to publish his scientific findings in traditional channels as and when he sees fit. Whereas one can easily identify and study the total direct information output of work supported by such an agency as the Atomic Energy Commission (AEC), this cannot be done for NIH.

In attempting to overcome these obstacles and difficulties, we conducted an intensive search for published and unpublished data relating to the biomedical R & D effort and to its information output. The search covered both government and private sources, in particular, NIH, the National Library of Medicine (NLM), the Federation of American Societies for Experimental Biology (FASEB), the Institute for Advancement of Medical Communication (IAMC), the National Science Foundation (NSF), the Library of Congress, Committees of Congress, and Herner and Company. We also called on many experienced persons in the Washington area for assistance, advice, and guidance in locating desired data. The exact meaning, significance, and probable reliability (in terms of how it was obtained and from what source) were carefully appraised for each compilation of data we found. The best of these "ready-made" data are presented and discussed in this paper. In each case the source is cited.

Early in the course of the study, we saw that the available data would be grossly inadequate to answer the questions posed; we therefore initiated a program of collecting additional, original data. This program was severely restricted by the time and manpower available; however, it has already resulted in interesting new data, some of which are included in this paper. (See the addendum for more detailed results.)

RESULTS

Funds for Biomedical R & D

In Table III-1, past and projected expenditures for biomedical R & D are compared with the gross national product (GNP), national costs of medical and health care, and total expenditures for U. S. scientific R & D. The changing pattern of support for biomedical R & D is shown in Table III-2. In the past decade, the Federal government's share has increased steadily, until in 1960 it exceeded half the total. During the same period, NIH has become by far the largest single source in the Federal government and in the nation as a whole.

Manpower

The growth in the number of professional workers* engaged in biomedical R & D is documented in Table III-3. In the period from 1954 to 1960, the total number more than doubled, and for the decade 1960-70 another twofold increase is projected. Manpower measured in terms of full-time equivalent man-years has increased somewhat less rapidly. These changes have been accompanied by steadily increasing expenditure per research worker, from $11,800 in 1954 to $18,000 in 1960; and the average expenditure per man is expected to reach $39,000 by 1970.

Organization of Research

Performing Organizations. Table III-4 illustrates the changing distribution of research workers and the simultaneous broadening of the institutional base of biomedical research. Most of the growth in research manpower has occurred in academic institutions; by 1961, more than three-quarters of all professional workers in biomedical R & D were in universities and non-profit research institutions. At the same time, the number of institutions and organizations engaged in biomedical R & D has increased markedly. In 1961, 1224 institutions received NIH research grants, as contrasted with 572 in 1957. Data on the total number are available only for 1961, when the Scientific Information Exchange (SIE) registered on-going biomedical research in 3,669 public and private organizations.

Projects. Reliable and meaningful data on the number of projects are available only for NIH (Table III-5). Although SIE has been registering a steadily increasing proportion of all biomedical research

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* Defined in the major data source (1) as "principal investigator or collaborator."

TABLE III-1
BIOMEDICAL RESEARCH AND DEVELOPMENT IN THE NATIONAL ECONOMY

(Dollars Stated in Millions)

	U.S. GROSS NATIONAL PRODUCT	U.S. EXPEND.FOR HEALTH & MED.CARE		U.S.EXPEND.FOR SCIENTIFIC R&D		U.S. EXPEND. FOR BIOMEDICAL R & D				FEDERAL GOVERNMENT EXPENDITURES FOR		
YEAR (1)	(2)	Amount (3)	% of GNP (4)	Amount (5)	% of GNP (6)	Amount (7)	% of GNP (8)	%of (3) (9)	% of (5) (10)	SCIENTIFIC R&D (11)	BIOMED. R&D (12)	% (12)/(11) (13)
1940	$100,600	$ 3,900	3.9	$ 345	0.34	$ 45*	0.045	1.2	13.0	$ 74	$ 3*	4.1
1941	---	---	---	---	---	---	---	---	---	198	---	---
1942	---	---	---	---	---	---	---	---	---	280	---	---
1943	---	---	---	---	---	---	---	---	---	602	---	---
1944	---	---	---	---	---	60*	---	---	---	1,377	10*	0.72
1945	---	7,500	---	---	---	---	---	---	---	1,591	---	---
1946	---	---	---	---	---	---	---	---	---	918	---	---
1947	---	---	---	---	---	88*	---	---	---	900	28*	3.1
1948	---	---	---	---	---	113**	---	---	---	855	39	4.6
1949	---	---	---	---	---	133**	---	---	---	1,082	51	4.7
1950	284,600	12,400	4.4	2,900	1.02	148	0.052	1.2	5.1	1,083	60	5.5
1951	329,600	---	---	3,400	1.03	163	0.050	---	4.8	1,301	73	5.6
1952	347,000	---	---	3,800	1.10	173	0.050	---	4.6	1,816	79	4.4
1953	365,000	---	---	5,150	1.41	203	0.056	---	3.5	3,101	96	3.1
1954	363,100	---	---	5,620	1.55	225	0.062	---	4.0	3,148	107	3.4
1955	397,500	17,800	4.5	6,390	1.61	240	0.060	1.3	3.8	3,308	118	3.6
1956	419,200	---	---	8,460	2.02	285	0.068	---	3.4	3,446	135	3.9
1957	442,800	21,000	4.7	10,040	2.27	397	0.090	1.9	4.0	4,462	186	4.2
1958	444,500	22,700	5.1	11,160	2.51	490	0.110	2.2	4.4	4,990	226	4.5
1959	482,800	25,200	5.2	12,430	2.57	587	0.122	2.3	4.7	5,803	290	5.0
1960	504,400	---	---	14,000	2.78	715	0.142	---	5.1	7,738	377	4.9
1961	520,000	---	---	16,000	3.08	890	0.171	---	5.6	8,789	496	5.6
1962	---	---	---	---	---	---	---	---	---	10,172	---	---
1970	800,000	---	---	48,000	6.00	3,000	0.375	---	6.3	---	---	---

Data sources:

Except for items marked with * or **, Columns (2), (5), (7), and (12) taken from U.S. Public Health Service. Resources for Medical Research, Report No. 3. Washington, D.C., Government Printing Office, 1963.

Column (3) and items marked with ** taken from U.S. Senate, Committee on Government Operations. Health Research and Training, Second Report. House Report No. 321, 87th Congress, 1st Session. Washington, D.C., Government Printing Office, 1961.

Column (11) taken from National Science Foundation. Federal Funds for Science 10, Fiscal Years 1960, 1961, and 1962: Surveys of Science Resources Series: NSF 61-82. Washington, D.C., Government Printing Office, 1962.

* Shannon, J.A. and Kidd, C.V. Medical Research in Perspective. Science 124, 3233, 14 December 1956, 1185-1190.

** U.S. Senate. Committee on Government Operations. Health Research and Training. Second Report. House Report No. 321, 87th Congress, 1st Session. Washington, D.C., Government Printing Office, 1961.

TABLE III-2
SOURCES OF SUPPORT OF U.S. BIOMEDICAL RESEARCH AND DEVELOPMENT
(Dollars Stated in Millions)

YEAR	U.S. EXPENDITURES FOR BIOMEDICAL RES. & DEV.	EXPENDITURES OF FEDERAL SOURCES		NIH EXPENDITURES FOR BIOMEDICAL R&D			NIH EXPENDITURES FOR EXTRAMURAL R&D		NIH EXPENDITURES FOR INTRAMURAL R&D	
		Amount	Percent of (2)	Amount	% of (2)	% of (3)	Amount	% of (5)	Amount	% of (5)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1946	$ ---	$ ---	---	$ 3.1	---	---	$ 0.8	25.8	$ 2.3	74.2
1947	88*	28*	31.8	8.4	9.5	30.0	3.4	40.5	5.0	59.5
1948	113**	39	34.5	16.4	14.5	42.1	8.9	54.3	7.5	45.7
1949	133**	51	38.3	21.2	15.9	41.6	10.9	51.4	10.3	48.6
1950	148	60	40.5	25.8	17.4	43.0	13.1	50.8	12.7	49.2
1951	163	73	44.8	30.4	18.7	41.6	15.6	51.3	14.8	48.7
1952	173	79	45.7	32.1	18.6	40.6	18.2	56.7	13.9	43.3
1953	203	96	47.3	38.2	18.8	39.8	20.3	53.1	17.9	46.9
1954	225	107	47.6	48.8	21.7	45.6	28.9	59.2	19.9	40.8
1955	240	118	49.2	58.8	24.5	49.8	33.9	57.7	24.9	42.3
1956	285	135	47.4	71.0	24.9	52.6	38.6	54.4	32.4	45.6
1957	397	186	47.0	125.2	31.5	67.3	80.6	64.4	44.6	35.6
1958	490	226	46.1	157.4	32.1	69.6	100.0	63.5	57.4	36.5
1959	587	290	49.4	209.6	35.7	72.3	140.7	67.1	68.9	32.9
1960	715	377	52.7	283.8	39.7	75.3	199.2	70.2	84.6	29.8
1961	890	496	55.7	385.3	43.3	77.7	286.9	74.5	98.4	25.5
1962	---	---	---	---	---	---	372.1	---	---	---

Data sources:

Except for items marked with * or **, Columns (2) and (3) taken from U.S. Public Health Service. Resources for Medical Research, Report No. 3. Washington, D.C., Government Printing Office, 1963.

Columns (5), (8), and (10) taken from Lindsy, D.R. and Allen, E.M. Medical Research: Past Support, Future Directions. Science 134, 3495, 22 December 1961, 2017-2024.

* Shannon, J.A. and Kidd, C.V. Medical Research in Perspective. Science 124, 3233, 14 December 1956, 1185-1190.

** U.S. Senate, Committee on Government Operations. Health Research and Training, Second Report. House Report No. 321, 87th Congress, 1st Session. Washington, D.C., Government Printing Office, 1961.

TABLE III-3

BIOMEDICAL RESEARCH AND DEVELOPMENT MANPOWER
(Professional Worker = Principal Investigator or Collaborator)

YEAR	TOTAL NUMBER OF PROF. WORKERS	FULL-TIME EQUIV. MAN-YEARS		ANNUAL DOLLAR EXPENDITURES	
		No.	% of Total	Per Prof. Worker	Per Full-time Equiv. Man-year
(1)	(2)	(3)	(4)	(5)	(6)
1954	19,200	14,000	72.9	$ 11,700	$ 16,070
1958	34,600	23,100	66.8	14,200	21,200
1960	39,700	27,285	68.7	18,000	26,200
1970	77,000	---	---	39,000	---

Data source: All data taken from or developed arithmetically from U.S. Public Health Service. Resources for Medical Research, Report No. 3. Washington, D.C., Government Printing Office, 1963.

TABLE III-4

PERFORMING ORGANIZATIONS IN U.S. BIOMEDICAL RESEARCH AND DEVELOPMENT

YEAR	DISTRIBUTION OF BIOMEDICAL RESEARCH WORKERS BY PERFORMANCE SECTOR								NIH-SUPPORTED R & D ORGANIZATIONS			BIOMEDICAL R&D ORGAN-IZATIONS REGISTERED BY SIE**
	Total		Government		Industry		Universities*			Av. Dollars /Organ.	Av. No. Projects /Organ.	
	No.	%	No.	%	No.	%	No.	%	No.			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1954	19,200	100.0	3,700	19.3	3,400	17.7	12,100	63.0	---	$ ---	--	---
1957	---	---	---	---	---	---	---	---	572	141,000	10	---
1958	34,600	100.0	6,900	19.9	6,500	18.8	21,200	61.3	---	---	--	---
1960	39,700	100.0	7,800	19.7	7,200	18.1	24,700	62.2	973	204,700	11	3,669
1961	---	---	---	---	---	---	---	---	1,224	234,400	10	---
1970	77,000	100.0	12,000	15.6	12,000	15.6	53,000	68.8	---	---	--	---

Data sources:

Columns (2), (4), (6), and (8) taken from U.S. Public Health Service. Resources for Medical Research, Report No. 3. Washington, D.C., Government Printing Office, 1963.

Column (10) taken from House of Representatives, Subcommittee of the Committee on Government Operations. The Administration of Grants by the National Institutes of Health, Hearings, March 28, 29, and 30, 1962, 87th Congress, 2nd Session. Washington, D.C., Government Printing Office, 1962.

Column (13) taken from U.S. Senate, Committee on Government Operations, Subcommittee on Reorganization and International Organizations. Coordination of Activities of Federal Agencies in Biomedical Research. Hearing, August 11, 1960, 86th Congress, 2nd Session. Washington, D.C. Government Printing Office, 1960.

Other data derived arithmetically.

* and non-profit research institutes

** Science Information Exchange

TABLE III-5

U.S. BIOMEDICAL RESEARCH AND DEVELOPMENT PROJECTS

	PROJECTS SUPPORTED BY NIH		PROJECTS REGISTERED BY SIE *		
				Non-Federally Supported	
YEAR (1)	No. (2)	Average Annual Expend. (3)	Total No. (4)	No. (5)	Av. Annual Expend. (6)
1950	1,400	$ 9,360	3,317	---	$ ---
1951	1,500	10,400	3,216	---	---
1952	1,700	10,700	4,269	---	---
1953	2,000	10,150	4,933	---	---
1954	2,600	11,120	6,015	---	---
1955	3,000	11,300	6,693	---	---
1956	3,100	12,450	7,967	---	---
1957	5,700	14,140	10,849	---	---
1958	6,500	15,390	12,410	---	---
1959	8,500	16,550	15,080	---	---
1960	10,700	18,620	30,012	4,283	12,644
1961	13,500	21,250	---	4,876	11,457
1962	14,975	24,800	---	4,600	11,975

Data sources:

Column (2) Lindsay, D.R. and Allen, E.M. Medical Research: Past Support, Future Directions. Science 134, 3495, 22 December 1961, 2017-2024.

Column (3) calculated from data in Table III-2, Col. (8), and Table III-5, Col. (2).

Column (4) U.S. Senate. Committee on Government Operations, Subcommittee on Reorganization and International Organizations. Coordination of Activities of Federal Agencies in Biomedical Research. Hearing, August 11, 1960, 86th Congress, 2nd Session. Washington, D.C., Government Printing Office, 1960.

Columns (5) and (6) supplied by Science Information Exchange, June 6, 1963.

* Science Information Exchange

projects, the completeness of its coverage is unknown. Published estimates of the number of projects supported by other Federal agencies and by private sources are based on the untenable assumption that the average annual expenditure per project is the same as for NIH projects. (The average expenditure for all non-Federally supported projects registered with SIE in 1960, 1961, and 1962 was considerably less than that for NIH projects.)

The duration of projects supported by NIH has been changing. Between 1950 and 1955, the proportion of 1-year grants decreased from 50 to 10 percent (2), while 3- to 5-year grants increased from 20 to 50 percent. In 1960, 16 percent of NIH grants were for 1 year or less, 19 percent for 1 to 2 years, 45 percent for 2 to 3 years, and 20 percent for 3 or more years. The average duration was 2.86 years (3).

Growth Trends

When the various growth curves for the U.S. biomedical R & D effort are plotted semilogarithmically, using data from Tables III-1 through III-5, the slopes suggest underlying exponential rates. The irregularities, however, are so large that the calculation of over-all growth rates as a basis for projections into the future is highly precarious.

Information Output

Only one previous study has attempted to assess the total output of papers directly coupled with a major biomedical R & D program. Lindsay and Allen (4) counted the reprints in NIH extramural project files and the papers generated by NIH intramural research to obtain the data shown in Table III-6 (which is modified in the addendum to this paper). They felt these figures represented 90 percent of the total papers generated by NIH-supported research. We have supplemented their data by adding corresponding figures for 1961, and for extra- and intramural research separately (see Appendix III-A for complete data, methods and calculations).

In 1962, Shilling studied the sources of financial support acknowledged in all the papers published in 100 key biological journals during the years 1950 and 1960 (5). Sixty-one of these journals are indexed in Index Medicus and therefore fall in the biomedical area.* Because the contents of these biomedical journals (9,420 articles in 1960) represent a sizable sample of American biomedical literature, we have used the data to illustrate some changes in biomedical R & D output during the last decade (Table III-7).

Publication Habits of Biomedical Workers

The output of biomedical R & D can be approached less directly by studying the publication habits of research workers. Here also we found little in the way of solid data, at least for biomedical research workers.

Gerard's impressive study of physiologists provides the only data on a representative cross section (6). In his study, one of the questions

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* The 61 journals are listed in Appendix III-B.

TABLE III-6

PAPERS GENERATED BY NIH-SUPPORTED RESEARCH*

YEAR	Extra- and intramural research (1)	Intramural research only (2)	Extramural research only (3)
1957	5,230 (5,700)	1,160	4,070 (4,500)
1958	5,895 (6,300)	1,329	4,566 (5,000)
1959	8,364 (9,000)	1,599	6,765 (7,400)
1960	11,000 (12,000)	1,616	9,384 (10,300)
1961	13,936	1,634	12,302
1962**	---	1,849	---

Data sources:		
	Column (1)	Data for 1957-1960, Lindsay, D.R. and Allen, E.M. Medical Research: Past Support, Future Directions. <u>Science</u> 134, 3495, 22 December 1961, 2017-2024. Figure for 1961 calculated by adding columns (2) and (3). In parentheses are corrected values obtained by increasing the figures for 1957-1960 in Column (3) by 10 percent to compensate for a systematic error.
	Column (2)	Issues of the <u>Annual Staff Bibliography of NIH</u>.
	Column (3)	Data for 1957-1960 derived by subtracting column (2) from (1), figure for 1961 obtained by analysis of NIH Research Grants Indexes for fiscal years 1961 and 1962 (see Appendix III-A for methods, raw data, and calculations).

* Modified in addendum to this paper.

**1962 values in columns (1) and (3) are not given since an accurate figure could not be obtained for 1962 papers resulting from the NIH extramural research program (see Appendix III-A for reasons).

TABLE III-7

CHANGES IN RESEARCH SUPPORT AS REFLECTED IN 61 BIOMEDICAL JOURNALS*

A. Source of Support

	1950 (total no. articles=7,195)		1960 (total no. articles=9,420)		Growth "Factor"† (of totals=1.3)
	No. articles	% total	No. articles	% total	
"Outside"**	4,798	66	8,751	93	1.8
Federal (all agencies)	1,830	25	4,683	50	2.6
Dept. of HEW	836	12	2,900	31	3.5

B. Distribution of "Outside" Support (in % of all articles acknowledging "outside" support)

	1950	1960
Federal (all agencies)	38	53
Dept. of HEW	18	33

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* Shilling, Charles W. Support of Scientific Research as Acknowledged in 100 Selected Biological Journals. BSCP Communiqué 8-62, June 1962, entire issue (56 p.).

** Includes all articles acknowledging financial support from sources outside author's institution.

† Calculated as the ratio of value for 1960 to that for 1950.

answered by some 4,000 research physiologists was how many papers they had published (as author or co-author) in the previous 3 years (roughly, 1950-52). Gerard's data can be summarized as follows:

No. papers in 3 yr.	% of physiologists
0	8
1 or 2	18
3 or 4	23
5 or 6	17
7 or 8	8
9 or 10	9
11 or 12	4
13 or 14	1
15 or more	10

The average was 1.7 "authorships"/man-year. Gerard noted that this figure was misleading because, if one multiplied the total number of physiologists by this average, the product greatly exceeded the annual output of American physiology papers; and he commented that multiple authorship of papers "may well cut the number to a half or a third."

One other source of good data on the publication habits of biomedical workers is the statistics compiled by the Section of Publications of the Mayo Clinic on the number of manuscript pages handled per year, compared with the total number of Staff Members for the same years (see Appendix III-C for complete data). This Section handles all manuscripts emanating from the Mayo Clinic. We have supplemented these data with the total number of papers published by Mayo Staff Members. The ratio of papers to staff members was 1.8 for 1950-54, 1.4 for 1955-59, 1.4 for 1960-62, and averaged 1.6 for the entire 13-year period.

We are currently studying how the publication habits of other types of biomedical populations have changed over the past two decades. Our findings to date are summarized in Tables III-8, III-9, and III-10 (see Appendix III-D for methods and complete data). The data for NIH staff papers indicate a rapid trend toward multiple authorship. The same trend is evident in the data for papers indexed in Index Medicus, but is not as well developed.

DISCUSSION

Correlations of R & D Effort with Publications

The pattern of research support indicated by acknowledgements in the selected sample of biomedical journals closely reflects that of U.S. biomedical R & D support [compare the percentages for Federal and for HEW support in Part B of Table III-7 with those for 1950 and 1960 for Federal and NIH shown in columns (4) and (6) of Table III-2]. The same phenomenon was noted by Milton and Johnson (7). However, none of the R & D growth

TABLE III-8

DISTRIBUTION OF RATES OF "AUTHORSHIP"*
(% of total authors with given rate of authorship)

A. In NIH Staff Bibliographies

Year	Authorships/year							Average authorship rate
	1	2	3	4	5	>5	>10	
1943	54	17	10	8	3	7	2	2.4
1954	49	18	10	7	5	11	3	2.6
1962	55	19	9	6	3	7	1	2.2

B. In Index Medicus

Year	Authorships/year						Average authorship rate
	1	2	3-4	5-7	8-10	>10	
1962	66	18	11	3	1	1	1.9

C. Comparison of NIH Staff Bibliographies and Index Medicus

Year	Authorships/year								Average authorship rate	
	1		2		> 2		>10			
	NIH	IM	NIH	IM	NIH	IM	NIH	IM	NIH	IM
1943	54	--	17	--	30	--	2	--	2.4	--
1954	49	--	18	--	36	--	3	--	2.6	--
1962	55	66	19	18	26	15	1	1	2.2	1.9

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* Rate of authorship is defined as the number of papers written per man per year. See Appendix III-D for complete data and methods of calculation.

TABLE III-9

DISTRIBUTION OF SINGLE AND MULTIPLE AUTHORSHIP

A. Papers in NIH Staff Bibliography

Year	Number of authors				Average No. authors per paper
	1	2	3	>3	
1939	59	27	11	3	1.6
1943	55	25	16	4	1.7
1952	43	25	20	11	2.0
1962	34	30	20	16	2.2

B. Papers in Index Medicus

Year	Number of authors				Average No. authors per paper
	1	2	3	>3	
1957*	59	23	10	8	1.5
1962	50	27	14	10	1.9

See Appendix III-A for complete data and methods of calculation.

* Data for this year from Taine, Seymour I., The National Library of Medicine Index Mechanization Project, Bulletin of the Medical Library Association, Volume 49, No. 1, Part 2, January 1961, entire issue (96 p.).

TABLE III-10

PUBLICATION PRODUCTIVITY OF VARIOUS AUTHOR POPULATIONS

(Total No. papers/total No. of authors)

Year	Mayo Clinic	NIH Staff	Index Medicus	Physiologists
1943	---	1.4	---	---
1952	---	---	---	0.83
1954	(1950-1954) 1.8	1.4	---	---
1962	(1960-1962) 1.4	1.0	1.0	---

All values derived from data in Appendixes III-C and III-D, except that for physiologists, which is based on Gerard, R. Mirror to Physiology; A Self-survey of Physiological Science. Ann Arbor, University of Michigan Press, 1958

TABLE III-11

CORRELATION OF R & D EFFORT AND INFORMATION OUTPUT

A.

	Growth Rates* for Funds (1950-1960)	Growth Rates* for Articles (1950-1960)	"Correlation" Index**
U.S. biomedical R & D	0.38	0.03	0.08
Federal biomedical R & D	0.53	0.16	0.30
NIH R & D	1.0	0.25 (HEW)	0.25

B.

	Growth Rates* for Funds (1956-1959)	Growth Rates* for Articles (1958-1961)	"Correlation" Index**
NIH R & D	0.65	0.40	0.62
NIH intramural R & D	0.38	0.08	0.21
NIH extramural R & D	0.88	0.49	0.56
NIH projects	0.58		0.84

* Growth rate = $\frac{y - x}{xt}$, where y = value for last year of period, x = value for first year period, and t = number of years in period; from Tables III-2, III-5, III-6, and III-7.

**"Correlation" index - growth rate for articles divided by growth rate for funds.

factors calculated for the period 1950-1960 agree at all closely with the corresponding growth factors for this sample of information output (see Table III-11, Part A). It is doubtful whether the output growth factors derived from this sample accurately portray the growth of biomedical research literature in general. Two additional considerations make this particular comparison of effort and output invalid. First, during the period 1950-1960, R & D funds, manpower, and projects were not increasing at a steady rate. Second, one would not expect that increases in effort would result immediately in increased output. A lag of 2 years would be expected from the nature of project research, from the known delay in publication, and from studies of the metabolism of biomedical information (8). Additional evidence for a 2-year lag is afforded by our analysis of the references given in the NIH Research Grants Index for fiscal year 1962 (see Appendix III-A). It is noteworthy that the sharp deceleration of the rate of expenditure of NIH & R & D funds that occurred in 1956 is followed in 1958 by a similar break in the growth rate of NIH-support-generated papers.

In attempting to establish valid correlations, a period of relatively constant increase of R & D effort should be chosen and the R & D indexes for this period compared with output indexes for a period 2 years later. During the period from 1956 to 1959, NIH (and total U.S.) R & D expenditures were increasing at a fairly constant rate, and we have good figures for output during 1958-1961. The corresponding growth rates for these two periods are compared in Part B of Table III-11. Expenditures of funds increased much more rapidly than any of the output measures. However, agreement between the increase in the number of projects and publication output was quite close.

One would expect that output would be related directly to manpower. Unfortunately, calculating NIH-supported R & D manpower to compare with NIH-support-generated papers would necessitate questionable assumptions; however, the number of projects seems to be directly related to manpower. The average annual expenditure per NIH project [column (3), Table III-5] is quite close to the annual expenditure per professional worker [column (5), Table III-3],especially for 1954 and 1960. Therefore, the number of projects can serve at least as a rough estimate of manpower.

Not only does the increase in projects correspond closely with that of publications, but the relation between the number of projects in a given year and the number of papers 2 years later is quite constant (between 1.3 and 1.6 during the period 1956-1960). The same type of relationship is found in the NIH Research Grants Index for fiscal year 1962, where the average number of references cited for projects older than 1 year is 1.4 (see Appendix III-A).

Authorship Rates and "Publication Productivity"

The ratio of the total number of papers to the total number of Mayo Clinic Staff Members (Table III-10) represents what may be called the "publication productivity" of this population of biomedical workers, as contrasted with Gerard's value (6), which gave the average authorship rate for all physiologists who responded to his questionnaire. The difference is similar to that between birth rate and parenthood rate, except that papers may have from one to a score of "parents."

We have calculated both authorship rates and publication productivity for NIH intramural staff and Index Medicus (see Tables III-8 and III-10), taking as our base only the active authors in the given population, i.e., those who published something during the given year. Gerard's value for authorship rate, on the other hand, is based on all members of the given population. The figures shown for NIH staff and Index Medicus are somewhat higher than they would be if calculated for the respective total populations of all NIH staff and of all members of the biomedical community. To facilitate comparison, Gerard's data have been converted to a 1-year basis and calculated only for those physiologists who wrote at least one paper in the 3-year period. The distribution of authorship rates for physiologist authors in 1950-1952 then becomes:

No. papers per year	% of physiologists
1 or 2	64
3 or 4	23
more than 4	12
Average authorship rate:	1.9 paper/yr.

Comparable figures for NIH authors are:

No. papers per year	% of authors		
	1943	1954	1962
1 or 2	71	67	74
3 or 4	18	17	15
more than 4	12	18	11
Average authorship rate (papers/yr.)	2.4	2.6	2.2

In 1950, papers in the American Journal of Physiology carried an average of 2.3 authors' names. If this figure is typical of the physiology literature for 1950-1952, then the publication productivity of physiologist authors in the early 1950's is lower than that of NIH authors in the same period (see Table III-10). The publication productivity for Mayo Clinic Staff Members is based on a count of all staff members, rather than of authors only; but it is reasonable to assume that each staff member published at least one paper during the 3- to 5-year periods for which average rates of authorship were calculated. Therefore, figures for the Mayo Clinic are roughly comparable to those for NIH staff.

From analyses that are proceeding, it is apparent that publication productivity varies with the relative "seniority" of the population, among other factors. We hope to study other types of biomedical R & D populations, e.g., medical school populations. Our best present estimate of publication productivity for the total population of U.S. professional-level workers (principal investigators and collaborators) in biomedical R & D is about 1.4 papers/worker-year for the period 1950-1960.

Implications for the Size of the Biomedical Literature

Assuming that the entire biomedical R & D effort generates papers at the same rate as projects supported by NIH funds, and that the "biomedical literature" as collected by the National Library of Medicine encompasses almost all the biomedical R & D output, then the identifiable direct output of the U.S. R & D effort in 1957 can be estimated from U.S. R & D funds in 1955 to be about 32,000 articles. (The average paper supported by NIH extramural funds and published in 1957 represented about $7,600 expended for research in 1955). This output is about 60 percent of the 54,000 articles Brodman & Taine estimated as comprising the total "substantive" U.S. biomedical literature in 1957 (9). In 1961, the output of the U.S. biomedical R & D effort would be about 49,000 articles, estimated on the basis of a 1959 expenditure of $12,000 to produce one 1961 paper. Inasmuch as 94 percent of the articles published in the sample of 61 biomedical journals for 1960 (see Table III-7) acknowledged "outside", support, which is presumably included in the figures we have for R & D expenditures, this estimate for 1961 biomedical R & D output probably represents most of the primary records for that year if the assumptions are reasonably valid.

These estimates for 1957 and 1961 may be compared with estimates based on extrapolated 1955 and 1959 manpower figures and a publication productivity of 1.4. The latter come to 32,000 papers for 1957 and 52,000 for 1961.

Staff Plans for Further Study

As time and personnel limitations permit, we plan to refine our analyses of authorship rates and publication productivity and to extend our study to include the 1942 volumes of the Current List of Medical Literature and annual staff bibliographies of various types of biomedical research institutions (see the addendum to this paper). The aim will be to get a better idea of the changes that have occurred over the past 20 years and to investigate the possibility, suggested by some incompletely analyzed data, that the publication productivity of biomedical research workers may be declining.

CONCLUSIONS

(1) The publication output of the biomedical R & D effort appears to be increasing at about the same rate as biomedical manpower and more slowly than biomedical R & D expenditures.

(2) The number of publications generated by biomedical R & D is closely related to the number of biomedical research workers 2 years before.

(3) Each NIH-supported research project generates about 1.4 publications per year after the project has run from 1 to 2 years.

(4) In the past decade, the U.S. population of biomedical scientists produced about 1.4 publications per man-year.

(5) In 1957, about 60 percent of U.S. biomedical literature resulted from the formal biomedical R & D effort.

November 19, 1963

Addendum to Staff Paper No. III

ADDITIONAL DATA

Publications Generated by NIH Support

After the original Table III-6 had been compiled, using as sources Lindsay and Allen's paper (4) and the NIH Research Grants Indexes for fiscal years 1961 and 1962, we learned from NIH staff that these sources had omitted some publications. Dr. Errett C. Albritton, Chief of Research Accomplishments, Division of Research Grants, supplied us with revised figures on the number of grantee publications identified in the files of the Division of Research Grants, and Mrs. Lynda McGee, Supervisory Scientific Reference Analyst, provided information on 861 grants that were not included in the 1962 index but generated 662 publications in 1961 and 889 in 1962. The corrected data are shown in a revised version of Table III-6.

Further Analyses of Index Medicus

To ascertain trends over the past two decades, we analyzed the papers indexed during 1942 and 1952 by the predecessors of the present Index Medicus. Every nth page of the appropriate sections of these publications were tabulated in the manner described in Appendix III-D. These data are given in Tables III-D-5 through III-D-8.

TABLE III-D-5

NUMBER OF AUTHORS PER PAPER IN 10 PERCENT SAMPLE OF 1942 QUARTERLY CUMULATIVE INDEX MEDICUS

No. of authors per paper	No. of papers	% of papers
1	2,734	70
2	833	22
3	250	6
4	60	2
more than 4*	5	1
Total	3,882	

Average no. authors/paper = 1.4

* Only the first author's name is given for papers having more than 4 authors.

No. of papers listed in 175 pages (of 1671) x sampling factor (9.6) = estimate of number of papers listed in 1942 Quarterly Cumulative Index Medicus = 37,300.

TABLE III-D-6

NUMBER OF AUTHORS PER PAPER IN 5-PERCENT SAMPLE OF 1942 QUARTERLY CUMULATIVE INDEX MEDICUS

No. of papers per author	No. of authors	% of authors
1	1,524	82
2	232	12
3	61	3
4	20	1
5	8	1
6	7	1
7	4	1
8	2	1
9	2	1
10	1	1
11	1	1
23	1	
Total	1,863	

No. of authors listed in 83.5 pages (of 1671) x sampling factor (20) = estimate of no. of authors listed in 1942 Quarterly Cumulative Index Medicus = 37,300.

Revised TABLE III-6

PAPERS GENERATED BY NIH-SUPPORTED RESEARCH

	Number of Papers		
Year	Generated by Extramural Research	Generated by Intramural Research	Total
	(1)	(2)	(3)
1957	4,070	1,160	5,230
1958	4,795	1,329	6,124
1959	7,035	1,599	8,634
1960	11,742	1,616	13,358
1961	12,965	1,634	14,599
1962*	---	1,849	---

Data sources: Column (1) Data for 1957-1960, Dr. Errett C. Albritton, Chief of Research Accomplishments, Division of Research Grants. Figure for 1961 obtained by analysis of NIH Research Grants Indexes for fiscal years 1961 and 1962 (see Appendix III-A for methods, raw data, and calculations) and adding publications omitted from 1962 index as per Mrs. Lynda McGee, Supervisory Scientific Reference Analyst

Column (2) Issues of the Annual Staff Bibliography of NIH

* 1962 values in columns (1) and (3) are not given since an accurate figure cannot yet be obtained for 1962 papers resulting from the NIH extramural research program (see Appendix III-A for reasons).

TABLE III-D-7

NUMBER OF AUTHORS PER PAPER IN 5-PERCENT SAMPLE OF 1952 CURRENT LIST OF MEDICAL LITERATURE

No. of authors per paper	No. of papers	% of papers
1	2,740	62
2	1,038	23
3	425	10
4	153	3
5	54	1
6	22	1
7	6	
8	1	
9	1	
10	1	
Total	4,441	

Average no. authors/paper = 1.6

No. of papers listed in 71.5 pages (of 1439) x sampling factor (20) = estimate of no. of papers listed in 1952 Current List of Medical Literature = 89,000.

TABLE III-D-8

NUMBER OF PAPERS PER AUTHOR IN 10-PERCENT SAMPLE OF 1952 CURRENT LIST OF MEDICAL LITERATURE

No. of papers per author	No. of authors	% of authors
1	6,970	75
2	1,449	16
3	518	6
4	219	2
5	99	1
6	38	1
7	21	1
8	12	1
9	6	1
10	5	1
12	4	1
17	1	
Total	9,342	

No. of authors listed in 31 pages (of 311) x sampling factor (10) = estimate of no. of authors listed in 1952 Current List of Medical Literature = 93,400.

Refinement of Analysis of NIH Staff Bibliographies

Individuals not employed by NIH are included in the author index of NIH staff bibliographies if they collaborated with NIH staff in writing papers. Because not all the publications of these individuals would be covered in the NIH bibliography, the original tabulations (Tables III-D-1 and III-D-2) needed to be refined by separating staff and non-staff authors if exact comparisons were to be made with our data on other populations for which the total publication outputs were known, e.g., the Mayo Clinic.

In the time available, it was possible to accomplish this refinement for only 1 year. In the 1962 NIH bibliography, 2,967 individuals were listed in the index, which included both authors of papers and all other members of the intramural "professional" staff (a total of 1,846 in fiscal year 1963), whether or not they had published anything since the last annual bibliography. Of 1,861 persons named as authors, only 740 were also designated as "professional" staff. Sampling a 1963 NIH telephone directory showed that, of the remaining 1,121 authors, about 370 were NIH employees who collaborated with members of the "professional" staff in writing a paper. A rough check of the 194 papers in the bibliography for which <u>none</u> of the authors were identified as "professional" staff revealed that for most, if not all, of these papers at least one author had been listed in the 1960 or 1961 staff directory. The remaining authors (about 500) undoubtedly represent collaborators from other institutions.

The number of papers per author in the 1962 bibliography was retabulated only for those authors designated as "professional" staff (740) in the same index. The results are given in Table III-D-9.

TABLE III-D-9

NUMBER OF PAPERS PER "PROFESSIONAL" STAFF AUTHOR IN 1962 NIH BIBLIOGRAPHY

No. of papers per "professional" author	No. of authors	% of authors
1	253	35
2	168	23
3	90	12
4	79	11
5	42	6
6	29	15
7	33	
8	13	
9	9	
10	11	
12	3	
13	2	
14	1	
16	2	
17	1	
19	1	
23	1	
25	1	
36	1	
Total	740	

Publication Habits of Other Research Communities

Attempts to find research institutions, and particularly medical schools, that had compiled comprehensive annual staff or faculty bibliographies over the last 10 to 20 years were unsuccessful in the limited time available. However, we obtained a suitable series of annual faculty bibliographies from 1957 to 1961 for the Medical College of Virginia. We tabulated these bibliographies in the same way as the NIH staff bibliographies. The results are shown in Tables III-D-10 and III-D-11.

TABLE III-D-10

NUMBER OF AUTHORS PER PAPER* LISTED IN BULLETIN OF THE MEDICAL COLLEGE OF VIRGINIA

	YEAR									
No. of authors perpaper	1957		1958		1959		1960		1961	
	No. of papers	% of papers	No. of papers	% of papers	No. of papers	% of papers	No. of papers	% of papers	No. of papers	% of papers
1	167	50	136	54	122	44	154	45	127	44
2	102	30	50	20	67	24	90	26	91	32
3	47	14	44	17	48	18	61	18	37	13
4	7	2	16	6	27	10	23	7	21	7
5	7	2	3	1	8	3	5	1	7	2
6	1	1	3	2	2	1	3	2	4	2
7	3		2		--		3		1	
9	--		--		1		--		--	
19	--		--		--		1		--	
Totals	334		254		275		340		288	
Average number authors per paper	1.8		1.9		2.0		2.0		2.0	

* See note to Table III-D-11.

TABLE III-D-11

NUMBER OF PAPERS* PER AUTHOR LISTED IN BULLETIN OF THE MEDICAL COLLEGE OF VIRGINIA

No. of papers per author	YEAR									
	1957		1958		1959		1960		1961	
	no. of authors		no. of authors		no. of authors		no. of authors		no. of authors	
	staff	non-staff**	staff	non-staff	staff	non-staff	staff	non-staff	staff	non-staff
1	109	32	108	25	95	116	132	18	115	12
2	39	-	28	3	31	8	33	3	43	-
3	13	-	15	-	22	1	22	-	22	1
4	21	-	9	-	7	-	14	-	16	-
5	9	-	4	-	6	-	7	-	4	-
6	5	-	3	-	3	-	5	-	3	-
7	3	-	1	-	2	-	7	-	4	-
8	1	-	4	-	4	-	3	-	3	-
9	2	-	1	-	-	-	-	-	-	-
10	1	-	-	-	2	-	2	-	-	-
12	1	-	-	-	1	-	-	-	-	-
13	-	-	1	-	-	-	2	-	1	-
14	-	-	-	-	-	-	1	-	-	-
Totals	204	32	174	28	173	125	228	21	211	13
Avg. no. papers per author	2.2		2.0		2.2		2.3		2.1	
Publication productivity	1.6		1.5		1.6		1.5		1.4	

* In Tables III-D-10 and III-D-11, only journal articles were counted as papers. The Bulletin listed 17 other types of publications in 1957, 13 in 1958, 10 in 1959, 6 in 1960, and 9 in 1961.

**Individuals who collaborated with the school's staff members in writing papers.

Correlations of R & D Effort with Publications

The corrected data on the number of publications resulting from the NIH extramural program change the previously calculated growth rate for articles to 0.58 (see Part B of Table III-11) and the "correlation" index for NIH projects to 1.0. The other relationships that were discussed are not significantly altered by the corrected data.

DISCUSSION

Incidence of Multiple Authorship

The new data relating to the number of authors per paper supplement those previously obtained, and indicate a remarkable similarity in the rate of change in the incidence of multiple authorship of publications by NIH staff and by Index Medicus (IM) authors over the past 20 years. It would seem that the latter population lags about 10 years behind the former with regard to this trend toward multiple authorship. Since the majority of IM authors are foreign (9), perhaps this difference means that the U.S. biomedical community leads the trend and that, if figures were available for it alone, they would be closer to those for NIH. The faculty of the Medical College of Virginia falls somewhere between the NIH and the IM populations with regard to the incidence of multiple authorship.

Authorship Rates and Publication Productivity

In Table III-12, the new data on authorship rates and publication productivity are combined with those we originally presented. In this table only the refined data on NIH intramural staff are included. When possible the calculations are made on two bases: (1) only the active authors in the population (those who published at least one paper in the given year), and (2) all members of the population.

Where serial data are available, a decrease in publication productivity is suggested, but the evidence is as yet inadequate to establish any trend with assurance. A decrease in publication productivity might be explained if the pressures to publish are being satisfied by producing papers that carry the names of more and more authors. It might also be caused, at least in part, by an increasing reliance on oral presentations as definitive reports and by factors that relate to the "creativity" of the biomedical community.

The importance of the factor of publication productivity in determining the load upon the entire biomedical communication complex warrants a considerable effort to collect more data. The analyses of the publication habits of NIH staff should be further refined by considering separately the staff actively engaged in research, and these analyses should be carried out for as many years as possible. In addition, other academic and research communities should be studied.

TABLE III-12

TRENDS IN AVERAGE AUTHORSHIP RATES AND PUBLICATION PRODUCTIVITY

(Values in parentheses calculated on basis of all members of given population; those not enclosed in parentheses calculated on basis of only the members who wrote at least one paper in the given year).

	Average Authorship Rates					Publication Productivity				
	IM	Physiol.	Coll. V.	Mayo	NIH	IM	Physiol.	Coll. V.	Mayo	NIH
1939	---	---	---	---	---	---	---	---	---	---
....										
1942	1.4	---	---	---	---	1.0	---	---	---	---
1943	---	---	---	---	---	---	---	---	---	---
....										
1950	---	---	---	---	---	---	---	---	(2.4)	---
1951	---	---	---	---	---	---	---	---	(2.0)	---
1952	1.5	1.9*(1.7)	---	---	---	.95	.83(.74)	---	(1.4)	---
1953	---	---	---	---	---	---	---	---	(1.7)	---
1954	---	---	---	---	---	---	---	---	(1.8)	---
1955	---	---	---	---	---	---	---	---	(1.5)	---
1956	---	---	---	---	---	---	---	---	(1.5)	---
1957	---	---	2.2(69)	---	---	---	---	1.6(.50)**	(1.8)	---
1958	---	---	2.0	---	---	---	---	1.5	(1.4)	---
1959	---	---	2.2	---	---	---	---	1.6	(1.1)	---
1960	---	---	2.3	---	---	---	---	1.5	(1.8)	---
1961	---	---	1.8	---	---	---	---	1.4	(1.1)	---
1962	1.9	---	---	---	3.1(1.3)†	1.0	---	---	(1.4)	2,2(.89)†

IM = author listed in Index Medicus; Physiol. = Physiologists; Coll. V. = faculty of Medical College of Virginia; Mayo = Mayo Clinic Staff Members; NIH = NIH intramural "professional" staff.

* Average for physiologists in sample who wrote at least one paper during 3-year period.

**Calculated on basis of all full- and part-time faculty (662).

†Calculated on basis of all "professional" staff (1846) listed in NIH directory for fiscal year 1963, the index for which served also for the 1962 NIH staff bibliography.

Implications for the Size of the Biomedical Literature

The corrected data on the volume of publications generated by the NIH grants program alter somewhat the previous estimate we made of the total direct output of U.S. biomedical R & D in 1961. Calculated on the basis of expenditures per publication 2 years later, the total volume for 1961 would be 54,000 publications. If the ratio of the number of projects to the number of publications 2 years later is 1.0 for research projects supported by all agencies, both private and governmental, then this estimate based on NIH expenditures per publication is somewhat conservative because the average expenditure for the non-federally supported projects registered with SIE is less than that for NIH projects (see Table III-5). Correcting for this difference, however, requires additional assumptions that would increase the probability of significant error without commensurate gain.

Attempting to estimate the future volume of U.S. biomedical publications requires that many variables be ignored, and the resulting figures should be recognized as having a considerably lower reliability than those made retrospectively. However, such attempts may be of some value if the major assumptions required are made explicit. With these reservations, we can offer estimates of 81,000 publications in 1965 and 108,000 in 1970, based on biomedical research manpower in terms of "professional workers" (1) and observed publication productivity. The major assumptions are:
(1) that the manpower figures for past years are reasonably reliable,
(2) that the goal for 1970 (77,000 professional workers) will be realized,
(3) that the growth in manpower between 1960 and 1970 will be linear,
(4) that a publication productivity of 1.4 is reasonable for the population of "professional workers" as defined, and (5) that this productivity factor remains constant.

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See also data sources given in footnotes to tables.

APPENDIX III-A

ANALYSIS OF NIH RESEARCH GRANT INDEXES, FISCAL YEARS 1961 AND 1962

Methods Used by NIH Staff to Compile References Listed in the Indexes

In compiling the 1961 Index, the NIH staff listed for each active grant all reprints of 1961 publications sent by grantees to the Division of Research Grants. The procedure for the 1962 Index differed significantly. All 1962 reprints sent to the Division of Research Grants by grantees were listed under the appropriate grant. In addition, the administrative progress reports on all active grants were reviewed for references to 1962 publications and any 1961 publications not listed in the 1961 Index.

Analyses Performed for Present Study

Data Tabulation. Data collection from the 1961 Index was limited to a simple count of the total number of references listed for all grants (5,402 references). More extensive tabulations were performed on data from the 1962 Index. The section listing all grants by number included 367 pages (pp. 815 through 1182). The number of references listed for each grant on p. 815 and every tenth page thereafter (37 pages in all) was tallied by first-year grants, second-year grants, third-year grants, etc. In addition, references to papers (or books) published in 1961 were separated from references to papers published in 1962 (see Table III-A-1). The numbers of investigators having different numbers of grants were tallied from the section of the Index in which all principal and co-principal investigators were listed alphabetically. All pages in that section were covered (see Table III-A-2).

Data Conversion for Comparison with Figures for Previous Years. Although the method used by the NIH staff in compiling the references listed in the 1961 Index was the same as that employed by Lindsay and Allen in their study, the Division of Research Grants had not yet received all 1961 reprints by the time the Index was prepared. The remainder of the 1961 reprints, and some additional 1961 publications, were included in the 1962 Index. For the same reason, the 1962 publications listed in the 1962 Index do not represent all the 1962 papers written by grantees. To arrive at a figure for 1961 comparable with those of Lindsay and Allen for 1957-1960, we totaled the 1961 publications listed in both the 1961 and 1962 Indexes.

Lindsay and Allen expressed the belief that their counts of the papers generated by NIH extramural research were about 10 percent too low. We have, therefore, corrected the figures for 1957, 1958, 1959, and 1960 papers generated by the extramural program by 10 percent, so that they would be comparable with the figure for 1961 papers, which resulted from a more complete search for grantees' publications.

TABLE III-A-1

BASIC DATA ON REFERENCES* TO GRANT-GENERATED PUBLICATIONS (1962 INDEX)

Age of Proj.	No. Proj.	Number of References Cited														Total No. References	Av. No. Ref./Proj.
		0	1	2	3	4	5	6	7	8	9	10	11	12	>12		
1st yr.	518	447	40	14	6	3	1	3	0	1	1	1	0	1	0	160	.31
2nd yr.	255	148	41	27	19	4	4	5	2	5	0	0	0	0	0	272	1.1
3rd yr.	270	160	42	26	16	9	5	4	2	2	0	2	1	0	1 (16)	304	1.1
4th yr.	150	59	29	21	14	8	7	3	1	3	0	1	2	0	1 (20),1 (23)	304	2.0
5th yr.	56	26	8	10	5	2	3	1	1	0	0	0	0	0	0	79	1.4
6th yr.	117	54	30	9	11	4	6	1	1	0	0	0	0	0	1 (14)	154	1.3
7th yr.	35	15	7	3	5	4	0	0	0	0	1	0	0	0	0	53	1.5
8th yr.	60	17	11	11	7	5	6	1	1	1	0	0	0	0	0	125	2.1
9th yr.	24	11	7	1	2	0	0	2	0	0	0	0	1	0	0	38	1.6
10th yr.	19	9	3	2	1	0	0	0	3	0	0	1	0	0	0	41	2.2
11th yr.	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	.50
12th yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13th yr.	2	1	0	0	0	0	0	0	0	0	0	0	0	0	1 (13)	13	6.5
14th yr.	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2	1.0
15th yr.	3	1	0	1	0	0	1	0	0	0	0	0	0	0	0	7	2.3
16th yr.	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals	1515	952	219	126	86	39	33	20	11	12	2	5	4	1	5 (16)(20)(23)(14)(13)	1553	1.0
Proj >1 yr. old	997	505	179	112	80	36	32	17	11	11	1	4	4	0	5 (16)(20)(23)(14)(13)	1393	1.4
Percentage of proj. >1 yr. old		51	18	11	8	4	3	>5	5								

* 45 percent of these references were to 1961 publications and 55 percent were to 1962 publications.

43. Journal of Investigative Dermatology
44. Journal of Morphology
45. Journal of Nutrition (The)
46. Journal of Parasitology
47. Journal pf Pharmacology and Experimental Therapeutics
48. Journal of Abnormal and Social Psychology
49. American Dietetic Association Journal
50. American Pharmaceutical Association Journal (Scientific Edition)
    (now the Journal of Pharmaceutical Science)
51. American Veterinary Medical Association Journal
52. Biological Photographic Association Journal
53. Human Biology
54. American Journal of Digestive Diseases
55. Physiological Reviews
56. Proceedings of the Society for Experimental Biology and Medicine
57. Quarterly Review of Biology (The)
58. Radiology
59. Stain Technology
60. Journal of the American Medical Association
61. Yale Journal of Biology and Medicine (The)

APPENDIX III-C

MANUSCRIPTS AND PAPERS OF MAYO CLINIC STAFF MEMBERS, 1950-1962

Year	Total no. of Staff Members (1)	Manuscript pages*		Papers**	
		Total (2)	Ratio of (2) to (1)	Total (3)	Ratio of (3) to (1)
1950	292	21,144	72.4	691	2.4
1951	314	19,461	62.0	630	2.0
1952	333	21,920	65.8	462	1.4
1953	329	22,922	69.7	564	1.7
1954	336	22,634	67.4	603	1.8
Average, 1950-54	321	21,616	67.3	590	1.8
1955	334	20,025	60.0	413	1.5
1956	347	20,109	58.0	511	1.5
1957	353	25,240	71.5	611	1.8
1958	351	23,574	67.2	483	1.4
1959	350	23,615	67.5	395	1.1
Average, 1955-59	347	22,513	64.9	483	1.4
1960	365	26,300	72.1	646	1.8
1961	385	24,300	63.1	427	1.1
1962	396	24,097	60.9	561	1.4
Average, 1960-62	382	24,899	65.2	545	1.4
Average, 1950-62	345	22,719	66.0	538	1.6

* Both with and without collaboration between staff members and fellows. Included in these figures, in addition to manuscript pages for scientific articles or papers, are book manuscripts (probably 25 to 40 percent of the total pages), editorial matter, book reviews, abstracts of oral reports for meeting programs, and tables used for the production of slides. Therefore, the number of manuscript pages cannot be compared directly with the number of published papers.

**Number of articles published in the Proceedings of the Mayo Clinic plus those published elsewhere and listed in that journal. A variable delay in listing publications of staff members accounts for some of the year-to-year variation.

Data source: for number of staff members and manuscript pages, Dr. Carl M. Gambill, Mayo Clinic.

APPENDIX III-D

ANALYSES OF NIH STAFF BIBLIOGRAPHIES AND 1962 INDEX MEDICUS

A. Analysis of Annual NIH Staff Bibliographies

The general procedure was to tally the number of authors for each paper (Table III-D-1) and, if an author index was included, to tally the number of papers listed for each author (Table III-D-2). An author index was first included in the 1954 bibliography. For the 1943 bibliography, we made an author index to facilitate tallying the number of papers listed for each author.

TABLE III-D-1

NUMBER OF AUTHORS PER PAPER IN ANNUAL NIH STAFF BIBLIOGRAPHIES*

No. of authors per paper	No. of Papers			
	YEAR			
	1939	1943	1952(FY)	1962
1	218	212	447	663
2	99	95	258	563
3	40	62	207	369
4	6	12	82	183
5	1	3	21	67
6	2	1	11	20
7	--	--	1	3
8	1	--	--	5
9	--	--	--	1
10	--	--	--	1
Indeterminate**	7	17	24	9
Totals	374	402	1,051	1,884

* In this tabulation, all publications (including books, reports, etc.) listed in the bibliographies were counted as "papers."

** A committee report or papers where some authors given as "<u>et al</u>."

TABLE III-D-2

NUMBER OF PAPERS PER AUTHOR IN ANNUAL NIH STAFF BIBLIOGRAPHIES

No. of papers per author	No. of authors		
	YEAR		
	1943	1954*	1962
1	148	517	1,026
2	47	193	362
3	29	107	167
4	21	74	111
5	8	50	60
6	6	25	44
7	3	24	37
8	3	16	15
9	---	7	12
10	2	11	13
11	2	7	---
12	2	3	4
13	---	8	2
14	---	2	1
15	---	1	---
16	1	1	2
17	2	---	1
18	---	2	---
19	---	---	1
20	---	1	---
21	---	1	---
22	---	1	---
23	---	1	1
25	---	---	1
36	---	---	1
Totals	274	1,052	1,861

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* A total of 1,449 papers were listed in this bibliography; the number of authors for 27 of the papers was indeterminate.

B. Analysis of 1962 Index Medicus

Using the author index of the cumulated issues for 1962, the procedure was to tally the number of authors for each paper and the number of papers listed for an author. The first page and every tenth page thereafter were tallied in this manner for a total of 170 of the 1699 pages in the author index.

TABLE III-D-3

NUMBER OF AUTHORS PER PAPER IN 10-PERCENT SAMPLE OF 1962 INDEX MEDICUS

No. of authors per paper	No. of papers	% of papers
1	7,110	50
2	3,824	27
3	1,996	14
4	836	6
5	306	2
6	112	1
7	55	1
8	27	
9	19	
10	8	
Total	14,293	

No. of papers listed in 170 pages X sampling factor (10) = estimate of total number of papers listed in 1962 Index Medicus = 143,000 (compare with NLM estimate for 1962 of 146,000 papers).

TABLE III-D-4

NUMBER OF PAPERS PER AUTHOR IN 10-PERCENT SAMPLE OF 1962 INDEX MEDICUS

No. of papers per author	No. of authors	% of authors
1	9,190	66
2	2,537	18
3 or 4	1,526	11
5 to 7	467	3
8 to 10	172	1
11 to 20	83	1
more than 20	8	
Total	13,983	

No. of authors listed in 170 pages x sampling factor (10) = estimate of total number of authors listed in 1962 Index Medicus = 140,000.

Calculations with Data from NIH Bibliographies and Index Medicus

(No. authors with one paper) + (no. authors with 2 papers x 2) + (no. authors with 3 papers x 3), etc. ÷ total no. of authors = average rate of authorship.

(No. papers with 1 author) + (no. papers with 2 authors x 2) + (no. papers with 3 authors x 3), etc. ÷ total no. of papers = average no. authors/paper.

Total no. of papers produced by the author population ÷ total no. of authors in the population = "publication productivity."

June 11, 1963
(Major revisions December 1963)

NAS-NRC Study of Communication Problems in Biomedical Research

Staff Paper No. IV

TRENDS IN ORAL COMMUNICATION*

INTRODUCTION

Scientists' Views on Oral Communication

Cries of "too many meetings" are often heard from scientists today, although this complaint is perhaps not as frequent as that of "too many papers." Criticism of duplication among meetings is also common. Astute observers of the scientific scene view some trends in oral communication with emotions ranging from concern to enthusiasm. In a recent editorial, Abelson (1) remarked:

> "The annual round of spring meetings reminds us that those great national gatherings are losing their effectiveness as media for scientific communication. At the recent Atlantic City meeting of the Federation of American Societies for Experimental Biology there were 3138 papers presented and as many as 34 simultaneous sessions. There are comparable situations in other areas of science. Planning one's program of attendance on such occasions can be frustrating, for one notes numerous papers of interest but discovers that many of the attractive presentations are being given concurrently. All too often the harassed scientist cannot make up his mind and foregoes all of the choices.... We permit and even encourage scientists to deliver virtually the same lecture at meeting after meeting. It is annoying and wasteful to make a special effort to hear a paper only to find that the speaker is repeating, almost verbatim, material he has presented earlier."

Brookes (2), in looking at the scientific communication system, commented:

> "Inevitably the scientist is beginning to find his way around the mountain of paper by organizing more and more conferences at which he can meet personally those whose work most concerns him and thus re-establish direct contact, bypassing the formal channels of communication by creating informal channels that are most stimulating...."

The provocative historian of science, de Solla Price (3), feels the trends he detects should be encouraged:

> "The first noteworthy phenomenon of human engineering is that new groups of scientists emerge, groups composed

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* Not for publication or publication reference.

> of our maximal 100 colleagues.... Probably during World War II, pressure of circumstances forced us to form such knots of men and keep them locked away in interacting seclusion. We gave them a foretaste of urgent collaboration in nuclear physics, and again in radar. These groups are still with us.... The organization is not perfect; a few of the best men may not attend, a few of those who do attend might not qualify if we had perfect objective judgment.... But there is a limit to the useful size, and, if too many are invited, an unofficial subgroup of really knowledgeable members will be forced into being.... Similar unofficial organizations exist in molecular biology, in computer theory, in radio astronomy, and doubtless in all sciences with tens of thousands of participants. By our theory they are inevitable, and not just a product of the war or the special character of each discipline. Conferences are just one symptom; it becomes insufficient to meet as a body every year, and there is a need for a more continuous means of close contact with the group of a hundred.... And so these groups devise mechanisms for day-to-day communication.... Such groups constitute an invisible college, in the same sense as did those first unofficial pioneers who later banded together to found the Royal Society in 1660.... Such groups are to be encouraged, for they give status pay-off without increasing the papers that would otherwise be written to this end."

Hypotheses

Other thoughtful statements on oral communication could be cited, but these illustrate the main schools of thought. Taken together, scientists' opinions on changes in oral communication suggest a number of often conflicting hypotheses that merit objective testing because, if true, they have consequential implications for scientific progress and for efforts to improve the functioning of the scientific information complex. Some of the more important of these hypotheses are: (1) that the written record is being bypassed and relegated to a largely archival function, (2) that scientists are spending relatively more of their time in oral communication, and (3) that meetings are becoming less effective and may constitute a serious waste of scientific manpower, particularly of senior scientists.

Difficulties of Research in Oral Communication

Despite the implications of the perceived trends and the general recognition of the importance of oral communication to scientists, studies and development projects devoted to the workings of this subsystem of the scientific information complex have been few, compared with those aimed at solving "the literature problem." Nor have important questions concerning the relation of oral communication to the scientific record been examined more than cursorily, e.g., what are the relative advantages of oral and written communication for different purposes, and how efficiently is orally reported information transformed into permanent records?

As a subject for study, oral communication poses one major difficulty not shared with other modes of scientific communication: it generally lacks concrete artifacts, such as documents, which lend themselves to objective treatment. For direct measures of the functions, processes, and activities of oral communication, one must, in most cases, observe or question representative samples of scientists. The other major difficulty is common to all study of scientific communication: the lack of a practical, widely accepted method of measuring the effectiveness of a communication activity or service in terms of its contribution to research productivity. This lack of suitable methodology rules out, for the present, any definitive test of the third hypothesis. The first two could be tested by known techniques, but to do this for the biomedical community with acceptable rigor will require major projects.

Purpose and Limitations of This Study

Although definitive tests of any of the stated hypotheses were not feasible with the resources and time available, we collected data on selected aspects of oral communication among biomedical scientists in the hope of providing some perspective for a general consideration of communication problems in biomedical research. Our inquiry was confined largely to "formal" oral communication (see below) and employed relatively crude, indirect measures, e.g., using travel expenditures as a measure of scientists' participation in meetings. The aim of this paper is to summarize our findings and to identify areas for future studies.

Definitions

In this paper, oral communication is classified as "formal" or "informal"; the formal type consists of the structured exchanges at events planned for oral communication by societies, groups, and committees, and the informal consists of all unstructured exchanges and "shop-talk." Events planned for oral communication fall into two categories: (1) regular meetings convened periodically on a continuing basis, and (2) ad hoc meetings convened on a one-time or short-term basis. Events in either category may be "open" (unrestricted attendance) or "closed" (attendance by invitation only). Informal oral communication can be divided into (1) face-to-face exchanges with colleagues, either local or remote, and (2) telephone conversations.

METHODS AND SOURCES

Data were collected from published materials and from records of professional societies and government agencies. The sources are identified in the tables, figures, and text. In tabulating international meetings, meetings were counted only if listed by an announcement service as "international" or if their titles clearly indicated their international character.

FINDINGS AND DISCUSSION

Regular Meetings of U.S. Biomedical Societies

U.S. biomedical societies existing in 1961 and the number of regular meetings held by each are listed in Appendix IV-A. Data on the increase in the numbers of societies and their meetings are summarized in Fig. IV-1. The criteria used for classifying a society as "biomedical" excluded some societies that have meetings at which biomedical research is presented (e.g., the American Heart Association and American Cancer Society, both of which have lay members). Although the source used for these data is probably reasonably comprehensive for well organized societies, in view of the inherent difficulties in making such a compilation it is probable that some organizations are omitted, particularly the relatively informal ones. The rather regular alternation of plateaus with growth spurts in Fig. IV-1 may well be artificially produced by the procedures used in preparing successive editions of this compilation.

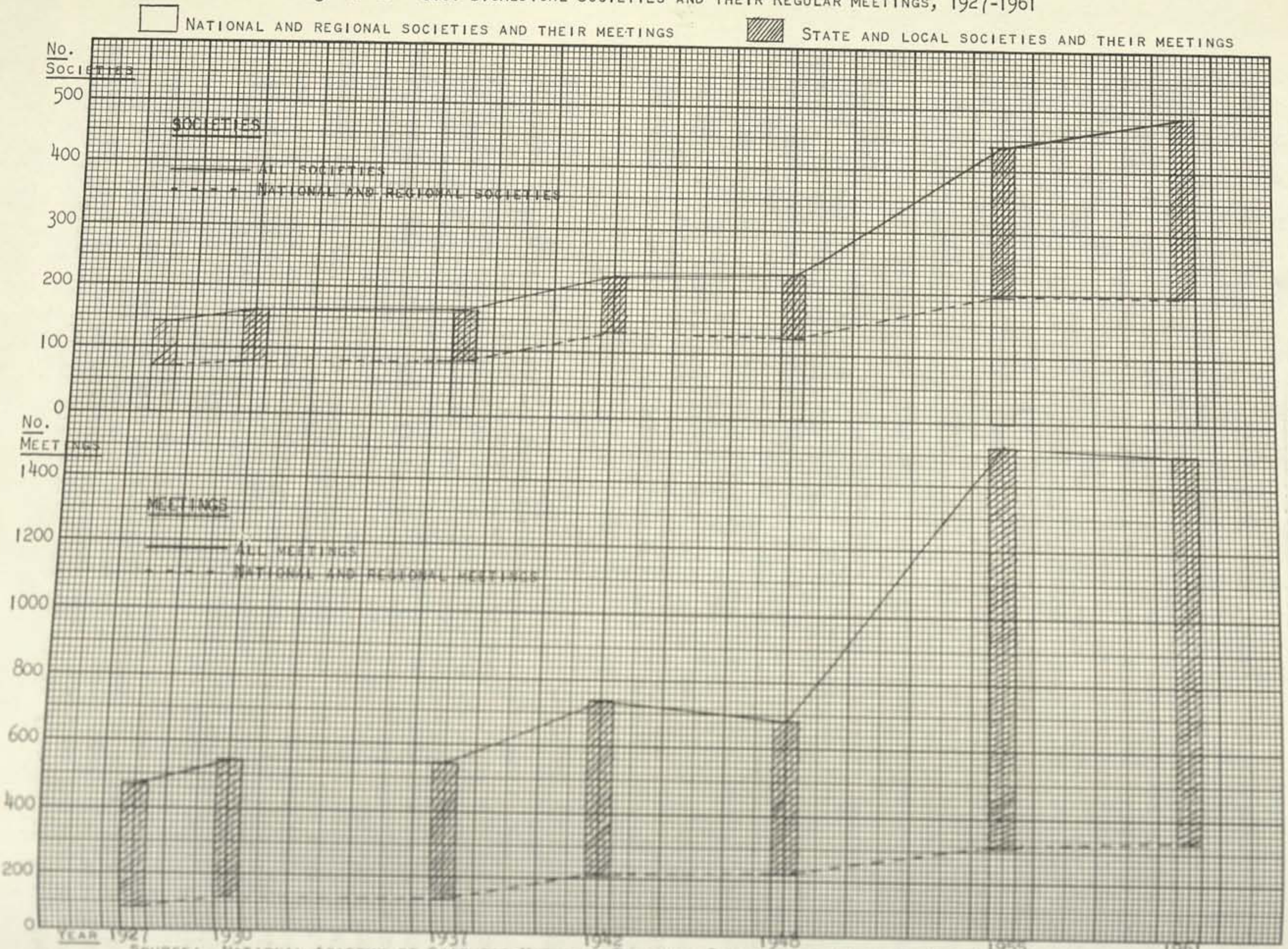
In the last three decades, the total number of regular meetings has tripled. The rate of increase apparently accelerated some time in the 1940's. Inasmuch as the average number of meetings per society of a given type has changed little during this period, the increase in meetings can be considered as secondary to the proliferation of societies. State and local societies typically hold more meetings than national or regional organizations (an average of 4.2/society in 1962, vs. 1.6 for national or regional organizations) and accounted for about four-fifths of the regular meetings in 1961, a larger proportion than in 1948 or earlier. This change can be attributed to the faster growth in the number of state and local societies.

Announcement of Meetings

Services. One of the more common ways in which scientists learn of forthcoming meetings, other than those held by their own societies, is through lists published in the journals they customarily read or compiled by activities set up specifically to serve this function. Such lists constitute an announcement service for meetings. Of the journal announcement services, Science and the Journal of the American Medical Association publish the most comprehensive lists of biomedical meetings. A second type of announcement service includes the following (among the more widely available and useful to the biomedical community): Scientific Meetings, Special Libraries Association, Science-Technology Division (first issue: 1957); 18-Month Calendar of National Meetings, Office of the Surgeon General, U.S. Public Health Service (first issue: 1958); and World List of Future International Meetings, Part 1. Science, technology, agriculture, medicine, U.S. Library of Congress (first issue: 1959).

The journal type of service depends chiefly on the efficiency of meeting organizers or society officials in sending notices to editors. The special services must rely heavily on scanning large numbers of journals for meeting notices. The coverage achieved by either type of service, therefore, ultimately rests on the initiative of the sponsors of meetings.

Fig. IV-1. U.S. Biomedical Societies and Their Regular Meetings, 1927-1961



Source: National Academy of Sciences-National Research Council. Scientific and Technical Societies of the United States and Canada, Eds. 1, 1927; 2, 1930; 3, 1937; 4, 1942; 5, 1948; 6, 1955; 7, 1961. Washington, D.C.

Number and Character of Meetings Announced. The number of different biomedical meetings held in 1956 and 1962 that were listed by a combination of major services are shown in Fig. IV-2*. In making this tabulation, marked overlapping of coverage by the services was observed, as would be expected. Not shown in Fig. IV-2 is the breakdown for ad hoc vs. regular meetings. In 1956, 32 (7 percent) of the total of 446 meetings listed were of the ad hoc variety, and in 1962, 98 (16 percent) of the total of 628. Of all 1956 meetings listed, 77 percent were held in the U.S. or Canada, compared with 65 percent in 1962.

Completeness of Combined Coverage. A rough idea of the completeness of coverage provided by this combination of services can be obtained by comparing the number of meetings in the U.S. and Canada that were announced in 1962 (408) with the number of regular meetings held by U.S. biomedical societies in 1961 (1500, Fig. IV-1). A reasonable assumption is that the majority of meetings announced by these services were those of national, regional, and state societies, rather than of local organizations. This comparison does not take into account the number of ad hoc meetings announced by these services but not included in the data for Fig. IV-1. Considering the extensive and lengthy preparation and planning usual for international meetings, it seems probable that the announcement services receive notices of them and that such meetings are well covered. Similar reasoning does not answer the question of whether ad hoc meetings are likely to be covered more or less completely than regular meetings.

Coverage of Individual Services. The number of meetings announced by any given service depends on the number about which it is informed and on its selectivity. Table IV-1 gives the total number of U.S. and Canadian biomedical meetings announced by each of the two most comprehensive journal services and by the 18-Month Calendar of National Meetings. The Journal of the American Medical Association listed the largest number of 1961 meetings, but this number was only about one-sixth that of the regular meetings of U.S. biomedical societies alone (Fig. IV-1). Table IV-2 shows the international meetings announced in Science and in the World List of Future International Meetings and its predecessor, the List of

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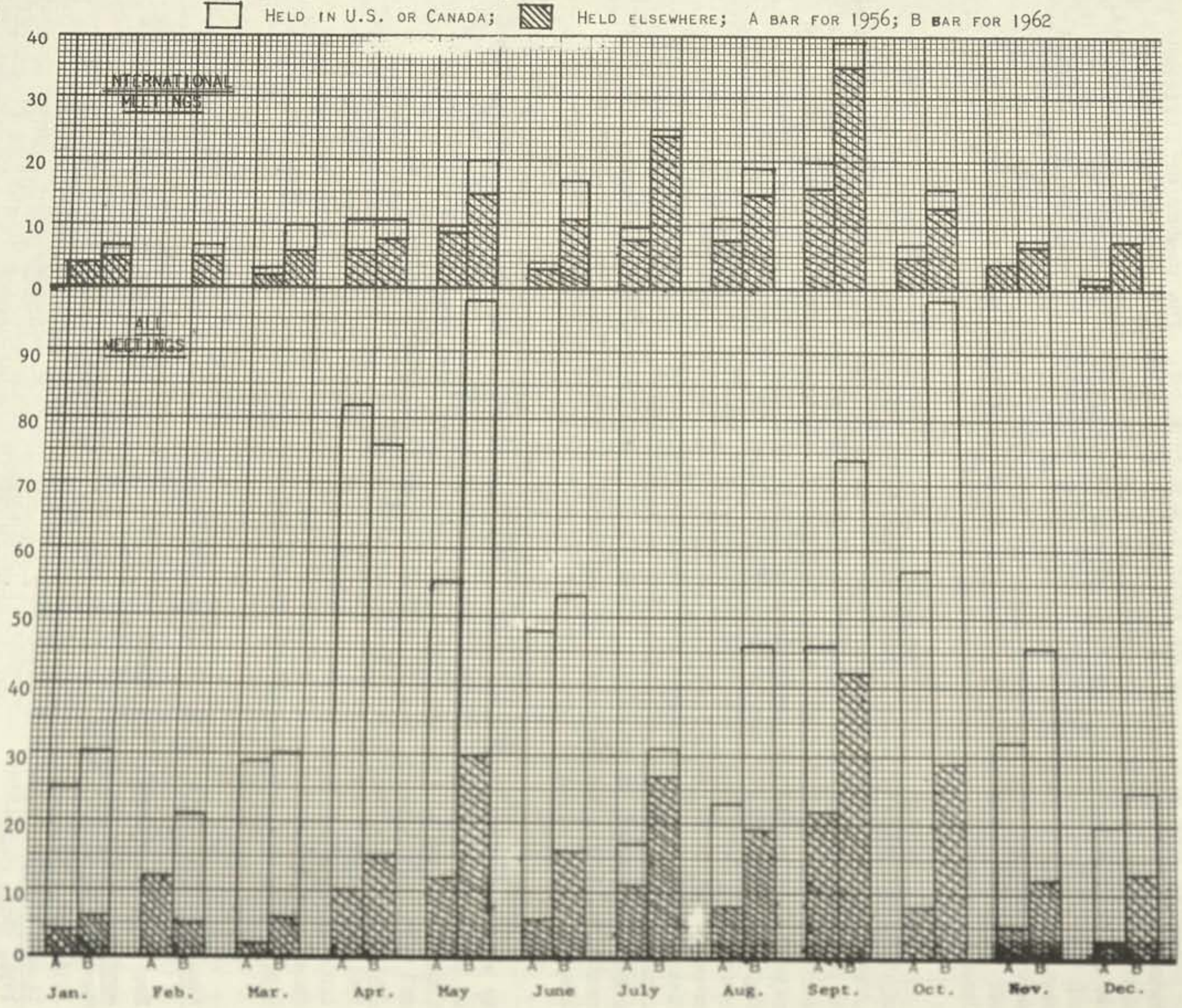
*Sources for Data Shown in Fig. IV-2

For 1956 Meetings: Science, Dec. 2, 1955, thru Dec. 21, 1956; Journal of American Medical Association, Jan. 7, 14, 21, Feb. 25, March 24, April 28, May 26, June 30, July 28, Aug. 25, Sept. 29, Oct. 27, Nov. 24 and Dec. 8, 1956; International Associations, Jan. thru Dec. 1956; List of International Conferences and Meetings, Oct. 1, 1955, April 1, 1956, July 1, 1956, Oct. 1, 1956.

For 1962 Meetings: Science, Oct. 1961, thru Dec. 1962; International Congress Calendar, 1962 Edition; World List of Future International Meetings, Part 1, Oct. 1961, Jan., March, May, July, Sept., and Nov. 1962; Scientific Meetings, Science Technology Div., Special Library Assoc., Oct. 1961, Jan., April, and Oct. 1962; Journal of the American Medical Association, Oct. 28, Nov. 25, 1961, Jan. 27, Feb. 24, Mar. 24, Apr. 28, May 26, June 23, July 28, Aug. 25, Sept. 29, and Oct. 27, 1962.

Fig. IV-2. Biomedical Meetings Announced in 1956 and 1962



Sources: See p. IV-6, footnote.

TABLE IV-1

U. S. AND CANADIAN BIOMEDICAL MEETINGS LISTED BY SCIENCE, JAMA, and USPHS CALENDAR OF MEETINGS

	Science*		JAMA**		USPHS Calendar†	
Year	No.	Aver. Length, days	No.	Aver. Length, days	No.	Aver. Length, days
1951	---	---	200	2.6	---	---
1956	80	4.1	212	3.2	---	---
1957	94	3.5	---	---	---	---
1958	72	3.6	---	---	94	3.7
1959	145	3.5	---	---	128	3.8
1960	165	3.7	---	---	95	3.4
1961	127	3.7	241	3.2	151	3.9

* Counts include meetings of societies listed in Appendix IV-A and other meetings whose subjects or sponsors indicated a likelihood that biomedical research was reported.

** Journal of the American Medical Association

† 18-Month Calendar of National Meetings, Office of the Surgeon General, USPHS.

TABLE IV-2

INTERNATIONAL BIOMEDICAL MEETINGS LISTED BY SCIENCE AND BY NSF AND LIBRARY OF CONGRESS SERVICES

	Science			NSF and Library of Congress Services*			
Year	No. held in U.S. & Can.	No. held elsewhere	Total	No. held in U.S. & Can.	No. held elsewhere	Total	Av. Length, days
1954	--	--	--	15	60	75	5.4
1955	--	--	--	--	--	--	--
1956	11	27	37	--	--	--	--
1957	10	37	47	14	87	101	4.7
1958	10	29	39	--	--	--	--
1959	10	34	44	--	--	--	--
1960	15	65	80	27	138	165	5.1
1961	15	65	80	--	--	--	--
1962	17	103	120	--	--	--	--
1963	--	--	--	17	154	171	5.4

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* 1954 and 1957 from List of International and Foreign Scientific and Technical Meetings, issues dated 1 January, 1 April, 1 July, 1 October, 1954, and 1 January, 1 April, 1 July, 1 October, 1957, National Science Foundation; 1960 and 1963 from World List of Future International Meetings, issue covering January 1960 to December 1962 and issues of December 1962, February, April, and May 1963, Library of Congress.

International and Foreign Scientific and Technical Meetings. Both services show a definite increase over the past decade in the number of international meetings listed. Science shows the larger relative increase, but the number announced in the World List more closely approximates the total numbers (86 for 1956 and 187 for 1962) listed by the combination of services depicted in Fig. IV-2.

Increase in Number of Meetings Announced. The number of all types of meetings announced by the combination of services (Fig. IV-2) increased by 41 percent in the 6-year period, 1956-1962, whereas announcements of international meetings increased by 117 percent and of ad hoc meetings, by 206 percent. That more meetings are being announced by these services does not necessarily mean that the number of meetings held is increasing. However, the much larger increases in ad hoc and international meetings would seem to reflect an actual change in the frequency of these types of meetings, rather than simply more complete coverage by the announcement services.

Distribution of Meetings Throughout the Year

The data on "all meetings" in Fig. IV-2 illustrate the well known bunching of meetings in the spring and fall and demonstrate the stability of this bimodal pattern. The picture for international meetings is somewhat different. In 1956, the familiar bimodal pattern is seen, but in 1962 there would seem to be a tendency to fill in the summer. The distribution of ad hoc meetings (not shown in Fig. IV-2) suggests the same phenomenon. Whereas in 1956 fewer than 3 percent of the meetings in July and August were of the ad hoc variety, in 1961 the ratio approached 30 percent.

Place of Meetings

Most of the meetings shown in Fig. IV-2 as "held elsewhere" (i.e., outside the U.S. and Canada) are international meetings. The remainder are largely meetings of foreign national groups. Announcements of such meetings by U.S. services are undoubtedly very incomplete.

Length of Meetings

Table IV-1 gives the average length of meetings in the U.S. and Canada. The relatively long average indicated here probably reflects the fact that the meetings announced were largely national and regional meetings, which tend to last longer than state and local meetings. International meetings are significantly longer on the average (see Table IV-2). There are no definite trends toward longer or shorter meetings.

Meetings of Selected Societies

Federation of American Societies for Experimental Biology (FASEB). Fig. IV-3 illustrates the increase in attendance and number of papers read at the annual meetings of the FASEB (Appendix IV-B contains more complete data). To accommodate the mounting volume of papers, the number of simultaneous sessions increased from 14 in 1946 to 34 in 1963. Attendance is seen to be closely related to the number of papers given; it averaged 2.7 to 5.3 attendants per paper for the entire period, 1942-1963, and 4.0 to 5.3 for 1957-1963. The growth of this meeting appears to have accelerated around 1957.* Measured in terms of papers given, the average annual growth rate for the period 1949-1957 was 0.06 per year; i.e., [(no. papers 1957)/(no. papers 1949) - 1]/8. For 1957-1963 it was 0.10 per year.

America Federation for Clinical Research (AFCR). The AFCR holds annual national and regional meetings. Data on membership, meeting registration, papers submitted, and papers given are included in Appendix IV-C. Figure IV-4 summarizes the data on the number of papers submitted for possible presentation at the national meeting and at "all meetings" (national plus regional). The AFCR has restricted the number of papers given more rigidly than FASEB. For the period 1955-1962, the average annual growth rate of AFCR meetings in terms of papers submitted was fairly uniform, at 0.16 for the national meeting and 0.22 for all meetings. The meetings of AFCR are held in conjunction with corresponding meetings of the American Society for Clinical Investigation. The two societies have made various agreements over the years that affect the number of papers presented at AFCR meetings and may explain the growth irregularities. Attendance figures are available only for the national meeting and show no obvious trend in the past few years.

American Medical Association (AMA). By comparison with the previous societies, which are exclusively research-oriented, the number of papers given at annual meetings of the specialty sections of the AMA has increased slowly. From 1956 to 1961, the average annual growth rate was 0.05.**

Correlation of Meeting Growth and Biomedical Research Manpower

The growth of FASEB and AFCR meetings approaches that of U.S. biomedical research manpower (see Table IV-3 for FASEB data). Both these meetings serve broad segments of the biomedical research community. The acceleration in the growth of FASEB meetings around 1957 correlates well with the acceleration in the rate of expenditures for biomedical research and development in 1956 (4).

Closed Meetings

Closed meetings are not usually listed by the announcement services, and it was not feasible to collect data reflecting the total number of such meetings. However, if one includes certain types of committee activities and other events (such as sessions of NIH study sections) at which substantive biomedical information is exchanged, the total number of closed meetings is probably of the same order of magnitude as that of open meetings.

Travel

Expenditures. "Official" travel by scientists is closely associated

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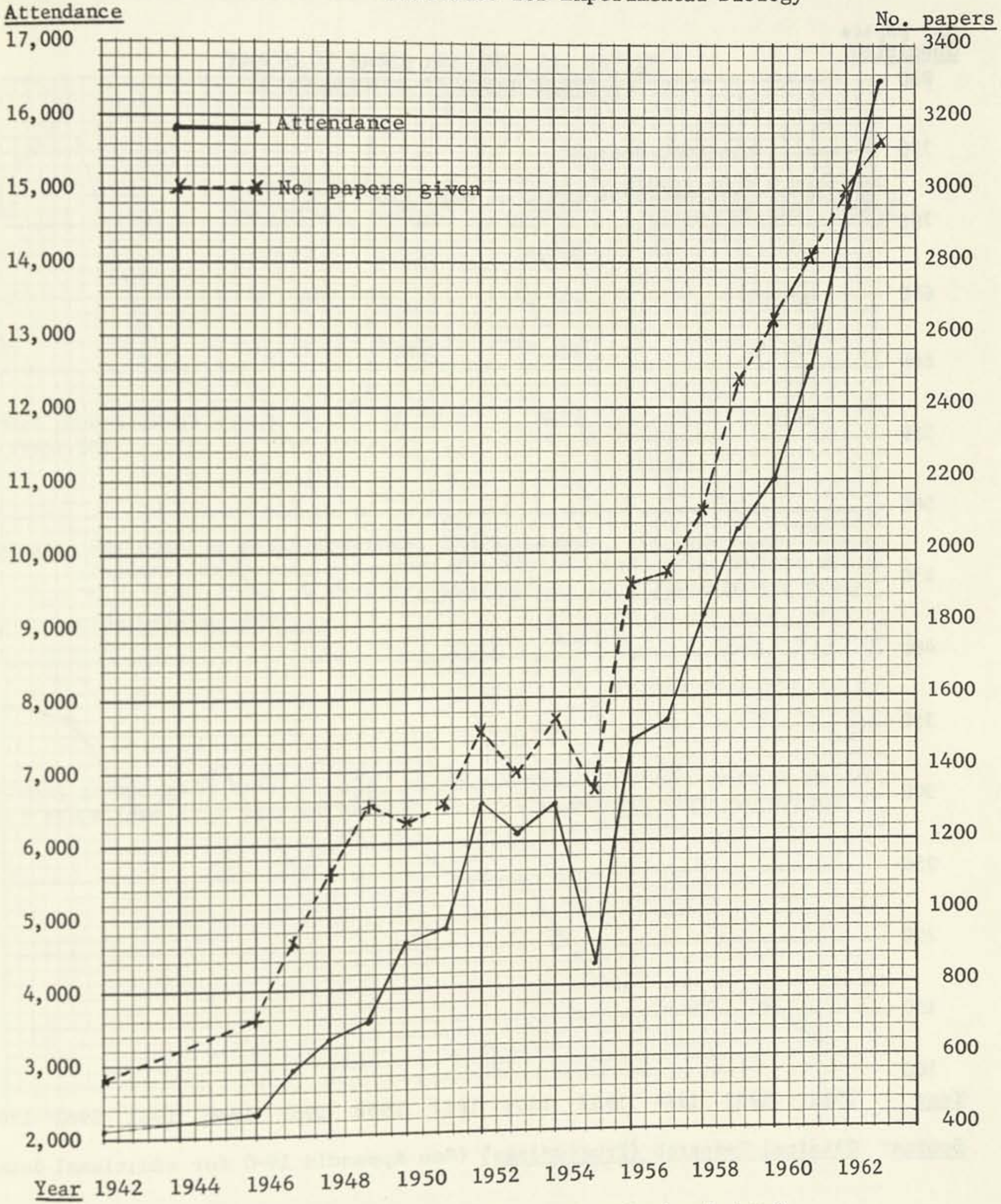
* The sharp dip for 1955 occurred when the meeting was held in San Francisco rather than Atlantic City.

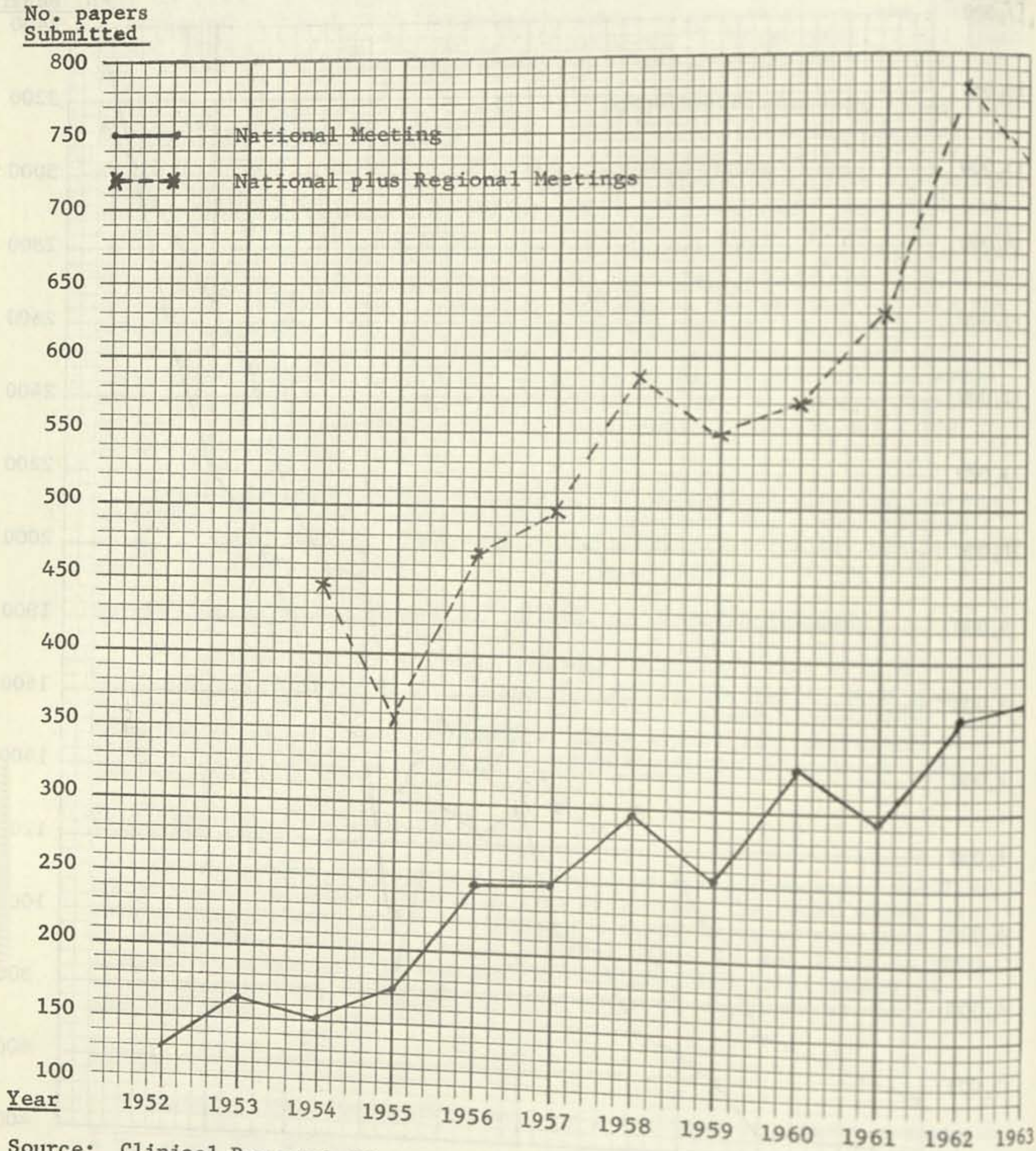
**Data source--Journal of the American Medical Association

Fig. IV-3. Annual Meetings of the Federation of American Societies for Experimental Biology



Source: FASEB Records (See Appendix IV-B for additional data)

Fig. IV-4. Number of Papers Submitted for Meetings of American Federation for Clinical Research



Source: Clinical Research (Proceedings) (See Appendix IV-C for additional data)

TABLE IV-3

GROWTH OF FASEB MEETINGS VS. GROWTH OF BIOMEDICAL RESEARCH MANPOWER

	FASEB Meetings		U. S. Biomed. R & D Manpower	
Year	Attendance	Papers	Total	Full-Time Equivalents
1954	6,453	1,539	19,200	14,000
1958	9,136	2,111	34,600	23,100
1960	11,015	2,654	39,700	27,285
Annual growth rate* (1954-60)	0.12	0.12	0.18	0.16

Sources: For data on FASEB meetings, FASEB records; for U.S. biomedical research manpower, Resources for Medical Research: Report No. 3. U.S. Public Health Service, Washington, D. C., Government Printing Office, 1963

* Annual growth rate rate = $\frac{y-x}{xt}$, where y = value for last year of period, x = value for first year of period, and t = number of years in period.

with both formal and informal oral communication and can serve as an indirect measure of oral exchange with other than local colleagues. If one assumes that the proportion of total travel expenditures by scientists that is charged to NIH research grants has not changed substantially, the data in Table IV-4 might be interpreted as indicating that biomedical scientists are traveling more. This assumption, however, is probably valid only for the last few years, perhaps from 1956 on; and during this period there is no clear trend in total travel expenditures from grant funds.

International Exchange. Considerable information is available that bears, at least indirectly, upon in-person oral communication between U.S. biomedical scientists and workers in other countries. Part I of Appendix IV-D gives a breakdown of American scientific and technical personnel with grants to work* in foreign countries during 1952 and 1962; Part II does the same for foreign personnel with grants to work in the U.S. In these tables, personnel are classified broadly as "students," "teachers," and "others." It is the last category that is most directly involved in exchanges among scientists engaged in research. The figures do not cover all international exchange (e.g., travel or institutional, personal, or research project funds, or special grants for international congresses).

In the past 10 years, although the number of U.S. biomedical personnel working abroad has increased by over 50 percent, that of personnel in fields classified here as "related" to biomedicine has increased by 102 percent. In making this tabulation, it was noted that the increase in fields less closely related to biomedicine, e.g., physics and engineering, has been even more marked. As for foreign personnel coming to the U.S. on grants, the increase in biomedical fields has been only 31 percent, compared with 144 percent in "related" fields. The ratio of the number of Americans working abroad to aliens working in the U.S. was 0.14 in 1952 and 0.17 in 1962.

It is of interest that, in 1952, 63 percent** of the American personnel working abroad in biomedical and related fields worked in Europe (including the British Isles); in 1962, the percentage had dropped to 52 percent . In 1952, 64 percent of the aliens with grants to do biomedical work in the U.S. came from Europe, but only 32 percent in 1962.

Exchange with U.S.S.R. and Eastern Europe. Appendix IV-E gives a summary of all exchanges of scientific and technical personnel between the U.S. and the U.S.S.R. and its European satellites. No breakdown into specific subject fields was available. The 3 years for which we have figures are characterized by marked variations, probably explained, at least in part, by large international congresses and changes in the cold-war climate. Over-all, the number of Americans who visited behind the Iron Curtain in these years is about one-and-one-half times the number of people from those countries who visited the U. S. Poland, Hungary, and

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*As used here, "work" includes studying or teaching, attending meetings, and visiting laboratories.

**The source for these data is the same as for those in Appendix IV-D.

TABLE IV-4

PERCENT OF NIH RESEARCH GRANTS EXPENDED FOR TRAVEL*

Fiscal Year	Amount of Research Grants, millions of $	% Spent on Travel		
		Total	Domestic	Foreign
1947	3.6	1.67	---	---
1949	13.6	1.83	---	---
1951	17.7	1.95	---	---
1956	39.6	2.54	---	---
1958	99.7	2.38	2.15	0.23
1960	202.9	2.53	2.15	0.38

Source: Office of the Assistant to the Director of NIH for Scientific and Technical Information, August 1, 1963; based on analysis of sample of grant expenditure reports (for fiscal year 1960, the sample consisted of 1,008 grants).

* Excludes travel charged to training and fellowship grants, research contracts, and grants made expressly to support scientific meetings.

Rumania, however, were exceptions, in that they sent more visitors to the U.S. than they received from the U.S.

Support of Meetings

Numerous Federal agencies provide direct support by grants or contracts for biomedical meetings. Of these, the Department of Health, Education, and Welfare contributes the most support, largely through the National Institutes of Health. Table IV-5 gives total HEW expenditures for the direct support of scientific meetings of all types during fiscal years 1960 through 1963, and indicates how much of the totals came from NIH. The basis on which Federal agencies reported these figures changed during the period in question, and the apparent decrease, both in terms of dollars and in percentages, of total extramural research funds, cannot be assessed from the information we have.* This table also indicates the total expenditures reported for direct support of all types of information activities. Again, the apparent changes cannot be evaluated. Some inferences can, however, be drawn. For the entire period, 1960, 1961, and 1962, NIH expenditures for extramural support of meetings accounted for over one-fourth of NIH expenditures for extramural support of all types of information activities (including publication, as well as meetings). All direct support of information activities amounted to less than 2 percent of total extramural research grants over the same period.

Total NIH Expenditures for Oral Communication

If the expenditures from NIH research grants for travel are added to those for direct support of meetings, an approximation of the total NIH extramural support for oral communication activities is obtained. For 1960, this total came to around $6.5 million, or 3.2 percent of research grant funds.

Review of Other Studies

Although the constraints of this study precluded our collecting the new data required for systematic testing of the critical hypotheses posed at the outset, the literature was reviewed for suitable methods and for any suggestive data bearing on the hypotheses and on other important aspects of oral communication that we were not able to explore in detail. Probably the only accurate estimate of the time scientists spend in oral communication is that developed in Ackoff's study of chemists (5). He found that academic chemists devote 18.4 percent of their working time to oral communication, as contrasted with only 5.5 percent for reading. It seems unlikely that biomedical scientists are grossly different, but serial time-studies are required to assess trends.

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* The difficulties are compounded when one attempts to compare data from different sources. For example, the source for the data in Table IV-4 reports that in fiscal year 1962, NIH awarded $840,000 for international meetings alone. If this amount is subtracted from the figure for NIH extramural expenditures in Table IV-5, the difference, $124,000, seems too small to represent NIH support of domestic meetings.

TABLE IV-5

DIRECT FEDERAL SUPPORT FOR BIOMEDICAL MEETINGS
(thousands of dollars)

Fiscal Year	Agency	Expenditures for Meetings			Expenditures for All Types of Information Activities		
		Intramural	Extramural†	Total	Intramural	Extramural†	Total
1960	HEW	364	1,638	2,002	5,008	4,515	9,523
	NIH	163	1,417(0.71%)	1,580	1,950	4,171(2.1%)	6,121
1961	HEW	570	1,887	2,457	6,096	5,815	11,911
	NIH	348	1,679(0.57%)	2,027	2,297	5,419(1.8%)	7,716
1962	HEW	657	1,341	1,998	7,165	7,134	14,299
	NIH	393	964(0.22%)	1,357	2,740	5,869(1.3%)	8,609
1963*	HEW	762	1,038	1,800	8,128	6,928	15,056
	NIH	423	780(0.17%)	1,203	3,038	4,665(1.0%)	7,703

* All data for 1963 are based on budgetary estimates.

† Percentages in parentheses relate the given figure to total NIH research grants (excluding fellowships and training and construction grants) in that fiscal year. These totals were $203 million for 1960, $294 million for 1961, $434 million for 1962, and an estimated $450 million for 1963 (Office of Special Assistant to the Director for Scientific Communication, NIH).

Sources: For 1960, Federal Funds for Science X, National Science Foundation, Washington, D.C., Government Printing Office, 1962; for 1961, 1962, 1963 data, Federal Funds for Science XI, National Science Foundation, Washington, D.C., Government Printing Office, 1963.

Explanatory Notes: Figures on intramural expenditures for meetings include costs of "all efforts directed toward planning, scheduling, announcing, supporting, sponsoring, conducting, and attending symposia, conferences and meetings held primarily for the discussion, exchange and oral dissemination of scientific and technical information." Included are travel and subsistence costs of federal employees participating in such meetings. Figures on extramural expenditures for meetings are limited to grants or contracts with individuals and organizations outside the government which have as their primary purpose the support of a scientific meeting. Travel and subsistence paid by participants from regular research grants are, therefore, not included. "Expenditures for all types of information activities" include costs of publication and distribution, bibliographic and reference services, and research and development in scientific communication, as well as scientific meetings; as with meetings, the figures for extramural expenditures include only grants and contracts made primarily to support information activities.

Studies by Glass (6) and by Menzel (7) on small samples have demonstrated the importance of oral communication to biological scientists for finding needed information and for learning of work of major significance to them. In two projects of an integrated series of studies, the American Psychological Association has made important advances by assessing the effectiveness of scientific conventions in meeting some of the needs of those who attend (8) and by determining the frequency with which oral reports become part of the written literature and establishing the time sequence (9). The findings of the latter study agree in broad outline with those obtained in a study of biomedical scientists (10) and indicate that factors other than quality of work affect when and whether the results of research reach publication after having been presented orally.

CONCLUSIONS

(1) Over-all, the increase in the number of biomedical meetings has been roughly proportional to the growth of the biomedical research community and is a direct consequence of this growth, as is the increase in the size of some of the larger research meetings.

(2) None of the major services that announce forthcoming biomedical meetings or combinations of these services approaches complete coverage of U.S. meetings, even if ad hoc and state or local meetings are excluded. Whether omissions in the coverage of a given service result from the exercise of selectivity aimed at tailoring the service for its clientele or from lack of information cannot be determined from the present data.

(3) The amount of information exchanged orally between U.S. biomedical scientists and their foreign colleagues is probably increasing as a result of the increase in international meetings and travel; however, whether this absolute increase represents a relative improvement in international exchange is unknown.

(4) It seems likely that biomedical scientists are, in general, traveling more than they did several decades ago. Whether this increased travel speeds research progress or is a substitute for other modes of communication that use time and money more efficiently has not been determined.

(5) Federal expenditures for oral communication activities account for a sizable fraction of the total governmental support of the biomedical information complex. No criteria exist to judge whether this allotment of funds is optimal.

(6) The importance of oral communication as a channel for information and as an activity that absorbs large amounts of scientists' time warrants much more effort in studying this subsystem of the biomedical information complex and in improving both formal and informal oral communication. At present, we do not have the data to evaluate apparent trends objectively, nor to answer many of the important questions.

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APPENDIX IV-A

U. S. BIOMEDICAL SOCIETIES* AND THEIR REGULAR MEETINGS, 1961

Name of Society	Membership	No. of Meetings
Academy of Applied Osteopathy	948	1
Academy of Denture Prosthetics	67	1
Academy of Medicine of Cincinnati	1,550	9
Academy of Medicine of Cleveland	2,200	13
Academy of Medicine of Washington, D.C.	150	3
Aerospace Medical Association	2,420	1
Alabama Society of Anesthesiologists	30	4
Alaska State Medical Association	115	1
American Academy for Cerebral Palsy	286	1
American Academy of Allergy	1,202	1
American Academy of Child Psychiatry	196	2
American Academy of Compensation Medicine, Inc.	225	1
American Academy of Dental Medicine	980	2
American Academy of Dermatology and Syphilology	2,177	1
American Academy of General Practice	25,842	1
American Academy of Microbiology, Inc.	515	1
American Academy of Neurological Surgery	69	1
American Academy of Neurology	2,051	1
American Academy of Occupational Medicine	350	1
American Academy of Ophthalmology and Otolaryngology	6,904	1
American Academy of Oral Pathology	350	1
American Academy of Orthopaedic Surgeons, Inc.	2,677	1
American Academy of Pediatrics	6,270	2
American Academy of Periodontology	640	1
American Academy of Physical Medicine & Rehabilitation	300	1
American Academy of Restorative Dentistry	186	1
American Academy of Tuberculosis Physicians		1
American Association for Cancer Research, Inc.	1,066	1
American Association for Cleft Palate Rehabilitation	600	1
American Association for the Study of Neoplastic Diseases	160	1
American Association for the Surgery of Trauma	406	1
American Association for Thoracic Surgery	542	1
American Association of Anatomists	1,300	1

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* Societies that hold meetings at which biomedical research may be reported and that require a doctorate degree for membership were selected from National Academy of Sciences-National Research Council. *Scientific and Technical Societies of the United States and Canada*, 7th ed. Washington, D.C., The Academy.

Name of Society	Membership	No. of Meetings
American Association of Endodontists	675	1
American Association of Genito-Urinary Surgeons	106	1
American Association of Immunologists	543	1
American Association of Industrial Dentists	148	2
American Association of Neuropathologists	147	1
American Association of Obstetricians & Gynecologists	200	2
American Association of Orthodontists	2,084	1
American Association of Pathologists & Bacteriologists	980	1
American Association of Plastic Surgeons	125	1
American Association of Public Health Dentists	178	1
American Association of Railway Surgeons	3,100	1
American Association of Veterinary Nutritionists	152	1
American Blood Irradiation Society	70	1
American Broncho-Esophagological Association	270	1
American Clinical and Climatological Association	260	1
American College of Allergists	1,164	1
American College of Anesthesiologists, Inc.	1,991	2
American College of Cardiology, Inc.	1,959	2
American College of Chest Physicians	7,116	1
American College of Dentists	2,692	1
American College of Gastroenterology, Inc.	891	1
American College of Obstetricians & Gynecologists	6,474	1
American College of Osteopathic Surgeons	520	1
American College of Physicians	11,000	1
American College of Radiology	3,839	1
American College of Surgeons	24,000	1
American College of Veterinary Pathologists	92	2
American Dental Association	94,696	1
American Dermatological Association, Inc.	113	1
American Federation for Clinical Research	3,494	5
American Fracture Association	360	1
American Gastroenterological Association	316	1
American Gastroscopic Society	216	1
American Geriatrics Society	7,500	2
American Goiter Association, Inc.	242	1
American Gynecological Society	136	1
American Institute of Homeopathy	350	1
American Institute of Ultrasonics in Medicine	250	1
American Laryngological Association	96	1
American Laryngological, Rhinological & Otological Society, Inc.	603	1
American Medical Association	176,000	2
American Medical Women's Association		1
American Neurological Association	403	1
American Ophthalmological Society	217	1
American Orthopaedic Association	294	1

Name of Society	Member-ship	No. of Meetings
American Orthopsychiatric Association	1,806	1
American Osteopathic Association	10,516	1
American Osteopathic College of Anesthesiologist	172	1
American Osteopathic College of Radiology	109	1
American Otological Society, Inc.	149	1
American Otorhinologic Society for Plastic Surgery	430	Bien.
American Pediatric Society	238	1
American Physiological Society	2,000	2
American Proctologic Society	702	1
American Psychiatric Association	12,000	1
American Psychoanalytic Association, Inc.	888	2
American Psychopathological Association, Inc.	150	1
American Roentgen Ray Society	815	1
American Society for Artificial Internal Organs	120	1
American Society for Clinical Investigation	706	1
American Society for Experimental Pathology	679	1
American Society for Pharmacology and Experimental Therapeutics	915	2
American Society for Surgery of the Hand	100	1
American Society for the Study of Sterility	893	1
American Society of Anesthesiologists, Inc.	4,602	1
American Society of Anthropometric Medicine & Nutrition	110	1
American Society of Biological Chemists, Inc.	1,666	1
American Society of Clinical Pathologists	2,563	1
American Society of Maxillofacial Surgeons	80	1
American Society of Ophthalmologic and Otolaryngologic Allergy	355	2
American Society of Plastic and Reconstructive Surgery	368	1
American Surgical Association	250	1
American Therapeutic Society	300	1
American Thoracic Society	5,220	1
American Urological Association, Inc.	1,878	1
Arizona Medical Association, Inc.	1,038	1
Arizona Radiological Society	30	2
Arizona Society of Anesthesiologists	43	4
Arizona State Dental Association	375	1
Arkansas Medical Society	1,250	1
Arkansas Radiological Society	33	2
Association for Research in Nervous and Mental Disease, Inc.	920	1
Association for Research in Ophthalmology, Inc.	1,403	?

Name of Society	Membership	No. of Meetings
Association for the Advancement of Psychoanalysis	58	12
Association for the Advancement of Psychotherapy, Inc.	330	8
Association of Allergists for Mycological Investigations, Inc.	50	1
Association of American Physicians	250	1
Association of Bone & Joint Surgeons, Inc.	75	1
Association of Military Surgeons of the U.S.	7,000	1
Atlanta Radiological Society	38	12
Boston Society of Psychiatry and Neurology	180	8
Boston Surgical Society, Inc.	315	5
Bronx Society of Neurology & Psychiatry, Inc.	92	6
Brooklyn Psychiatric Society (Brooklyn District Branch, American Psychiatric Association)	149	4
California Academy of Preventive Medicine, Inc.	107	1
California Medical Association	17,000	1
California Society of Anesthesiologists, Inc.	789	1
Central Association of Electroencephalographers	300	2
Central Association of Obstetricians & Gynecologists	699	1
Central California Psychiatric Society, District Branch of American Psychiatric Association	50	4
Central Neuropsychiatric Association	250	1
Central New York Psychiatric Society, District Branch of American Psychiatric Association	90	4
Central Society for Clinical Research	800	1
Central States Society of Industrial Medicine & Surgery	677	2
Central Surgical Association	422	1
Chicago Dental Society	3,682	12
Chicago Medical Society	6,507	13
Chicago Pathological Society	195	12
Chicago Roentgen Society	225	6
Chicago Society of Internal Medicine	368	8
Chicago Urological Society	105	5
Cincinnati Dermatological Society	40	9
Cincinnati Pediatric Society	99	4
Cincinnati Society of Anesthesiologists	50	13
Cincinnati Society of Neurology & Psychiatry	120	8
Clinical Orthopaedic Society	356	1
Clinical Society of Genito-Urinary Surgeons	43	2
College of American Pathologists	1,746	1
College of Physicians of Philadelphia	1,208	8
Colorado Psychological Association	200	3
Colorado State Medical Society	2,446	2
Congress of Neurological Surgeons	502	1
Connecticut Society of Pathologists	60	6
Connecticut State Medical Society	3,755	1
Connecticut State Society of Anesthesiologists	125	4
Cranial Academy	284	2

Name of Society	Member-ship	No. of Meeting
Dallas-Fort Worth Radiological Society, Inc.	70	10
Delaware Academy of Medicine	500	1
D. C. Society of Anesthesiologists	110	4
East Bay Psychiatric Association	116	8
Eastern Missouri Psychiatric Society, District Branch of the American Psychiatric Association	140	7
Eastern Surgical Society	60	1
Endocrine Society	1,300	1
Florida Medical Association	4,000	1
Florida Pediatric Society	170	2
Florida Psychiatric Society	106	2
Florida Radiological Society	115	2
Florida Society of Anesthesiologists	123	2
Fort Worth Surgical Society	35	9
Georgia Psychiatric Association	55	3
Georgia Society of Anesthesiologists	70	4
Great Northern Railway Surgeons' Association	223	1
Greater St. Louis Society of Radiologists	47	5
Harvey Cushing Society, Inc.	674	1
Hawaii Association of Plantation Physicians	42	1
Hawaii Dermatological Society	24	12
Hawaii Medical Association	597	1
Hawaii Psychiatric Society	34	6
Hawaii State Dental Association	361	1
Honolulu County Medical Society	456	12
Honolulu General Surgical Society	94	6
Honolulu Obstetrical & Gynecological Society	50	12
Honolulu Pediatric Society	42	12
Houston Radiological Society	39	8
Idaho State Medical Association	550	1
Illinois Psychiatric Society	273	12
Illinois Psychological Association	581	2
Illinois Radiological Society	55	2
Illinois Society of Anesthesiologists	211	5
Illinois State Medical Society	9,811	1
Indiana Academy of General Practice	855	1
Indiana Neuropsychiatric Association	83	7
Indiana Psychological Association	211	2
Indiana Roentgen Society	84	2
Indiana Society of Anesthesiologists	125	2
Indiana State Dental Association	1,750	1
Indiana State Medical Association	4,256	1
Industrial Medical Association of Philadelphia, Inc.	226	9
Industrial Medical Association of Pittsburgh	258	2
Intermountain Psychiatric Association	82	1
Interstate Postgraduate Medical Association of North America	1,500	1
Iowa Academy of Surgery	68	2

Name of Society	Membership	No. of Meetings
Iowa Association of Pathologists	60	2
Iowa Dental Association	1,400	1
Iowa Neuropsychiatric Society	84	2
Iowa Orthopaedic Society	43	3
Iowa Radiological Society	81	2
Iowa Society of Anesthesiologists	85	11
Iowa State Medical Society	2,415	1
Iowa Veterinary Medical Association	840	1
Jackson County Medical Society	897	4
John A. Andrew Clinical Society	300	1
Kansas City Southwest Clinical Society	750	1
Kansas District Branch, American Psychiatric Association	150	2
Kansas Medical Society	1,833	1
Kansas Radiological Society	45	3
Kansas Society of Anesthesiologists	46	1
Kansas State Osteopathic Association	150	1
Kentucky Dental Association	950	1
Kentucky Psychiatric Association	50	2
Kentucky Radiological Society	66	9
Kentucky State Medical Association	2,382	1
Kings County Radiological Society	36	9
Lake County Medical Society	400	12
Los Angeles Radiological Society	157	5
Los Angeles Society of Allergy	48	4
Los Angeles Society of Internal Medicine	386	5
Los Angeles Society of Ophthalmology & Otolaryngology	375	1
Louisiana District Branch of the American Psychiatric Association		12
Louisiana Societies of Anesthetists	60	12
Louisiana State Medical Society	2,600	1
Maine Medical Association	828	2
Maine Radiological Society	32	4
Maine Society of Anesthesiologists	33	5
Maryland Psychiatric Society	176	7
Massachusetts Dental Society	3,059	2
Massachusetts Medical Society	7,795	1
Massachusetts Society of Anesthesiologists	360	4
Massachusetts Society of Pathologists	147	4
Massachusetts Thoracic Society	160	5
Medical & Chirurgical Faculty of the State of Maryland	3,152	2
Medical Association of Georgia	2,815	1
Medical Association of the State of Alabama	2,109	1
Medical Society of Delaware	430	1
Medical Society of New Jersey	6,734	1
Medical Society of the County of Kings and Academy of Medicine of Brooklyn, Inc.		9

Name of Society	Member-ship	No. of Meetings
Medical Society of the County of New York	6,948	8
Medical Society of the District of Columbia	2,198	9
Medical Society of the State of New York	25,056	1
Medical Society of the State of North Carolina	3,227	1
Medical Society of Virginia	2,930	1
Memphis Eye, Ear, Nose & Throat Society	32	12
Metropolitan Dermatological Society of Los Angeles	61	8
Michigan Allergy Society	100	5
Michigan Industrial Medical Association	197	1
Michigan Society of Anesthesiologists, Inc.	163	5
Michigan Society of Neurology & Psychiatry and Michigan District Branch of the American Psychiatric Association	256	8
Michigan State Medical Society	6,652	1
Mid-Central States Orthopaedic Society, Inc.	178	1
Middle Atlantic Society of Orthodontists	150	1
Mid-South Postgraduate Medical Assembly	1,600	1
Milwaukee Roentgen Ray Society	43	12
Minnesota Academy of Medicine	105	8
Minnesota Academy of Occupational Medicine & Surgery	85	5
Minnesota Psychiatric Society	105	Bien.
Minnesota Radiological Society	108	3
Minnesota Society of Anesthesiologists	118	2
Minnesota State Medical Association	3,700	1
Mississippi Psychiatric Society	24	1
Mississippi Radiological Society	25	12
Mississippi State Medical Association	1,400	1
Mississippi Valley Medical Society	1,100	1
Missouri Society of Anesthesiologists	105	2
Missouri State Medical Association	3,770	1
Montana Academy of Oto-Ophthalmology	36	Bien.
Montana Medical Association	610	2
Nassau Neuropsychiatric Society	110	9
National Dental Association, Inc.	770	1
National Eclectic Medical Association	1,000	1
National Foundation for Metabolic Research	500	1
National Medical Association, Inc.	5,000	1
National Proctologic Association	50	1
Nebraska Dental Association	760	1
Nebraska Society of Anesthesiologists	14	2
Nebraska State Medical Association	1,229	1
Nebraska State Radiological Society, Inc.	36	8
Neuropsychiatric Society of Virginia	101	2
Neurosurgical Society of America	85	1
Nevada Academy of General Practice	47	1
Nevada State Medical Association	249	1
New England Dermatological Society	143	4

Name of Society	Membership	No. of Meetings
New England Obstetrical & Gynecological Society	675	2
New England Ophthalmological Society	223	8
New England Oto-Laryngological Society	300	3
New England Pediatric Society	575	5
New England Roentgen Ray Society	283	8
New England Society of Anesthesiologists	275	3
New England Society of Pathologists	210	5
New England Society of Psychiatry	517	2
New England Surgical Society	283	2
New Hampshire Dental Society	300	1
New Hampshire Medical Society	660	1
New Hampshire Roentgen Ray Society	22	2
New Hampshire Society of Anesthesiologists	50	2
New Jersey District Branch of the American Psychiatric Association	248	6
New Mexico Association of Osteopathic Physicians & Surgeons	116	1
New Mexico Dental Association	243	1
New Mexico Medical Society	600	1
New Mexico Society for Biological & Medical Research	106	3
New Mexico Society of Anesthesiologists	13	5
New Mexico Society of Internal Medicine	37	1
New Mexico Veterinary Medical Association	70	1
New Orleans Society of Neurology & Psychiatry	117	9
New York Academy of Dentistry	548	8
New York Academy of Medicine	3,735	4
New York Neurological Society	250	8
New York Pathological Society	296	8
New York Psychiatric Society	48	4
New York Rheumatism Association, Inc.	224	3
New York Rhino-Otolaryngological Society	19	8
New York Roentgen Society	296	4
New York Society for Circulatory Diseases	500	2
New York Society for Clinical Psychiatry	600	5
New York State Capital District Branch, American Psychiatric Association	35	6
New York State Society of Anesthesiologists, Inc.	1,000	1
New York State Society of Industrial Medicine, Inc.	400	4
Noah Worcester Dermatological Society	100	2
North Carolina Neuropsychiatric Association	149	2
North Carolina Society of Anesthesiologists		1
North Carolina Trudeau Society	89	1
North Dakota Radiological Society	13	1
North Dakota Society of Obstetrics & Gynecology	72	2
North Dakota State Medical Association	447	1
North Florida Radiological Society	35	4

Name of Society	Membership	No. of Meetings
North Pacific Pediatric Society	280	2
North Pacific Society of Internal Medicine	105	2
North Pacific Society of Neurology and Psychiatry	200	1
North Pacific Surgical Association	140	1
Northeastern New York Radiological Society	46	5
Northern California Psychiatric Society	320	10
Northwestern Pediatric Society	197	2
Odontological Society of Western Pennsylvania	1,364	10
Ogden Surgical Society	114	1
Ohio Psychiatric Association	232	1
Ohio Society of Anesthesiologists, Inc.	440	1
Ohio State Medical Association	9,500	1
Ohio Valley Proctologic Society	35	4
Oklahoma District of the American Psychiatric Association	56	4
Oklahoma Rheumatism Society	50	13
Oklahoma Society of Anesthesiologists	65	2
Oklahoma State Medical Association	1,750	1
Omaha Mid-West Clinical Society	190	1
Ontario District Branch, American Psychiatric Association	25	3
Oregon Radiological Society	46	9
Orleans Parish Medical Society	1,218	9
Pacific Coast Obstetrical and Gynecological Society	110	1
Pacific Coast Oto-Ophthalmological Society	800	1
Pacific Coast Society of Orthodontists	515	Bien.
Pacific Coast Surgical Association		1
Pacific Northwest Dermatological Society, Inc.	47	2
Pacific Northwest Radiological Society	150	1
Pacific Roentgen Society	418	1
Pathological Society of Philadelphia	300	10
Pennsylvania Dental Association	5,400	1
Pennsylvania Medical Society	11,734	1
Pennsylvania Osteopathic Association, Inc.	1,122	3
Pennsylvania Psychiatric Society	350	1
Pennsylvania Radiological Society	200	1
Philadelphia Allergy Society	90	2
Philadelphia County Medical Society	3,600	4
Philadelphia Neurological Society	174	8
Philadelphia Roentgen Ray Society	205	8
Physiological Society of Philadelphia	700	9
Pittsburgh Pediatric Society	163	5
Polk County Medical Society	385	8
Portland Surgical Society	111	13
Psychonomic Society, Inc.	708	1
Quebec District Branch of the American Psychiatric Association	70	10

Name of Society	Membership	No. of Meetings
Queens County Psychiatric Society	60	4
Radiological Society of Greater Cincinnati	43	10
Radiological Society of Hawaii	18	12
Radiological Society of New Jersey	125	2
Radiological Society of North America, Inc.	3,454	1
Radiological Society of Southern California	123	3
Ramsey County Medical Society	535	9
Reno Surgical Society	43	1
Rhode Island Medical Society	961	2
Rhode Island Society for Neurology and Psychiatry: Rhode Island District Branch, American Psychiatric Association	50	4
Richmond Academy of Medicine, Inc.	660	4
Rochester Roentgen Ray Society	42	12
Rocky Mountain Radiological Society	139	1
Rocky Mountain Society of Orthodontists	62	1
Rocky Mountain Traumatic Surgical Society	100	1
St. Louis Academy of General Practice	190	4
St. Louis Medical Society	1,372	9
St. Louis Society of Internal Medicine	38	12
San Francisco Radiological Society	57	4
Sioux Valley Medical Association	500	1
Society for Experimental Biology and Medicine	3,411	19
Society for Gynecologic Investigation	68	1
Society for Investigative Dermatology, Inc.	850	1
Society for Pediatric Research	212	1
Society for the Study of Blood	153	4
Society for Vascular Surgery	176	1
Society of Biological Psychiatry	179	1
Society of Clinical Surgery	50	2
Society of Experimental Psychologists, Inc.	75	1
Society of General Physiologists	350	1
Society of Neurological Surgeons	50	1
Society of Pelvic Surgeons	42	1
Society of University Surgeons	369	1
South-Atlantic Association of Obstetricians and Gynecologists	174	1
South Bay Radiological Society (Northern Section)	60	12
South Bay Radiological Society (Southern Section)	27	12
South Carolina District Branch of the American Psychiatric Association	23	2
South Carolina Medical Association	1,458	1
South Carolina Radiological Society	38	2
South Dakota Radiological Society	12	1
South Dakota State Medical Association	461	1
Southeastern Allergy Association	75	1
Southeastern Surgical Congress	1,834	1
Southern California Psychiatric Society	500	12
Southern Medical Association	14,000	1

Name of Society	Member-ship	No. of Meetings
Southern Minnesota Medical Association	350	1
Southern Psychiatric Association	230	1
Southern Society for Clinical Research	279	1
Southern Society of Anesthesiologists	750	1
Southern Society of Clinical Surgeons	75	1
Southern Society of Orthodontists	283	1
Southern Surgeons Club	42	1
Southern Surgical Association	344	1
Southwestern Society of Orthodontists	212	1
Southwestern Surgical Congress	1,100	1
State Medical Society of Wisconsin	3,600	1
Suffolk County (New York) District Branch Society of the American Psychiatric Association	57	5
Tennessee Academy of Ophthalmology and Otolaryngology	120	1
Tennessee Radiological Society	62	1
Tennessee State Medical Association	2,501	1
Tennessee State Society of Anesthesiologists	55	1
Texas District Branch Society of the American Psychiatric Association	166	2
Texas Industrial Medical Association, Inc.		2
Texas Medical Association	8,206	1
Texas Neuropsychiatric Association	266	1
Texas Radiological Society		1
Texas Society of Anesthesiologists	165	1
Texas Society of Pathologists, Inc.	116	2
Tissue Culture Association	622	1
Tri-State Medical Association	650	1
Tri-State Radiological Society	14	4
Utah Oto-Ophthalmological Society	35	12
Utah Society of Pathologists	16	Bien.
Utah State Medical Association	905	1
Utah State Radiological Society, Inc.	22	4
Utah State Society of Anesthesiologists	35	12
Vermont State Medical Society	445	1
Virginia Academy of General Practice	429	1
Virginia Society of Anesthesiologists	45	2
Virginia State Dental Association	1,170	1
Washington Psychiatric Society	279	12
Washington State Medical Association	2,882	1
Washington State Radiological Society	65	9
Washington State Society of Anesthesiologists, Inc.	118	4
West Virginia Radiological Society	28	2
West Virginia Society of Anesthesiologists	38	2
West Virginia Society of Osteopathic Medicine	93	Bien.
West Virginia State Dental Society	557	1
West Virginia State Medical Association	1,467	1
West Virginia Veterinary Medical Association, Inc.	80	2

Name of Society	Membership	No. of Meetings
Westchester County District Branch of the American Psychiatric Association	140	5
Westchester Radiological Society	31	1
Western Association of Physicians	66	1
Western Industrial Medical Association	390	1
Western Missouri District Branch of the American Psychiatric Association	48	3
Western New York Society of Industrial Medicine & Surgery	151	3
Western Orthopedic Association	802	1
Western Society for Clinical Research	306	1
Western Surgical Association	362	1
Wisconsin Radiological Society	82	1
Wisconsin Society of Anesthesiologists	84	2
Wisconsin Society of Pathologists	98	3
Wisconsin Surgical Society	140	2
Women's Medical Society of New York State	250	2
Women's Veterinary Medical Association	200	1
Wyoming State Medical Society	265	1

APPENDIX IV-B

ANNUAL MEETINGS OF THE FEDERATION OF AMERICAN SOCIETIES FOR EXPERIMENTAL BIOLOGY

	Attendance						
Year	Total	Members of FASEB Societies	Non-members	No. of Papers Presented	No. of Symposia and Spec. Sessions	No. of Sessions	Largest No. of Simultaneous Sessions
1923	242	---	---	---	---	---	---
1942	2,083	751	1,332	572	11	---	---
No Annual Meeting held in 1943, 1944, 1945							
1946	2,309	1,016	1,293	723	9	79	14
1947	2,900	---	---	934	3	85	14
1948	3,324	---	---	1,122	4	94	17
1949	3,517	---	---	1,304	4	113	14
1950	4,628	---	---	1,266	4	118	16
1951	4,787	---	---	1,298	3	126	17
1952	6,494	---	---	1,510	7	149	20
1953	6,085	1,643	4,442	1,389	5	140	21
1954	6,453	1,720	4,733	1,539	10	146	22
1955	4,337	1,226	3,111	1,354	4	130	18
1956	7,380	1,934	5,446	1,915	5	186	22
1957	7,688	1,942	5,746	1,945	8	185	23
1958	9,136	2,295	6,841	2,111	10	208	25
1959	10,327	2,511	7,816	2,475	16	234	30
1960	11,015	2,624	8,391	2,654	18	254	28
1961	12,567	2,852	9,715	2,815	14	270	29
1962	14,814	3,177	11,637	2,990	20	286	31
1963	16,484	---	---	3,138	26	313	34

Source: FASEB Records

APPENDIX IV-C

MEETINGS OF THE AMERICAN FEDERATION FOR CLINICAL RESEARCH

TABLE IV-C-1

ANNUAL MEETINGS OF THE AMERICAN FEDERATION FOR CLINICAL RESEARCH

Year	Membership	Annual (National) Meeting Registration	No. Papers Submitted	No. Papers Given
1948	800	---	---	---
1949	1,075	---	---	---
1950	1,300	---	---	---
1951	1,561	---	---	---
1952	1,748	---	128	24
1953	1,985	---	165	24
1954	2,036	---	153	26
1955	2,312	---	173	41
1956	2,500	---	247	48
1957	2,700	---	246	52
1958	2,760	---	296	85
1959	2,878	---	255	82
1960	3,172	2,283	331	94
1961	3,453	2,240	296	77
1962	3,728	2,655	365	71
1963	3,818	2,461	373	113

Sources: AFCR Records and Clinical Research (Proceedings)

TABLE IV-C-2

NUMBER OF PROGRAM ABSTRACTS SUBMITTED FOR MEETINGS OF THE AMERICAN FEDERATION FOR CLINICAL RESEARCH

Year	National Meeting	Eastern Section	Midwest Section	Southern Section	Western Section	Total
1954	153	120	55	74	43	445
1955	173	48	48	45	44	358
1956	247*	47	65	58	51	468
1957	246	69	54	76	49	494
1958	296	81	64	103	49	593
1959	255	84	48	91	72	550
1960	331	No Meeting	49	103	85	568
1961	296	95	64	103	70	628
1962	365	137	66	117	96	781
1963	373	80	72	120	86	731

Source: Clinical Research (Proceedings)

* 36 of these abstracts were published in Journal of Clinical Investigation

APPENDIX IV-D

SCIENTIFIC AND TECHNICAL PERSONNEL WITH GRANTS TO WORK ABROAD, 1952 AND 1962

The following information has been derived from compilations by the Reports Branch, Department of State. The categories tabulated have been adapted from those in the State Department compilations by regrouping as follows: students = "students" plus "student leaders"; teachers = "teachers" plus "lecturers"; others = "research scholars," "specialists," and "leaders"; nutrition = "nutrition and metabolism"; medicine = "medicine (general)," "public health," "psychiatry," "surgery (general)," "pediatrics," "gynecology and obstetrics," "ophthalmology," "internal medicine," "medicine (atomic)," and "medical sciences (other)"; paramedical = "nursing," "dietetics," "endemic disease control," "health facility development," "industrial hygiene," "occupational therapy," "psychiatric social work," and "speech pathology"; pharmacy = "pharmacy" and "pharmaceutical chemistry"; agriculture = "animal science," "food technology," "agricultural and food chemistry," and "veterinary medicine"; biology = "biology," "biology (general)," "entomology," "plant physiology," "phytopathology," "biology (atomic)," "zoology," and "biological science (other)"; and chemistry = "chemistry," "organic chemistry," "physical chemistry," and chemistry (other)."

Part I. American Personnel Working in Foreign Countries

Subject Field	Students		Teachers		Others		Total	
	'52	'62	'52	'62	'52	'62	'52	'62
Biomedical (A)								
Anatomy	--	--	1	--	--	--	1	--
Bacteriology	1	1	1	--	3	--	5	1
Biochemistry	1	2	1	4	3	7	5	13
Genetics	--	1	--	1	3	--	3	2
Nutrition	--	--	--	--	1	--	1	--
Pharmacology	1	1	--	--	--	--	1	1
Physiology	2	2	--	1	--	2	2	5
Medicine	1	6	6	8	5	13	12	27
Dentistry	--	--	--	9	3	3	3	12
Paramedical	--	--	8	3	1	--	9	3
	6	13	17	26	19	25	42	64
Related Fields (B)								
Agriculture	2	1	--	2	3	1	5	4
Anthropology	13	7	--	7	5	4	18	18
Biology	5	8	6	25	6	8	17	41
Chemistry	5	19	4	20	7	9	16	48
Psychology	--	9	--	8	--	6	--	23
	25	44	10	62	21	28	56	134
Totals (A + B)	31	57	27	88	40	53	98	198

Part II. Foreign Personnel Working in U.S.

	Students		Teachers		Others		Total	
Subject Field	'52	'62	'52	'62	'52	'62	'52	'62
Biomedical (A)								
Anatomy	1	--	--	--	1	--	2	--
Bacteriology	9	21	--	--	3	10	12	31
Biochemistry	23	33	--	1	8	68	31	102
Biophysics	1	2	--	--	2	2	3	4
Genetics	4	8	1	2	3	1	8	11
Nutrition	1	7	--	1	--	--	1	8
Pathology	--	6	--	--	1	3	1	9
Pharmacology	2	10	1	--	--	12	3	22
Physiology	4	6	--	--	1	12	5	18
Medicine	219	146	4	3	108	128	331	277
Dentistry	17	30	--	--	--	4	17	34
Pharmacy	6	29	--	1	1	8	7	38
Paramedical	24	33	2	1	2	--	28	34
	311	331	8	9	130	248	449	588
Related Fields (B)								
Agriculture	23	50	1	1	2	6	26	57
Anthropology	2	16	2	--	2	3	6	19
Biology	16	81	--	3	7	29	23	113
Chemistry	67	152	2	11	37	118	106	281
Psychology	62	85	2	3	9	14	73	102
	170	384	7	18	57	170	234	572
Totals (A + B)	481	715	15	27	187	418	683	1160

APPENDIX IV-E

TRAVEL
OF
SCIENTIFIC AND TECHNICAL PERSONNEL
TO AND FROM
SOVIET UNION AND EASTERN EUROPE

	USSR		Poland		Czecho-slovakia		Hungary		Rumania		Bulgaria		Total	
	To U.S.	From U.S.	To U.S.	From U.S.	To U.S.	From U.S.	To U.S.	From U.S.	To U.S.	From U.S.	To U.S.	From U.S.	To U.S.	From U.S.
1959	415	675	51	10	22	116	17	5	11	6	3	10	519	822
1960	311	90	55	29	35	117	26	27	18	1	6	2	451	266
1961	217	722	58	34	47	43	28	22	17	4	3	33	370	858
	943	1487	164	73	104	276	71	54	46	11	12	45	1340	1946

Source: Report on Exchanges with the Soviet Union and Eastern Europe (Report Nos. 15, 16, 17, 18, 19, and 20), Soviet and Far Eastern Exchanges Section, Department of State.

Note: Report Nos. 1 - 14 do not indicate how many exchanges concerned scientific and technical personnel.

June 11, 1963
(Revised December 1963)

NAS-NRC Study of Communication Problems in Biomedical Research

Staff Paper No. V

CHARACTERISTICS OF THE BIOMEDICAL SERIAL LITERATURE*

INTRODUCTION

The biomedical serial literature comprises the formal types of written records, which may be categorized grossly as serial publications, books, and technical reports.** In addition to the periodicals that scientists refer to as "journals," biomedical librarians use the term, "serials," for several other types of publications, such as abstracting and indexing publications, monograph series, annual review series, and volumes of proceedings of recurrent conferences. From the point of view of those charged with keeping and finding documents, the common features of serials are that they are issued on a recurrent basis and bear titles indicating continuity. Because serials are the primary source of recorded information for research workers, we gave the most attention to this segment of the literature.† The aim of this paper is to summarize such of our findings as may provide a foundation of reliable data and a broad perspective for consideration of "the literature problem."

METHODS AND SOURCES

Our general approach was to review critically previous studies and to use suitable data therein. Editorial statements about the size and growth of the literature, and studies in which the methodology was not adequately described, were reviewed but not used as sources of facts, nor were studies that relied primarily on "second-hand" data. Information from studies meeting our criteria was supplemented by data readily available from other sources. In addition, to the extent possible within the constraints of time, cost, and manpower, we collected original data to fill important gaps.

The number of studies meeting our criteria for dependable sources of information is small. Most of the considerable number of published and unpublished studies of biomedical and related literature are either estimates based on other estimates or unsystematic observations for which the methodology and definition of samples are described only vaguely. Of the few suitable sources, the majority are not useful for assessing changes with time. In addition, the essential subjectivity of any definition of the "biomedical" literature or, for that matter, of the literature of any

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* Not for publication or publication reference.

** Series of technical reports qualify as serials by our definition, but are not usually treated as such in the biomedical community.

† See Staff Paper No. VII for an analysis of biomedical technical reports.

field of science posed a major difficulty, particularly when we attempted to compare data from different sources.

Analyses of Standard References

Special analyses were made of data in Biomedical Serials, 1950-60; Index-Handbook of Cardiovascular Agents, Vols. 1 and 2; Poliomyelitis Current Literature and Poliomyelitis and Related Diseases; and Bibliography of Medical Reviews, Vol. 7, 1962. The procedures followed either are obvious or are described when the results are presented.

Collection of Original Data

The annual bibliography of NIH staff for 1961 (1), and the NIH Research Grants Index, Fiscal Year 1962, were used to ascertain the characteristics of published material resulting from the intra- and extramural research programs of NIH, respectively. Each of the citations in these publications was tabulated by the title of the serial or other type of publication in which it appeared. These tabulations were analyzed in several ways that will be described below.

A simple study of the shelf space required for biomedical serials was performed at Wayne State University Medical Library, which has complete sets of bound volumes for 351 journals from 1940 to the present. From an alphabetical list of these journals, a sample of every third title was taken; and the total thickness of a year's publication was measured across the top of the volume (or volumes). The years 1941, 1946, 1951, 1956, and 1961 were selected for measurement.

RESULTS

Biomedical Serial Literature as Conventionally Defined

Number of Serials. The biomedical field, as conventionally defined by librarians and bibliographers, includes clinical medicine and the preclinical sciences taught in medical schools. In addition, any or all of the following may be included, depending on who is defining the field: pharmacy, dentistry, nursing, homeopathy, osteopathy, hospital administration, and veterinary medicine. Table V-1 compares the figures for the total number of "substantive" biomedical serials developed by four studies and compilations since 1950 which shared a roughly comparable definition of the field and which actually examined the serials or checked them to be certain that each was still being published (2, 3, 4, 5).

Birth and Death of Serials. Turnover in biomedical serials was rapid during the decade 1950-1960. The third edition (1961) of World Medical Periodicals dropped 130 serials listed in its second edition (1957) and added 1,130 new ones; the latter did not all live until 1961. An analysis of Biomedical Serials, 1950-60 indicates that about one-third of the journals born after 1950 had died* by 1960. During the same period, a similar proportion of the serials born before 1951 also died. Of the journals born

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[*] A serial "dies" when it either ceases publication or is absorbed into a pre-existing serial.

TABLE V-1

ESTIMATES OF NUMBER OF CURRENT SUBSTANTIVE BIOMEDICAL SERIALS*

Source	Number of Serials 1950-1951	1957	1960-1961
Welch Library Project (2)	4,454**	---	---
Brodman and Taine Study (3)	---	3,879†	---
World Medical Periodicals (4)	---	4,360	5,803
Biomedical Serials, 1950-60 (5)	5,323††	---	5,711

* Biomedical serials containing "indexable," original, or "informative" material believed to be alive at the given time; all the figures, however, include abstracting and indexing serials.

** This project lasted from 1948-1953, but it is reasonable to assume that its report generally reflected the status in 1950-1951. The authors note that the first edition of World Medical Periodicals (1951) includes some 1300 substantive serials in addition to those they had counted. Their figure includes 289 Congress proceedings, a class of publication omitted by the other studies.

† The authors state that the difference between their figure and that given by World Medical Periodicals for the same year is explained by a deficiency of the NLM collection in Latin-American and Japanese journals at that time, and that "the Welch Medical Library figures are higher on account of differences in definition of current substantive periodicals."

†† The figure for 1950-1951 was obtained by checking the date of founding for each serial listed in the reference and counting only those existing in 1950. For 113 serials, the founding date was given as "195?," and for 72 as "19??." These serials were not included in the figure for 1950-1951.

during this decade, four-fifths were foreign; mortality rates were much the same for these as for U.S. journals. Some examples of serials that were born or died during this decade are listed in Appendix V-A.

Georgraphical and Language Distribution. The six countries and languages accounting for most biomedical serials are shown in Table V-2. Rank order based on the number of articles differs somewhat from that based on the number of serials.

Number of Articles. No one has actually counted the number of articles in all biomedical serials; however, two studies arrived at estimates by systematic sampling. For the early 1950's, the Welch Medical Library Project estimated the total to be about 300,000 (2); and Brodman and Taine arrived at a figure of around 220,000 for 1957 (3).

Review Articles. The following figures taken from the Bibliography of Medical Reviews, Vols. 6 and 7, Cumulation (Preface), of the National Library of Medicine illustrate the sharp increase in the number of biomedical reviews since 1955.

Year	Approximate no. of review articles
1955	1,000
1956	2,000
1957	2,880
1958	3,280
1959	2,380
1960	3,320
1961	4,800

The average annual increase over the 7-year period is 63 percent. It should be noted, however, that the impressive total of 4,800 reviews in 1961 amounts to only 3.4 percent of the 140,000 articles listed by Index Medicus (6) for that year. About half the listed reviews could be roughly classified as "research-oriented" and the other half as "practice-oriented."*

Shelf Space. The shelf-space requirement of serial journals is a matter of practical importance to libraries. The average thickness of a year's publication for the average journal in a random sample of biomedical journals (Appendix V-B) was found to be as follows:

Year	Thickness, cm.	Increase over 10-yr. period, %
1941	3.6	
1946	3.8	
1951	4.2	17
1956	4.4	
1961	4.6	10

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* A random sample (20 percent) of the listed articles was examined. When the title of the article left doubt of its classification, the general orientation of the journal in which it appeared was appraised.

TABLE V-2

DISTRIBUTION OF BIOMEDICAL LITERATURE BY COUNTRY OF PUBLICATION AND LANGUAGE

Country of Publication	% of Serials, 1950-1951	% of Serials, 1957	% of Articles, 1957
U. S.	28	23	24
Great Britain	7	7	7
France	7	8	10
Italy	7	10	8
Germany	7	9	12
Japan	5	4	9
Language			
English	46	38	37
Spanish	14	10	6
French	13	11	11
German	12	11	13
Italian	10	8	8
Japanese	5	4	8

Sources: For 1950-1951, analysis of 4,544 serials by the Welch Library Project (2). This study did not give a breakdown by articles.

For 1957, Brodman and Taine (3).

In 1941, the shelf space required by all the journals measured was 126 meters; in 1961, these journals occupied 161 meters.

Changes in Selected Biomedical Journals. A recent study by Shilling (7) analyzed the growth of 100 "key" U.S. biological journals; of these 61 are indexed by Index Medicus and can therefore be considered part of the biomedical literature, as conventionally defined.* His data indicate that these selected U.S. biomedical journals carried 31 percent more articles in 1960 than in 1950 and 6.5 percent more pages devoted to articles. Calculations from his data give averages of 8.1 pages per article in 1950 and 6.7 in 1960.

The Literature of Specialized Biomedical Fields

Cardiovascular Agents. Estimates were made of the number of papers** published annually in this field for the period 1931-1955 by counting the papers listed in 46 percent of the pages of Volume I of the Index Handbook of Cardiovascular Agents and 31 percent of the pages of Volume II, Part I. Corresponding data for 1956-1959 were obtained from unpublished files in the office of the Handbook.

The rate of publication remained fairly steady at about 300 to 400 articles a year from 1931 to 1940. It then rose irregularly to almost 3,000 papers in 1950 and thereafter fluctuated at a level of 2,000 to 3,000 articles a year.

Psychopharmacology. Data provided by the Psychopharmacology Service Center, NIMH, indicate that the annual output of papers in this field rose steadily from about 900 in 1955 to 2,600 in 1959. In 1960, the count dropped to 1,450 and, in 1961, rose again to 2,450. The rate of publication seems now to be reaching a plateau.

Poliomyelitis. The following approximate figures were derived from Poliomyelitis Current Literature (1946-1958) and Current Literature, Poliomyelitis and Related Diseases (1959-1962).

Year	No. of papers
1946	100
1950	450
1955	1,400
1956	1,570
1960	1,250
1962	1,160

The output of papers reached a peak in 1956. (All papers listed in these sources were counted as polio literature, although after 1956 their coverage enlarged to include other diseases.)

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* The titles of these 61 journals are given in Appendix III-B (Staff Paper No. III).

** The term, "paper," is used throughout to cover all types of cited documents: journals, articles, books, technical reports, abstracts, reports of meetings, etc.

Biomedical Literature as Defined Operationally

Scatter. The papers listed in the annual bibliography of NIH staff for 1961 (1) were distributed among more than 300 "titles" (serials, books, etc.). The majority of the papers were concentrated in a relative small proportion of the titles. The scatter of the 15,966 papers listed in the NIH Research Grants Index, Fiscal Year 1962 (all papers cited by grantees as representing the product of their work) shows a still more striking concentration in a small fraction of the serials.

Percent of Titles	Percent of Papers	
	NIH Staff	NIH Grantees
10	52	72
25	73	87
50	87	95

The titles containing the most papers in each of these samples are listed in Appendix V-C. Approximately 100 titles account for 77 percent of the NIH staff papers and 65 percent of the NIH grantee papers. Sixteen titles are among the first 25 in each list.

Distribution of Papers Among Different Kinds of Titles. Table V-4 indicates the distribution of papers in these two NIH samples among different kinds of titles.

TABLE V-4

DISTRIBUTION OF SAMPLE PAPERS AMONG DIFFERENT TYPES OF TITLES*

	NIH Staff Papers		NIH Grantee Papers	
	No.	Percent	No.	Percent
In "Journals"	1,370	84	14,335	90
In "Proceedings"	98	6	822	5
In "Others"	158	10	809	5
Totals	1,626	100	15,966	100

* Definitions:

"journals": serial periodicals issued more than once a year.

"proceedings": titles publishing reports given at meetings but not qualifying as journals;

"other": miscellaneous types of documents not falling into the above categories, e.g., textbooks, monographs, monograph and review series issued annually or less frequently, and technical reports.

Nature of Journals Containing Sample Papers. For each sample, the journals containing more than one paper were classified according to the general type of material published, as follows: Type 1: most of the substantive items are articles of regular length in which the author describes his own work; Type 2: same as Type 1 except that the majority of items are brief descriptions of an author's work or abstracts of oral reports submitted for (or given at) a meeting; and Type 3: most items are review articles or abstracts of articles published elsewhere.* For NIH staff papers, about 86 percent of the journals were of Type 1, 4 percent of Type 2, 5 percent of Type 3, and 5 percent of undetermined type. For NIH grantee papers, the corresponding percentages were 83, 5, 10, and 3.

Language of Publication

English is the primary language in roughly 90 percent of the journals in which NIH staff papers appeared, compared with 70 percent of the journals containing NIH grantee papers.

DISCUSSION

Definitions of Subject Fields and Their Literatures

Figures on the size and growth of the literature of a subject-matter field, narrow or broad, must be interpreted cautiously when they are based on subjective definitions, e.g., the biomedical literature as conventionally defined. Although an individual may feel that he has a clear idea of the boundaries of a given field, no two individuals are likely to agree exactly when asked to determine which of a group of documents should be considered as falling within the field. Nor can one assume that the classification decisions of an individual or group do not change with time. In addition to these considerations, the great practical difficulties in approaching complete enumeration of the documents in any field must be appreciated when one tries to assess changes using data based on subject-matter classifications.

For the purpose of this study, we wanted serial measurements of the volume and character of printed matter that could be interpreted functionally, i.e., measures (1) of the information produced by the biomedical research community (output); (2) of the information used by, or potentially useful to, this population (input); and (3) of the loads on information services for this population. Aside from the inherent nonreproducibility of figures based on classification decisions, most of the available data on numbers of journals or papers do not lend themselves to this kind of interpretation, except with regard to loads on information services. Such services (e.g., libraries and abstracting-indexing services) generally use subject-matter definitions to delimit their scope and thereby determine the load they must handle.

By using operational definitions, we have developed some crude measures of the information output of the biomedical research community. To

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* Some periodicals devoted primarily to abstracts of articles published elsewhere also carry review articles, e.g., Excerpta Medica and Modern Medicine.

characterize the input similarly is considerably more difficult and was not attempted, although it is feasible. Information actually used can be determined by observation; by interviews, questionnaires, and diaries; and by citation studies. Potentially useful information can be identified by giving members of the community a large number of documents and learning which they find useful. A few small studies of information input to biomedical research workers have been done, e.g., Glass's study, "How Scientists Actually Learn of Work Important to Them" (8), but the data on input accumulated thus far are inadequate for generalization and for assessing trends. We therefore concentrated on assessing the load on information services, using the best available data from previous studies, and on characterizing the document output of the biomedical community, using data on the samples of literature we have operationally defined.

Growth in Number of Biomedical Serials

Little effort is warranted in attempting to reconcile carefully the considerable differences between figures for the number of biomedical serials extant in a given year (Table V-1). The four studies were based on somewhat different interpretations of what is "biomedical" and "substantive." Inasmuch as journals considered "non-substantive" number in the thousands (2,3), a considerable variation between the results would be expected even if all had been derived from the same collections, which they were not. But these differences do not explain why both figures for 1957 are lower than those for either 1950-1951 or 1960-1961. Only for the 1950-1951 and 1960-1961 figures that are based on "Biomedical Serials, 1950-1960" can one be certain that the compilers' criteria were the same for the different years. Using the figures from this single source, the increase for the whole decade was 7 percent, with an uncertainty of ± 3.5 percent arising from ambiguity of the founding dates of a number of journals. Taking the lower figure for 1950-1951 and the higher figure for 1960-1961, the increase would be 30 percent.* If the 1957 figures are excluded, only two points remain to establish the shape of the growth curve. It could be exponential, but, whether the over-all increase in 10 years is 3.5 or 30 percent, the slope of the curve would bear little resemblance to that so often used to depict the "explosive" growth of the literature.

In 1879, Billings counted 850 biomedical serials (9). A steady increase of around 30 percent each decade since then could account for the 1950-1951 figures. Unfortunately, we have no good data to check intermediate points of the curve and establish its shape. There is some evidence, however, to support the alternative hypothesis, viz., that growth was initially more rapid but slowed at some time before 1950. The most recent census of the world's scientific and technical serials (10) supports the idea that an unrecognized slowing may have taken place. This careful study indicated that the total number of all scientific and technical serials alive today (excluding those in the social sciences) is closer to 35,000 (± 10 percent) than to the previous estimates of 100,000. The previous overestimations are explained by duplications in counting the

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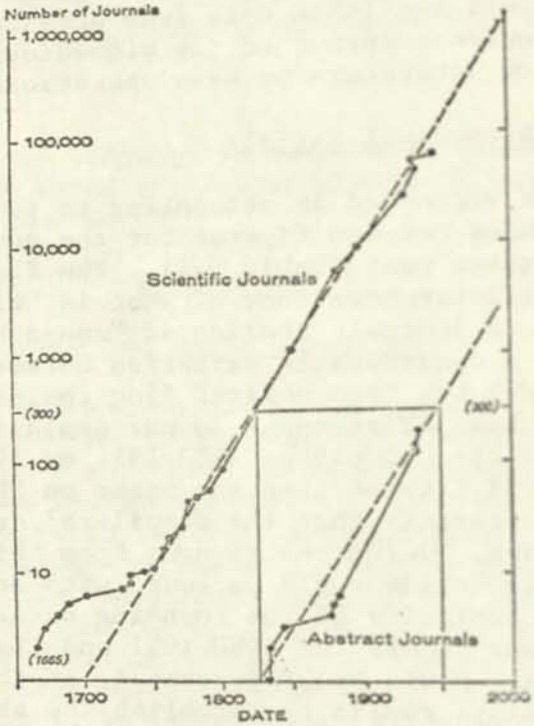
* The compilers' comments on the low figure (see Table V-1) indicate that it represents a significant underestimation.

carrying of dead titles, and the inclusion of periodicals that do not qualify as scientific or technical. de Solla Price's now-famous curve showing the exponential growth of scientific periodicals (11) should be corrected for recent years.



The relatively slow recent increase suggested by the best data on biomedical serials for 1950-1951, and 1960-1961 (Table V-1) and by the data on shelf space are consistent with this hypothesis.*

Geographical Distribution of Serial Publication

The data in Table V-2 on the percentage of biomedical serials published in the U.S., when added to the fact that 80 percent of the serials born between 1950 and 1960 were foreign, may indicate a trend toward a decrease in the quantitative importance of the U.S. as <u>the</u> biomedical publisher and of English as <u>the</u> biomedical language.

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*The National Library of Medicine has found that shelf space is a useful measure for growth of the literature; NLM has estimated a doubling time for its collections of around 25 years (6).

Increase in Number of Papers

No suitable figures on the total number of U.S. and foreign biomedical papers are available, except for 1950-1951 and 1957, and these do not appear to be comparable. Shilling's data on 61 selected U.S. biomedical journals, which indicated a 31-percent increase in 10 years (7), would not seem generalizable for either U.S. or world biomedical journals. His sample consisted of well-established, relatively large journals, which published an average of 153 articles each in 1960, compared with an average of 58 for all journals covered by *Index Medicus* in 1957 (3). The estimates developed in Staff Paper No. III for the output of the U.S. biomedical research Community indicate a more rapid growth for this segment of the biomedical literature (from 32,000 in 1957 to 52,000 in 1961). For the literature of dynamic subject-matter fields, such as cardiovascular agents and psychopharmacology, the increase in the number of papers during the period 1950-1960 is considerably greater than that of U.S. biomedical research output in general. It is interesting to speculate that the peaks in output may be related to fundamental discoveries; e.g., the 1950 peak in the cardiovascular literature followed the discovery of potent antihypertensive agents (12). Other fields show a more uniform and less rapid growth; and undoubtedly there are fields in which the amount of literature decreased during this 10-year period, but bibliographies and abstracting-indexing services are seldom continued for fields in which interest is declining. Poliomyelitis may be an example of such a field. The literature citing service for this field was discontinued in 1962.

A Paradox

The existence of many biomedical subject-matter areas that are growing rapidly, while biomedical literature as a whole is increasing much more slowly, poses a superficial paradox. The explanation hinges mainly on four facts: (1) the literatures of these subject-matter areas are not mutually exclusive, i.e., papers counted in one may be included in others; (2) bibliographic services for dynamic areas tend to broaden with time, i.e., papers are included that earlier would have been considered irrelevant; (3) some of the literature relevant to certain biomedical subject-matter areas falls outside the conventional boundaries of the biomedical literature, e.g., the literature of biophysics, mental health, and other "bridging" fields; and (4) the expanding literatures of active fields are partially counterbalanced by contraction in other fields.

Characteristics of the Output of Current Biomedical Research

Relation to the Biomedical Literature as Conventionally Defined. If the coverage of *Index Medicus* represents the conventional concept of the biomedical literature, it can be seen that the output of U.S. biomedical research falls largely within this universe. Most of the titles listed in Appendix V-C are covered by *Index Medicus*, and in Staff Paper No. VIII we have shown that about 88 percent of all the papers listed in *NIH Research Grants Index*, 1962, were covered by *Index Medicus*. There are important differences, however, in that biomedical research output extends far beyond the conventional confines of biomedical literature, into mathematics and the physical and social sciences. As more physical and social scientists become engaged in biomedical research, the scatter will increase.

Comparison of Output of NIH Intramural and Extramural Research. Appendix V-C reveals that a large common core of titles publish most of the output of these two populations, and presumably of the U.S. biomedical research community. Many of the differences may be explained by the special research interests of the intramural research staff and by the fact that the NIH staff bibliography, unlike the Grants Index, does not list abstracts of oral reports at meetings. The high ranking of a number of journals in the Grants Index, such as Federation Proceedings, Clinical Research, and Bacteriological Proceedings, is explained by the large number of meeting abstracts they publish. NIH staff papers are less scattered than those of NIH grantees: a lower proportion go to foreign journals; and basic science journals are more favored.

Character of the Papers Listed in NIH Research Grants Index. Although it was not possible to look up individual citations and determine what proportion are either meeting abstracts or brief, preliminary reports, such as the "reports" in Science, the analysis by type of journal, together with the distribution of the papers among journals, indicates that probably up to 20 percent of all the papers fall into these categories.

CONCLUSIONS

(1) From 1950 to 1960, the total number of biomedical serials, as conventionally defined, probably increased by less than 20 percent. There are suggestions that the growth rate of biomedical serials decreased at some time before 1950.

(2) During the same period, the increase in the total number of biomedical articles, similarly defined, probably did not exceed 30 percent.

(3) The literature of certain more restricted fields has increased more rapidly.

(4) Papers generated by the major segment of the U.S. biomedical research community are concentrated in a relatively small proportion of the world's scientific serials. Significant numbers, however, are finding their way into publications that would not be considered biomedical in the conventional sense.

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APPENDIX V-A

EXAMPLES OF FOREIGN AND U.S. BIOMEDICAL SERIALS THAT HAVE BEEN BORN SINCE 1950 OR DIED BETWEEN 1951 AND 1960*

Part I: Examples of Serials Born After 1950 (Foreign)

Jornal de Historia da Medicina
J. of the All-India Institute of Mental Health
Journal of Analytical Psychology (London)
J. of Cardiovascular Surgery
J. of Child Psychology and Psychiatry, and Allied Disciplines
J. of Chromatography
Chromatographic Data (Supplement)
J. of the College of Radiologists of Australasia
J. du Droguiste-Herboriste
J. of the Egyptian Society of Endocrinology and Metabolism
J. of Embryology and Experimental Morphology
J. of Experimental Medical Sciences
J. of Family Welfare
J. of Forensic Medicine
J. of General and Applied Microbiology
J. de Genetique Humaine
J. of Hygiene, Epidemiology, Microbiology, and Immunology
J. of the Indian Medical Profession
J. of the Institute of Science Technology
J. of the L.M. College of Pharmacy
J. of the Maulana Azad Medical College
J. Medical de L'Orleannais
J. of Mental Deficiency Research
J. of the Microbiological Society of Thailand
J. of Microbiology, Epidemiology and Immunobiology
J. of the Ministry of Health
J. of Neurochemistry
J. of Nihon University, School of Dentistry
J. of Obstetrics and Gynaecology of India
J. of the Oslo City Hospitals
J. of the Philippine Federation of Private Medical Practitioners
J. of Postgraduate Medicine
J. of Psychosomatic Research
J. of Radiation Research
J. of Reproduction and Fertility
J. of the Royal College of Surgeons of Edinburgh
J. of Scientific & Industrial Research
J. of Small Animal Practice
Journal of Tropical Pediatrics
J. of Vitaminology
Canada's Mental Health
Canadian Journal of Genetics and Cytology

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* Source: National Library of Medicine. Biomedical Serials, 1950-1960. Washington, D.C., Government Printing Office, 1962.

Part I (continued)

Canadian Journal of Microbiology
Canadian Journal of Surgery
Cardiologie
Catalogue Mensuel des Traductions Effectuees Dans les Services et Centres
Francais de Documentation (Doc)
Central African Journal of Medicine
Centre-Est Medical
Ceskoslovenska Farmacie
Ceskoslovenska Fysiologie
Ceskoslovenska Hygiena
Ceskoslovenska Morfologie
Ceskoslovenska Parasitologie
Chemidropha Wissenschaftliche Hausmitteilung
Chirurgia
Chirurgia Generale
Chirurgia Maxillofacialis & Plastica
Chirurgische Praxis
Chiryo Nenkan, Karento Terapi
Chung Chi i K'an Zhongji Yikan (Medicine for intermediate groups)
Chung Hua Erh Pi Yen Hou K'o Tsa Chih (Otorhinolaryngology)
Chung Hua Fang She Hsueh Tsa Chih (Radiology)
Chung Hua Fu Ch'an K'o Tsa Chih (Obstetrics and Gynecology)
Chung Hua i Hsueh Tsa Chih (Medical journal)
Chung Hua K'ou Ch'iang K'o Tsa Chih (Stomatology)
Chung Hua Nei K'o Tsa Chih (Internal medicine)
Chung Hua P'i Fu K'o Tsa Chih (Dermatology)
Chung Hua Ping Li Hsueh Tsa Chih (Pathology)
Chung Hua Shen Ching Ching Shen K'o Tsa Chih (Neurology and psychiatry)
Chung Hua Wai K'o Tsa Chih (Surgery)
Chung Hua Yen K'o Tsa Chih (Opthalmology)
Chung i Lun T'an (Medical treatises)
Chung i Tsa Chih (Medical journal)
Chung Kuo Hsin i Yao (Modern Chinese medicine)
CIBA Foundation Study Group
Ciencia y el Arte de la Medicina
Cirugia de Cuba
Cirugia Panamericana
Cirugia; Revista de Estudios Quirurgicos
Clinica Chimica Acta
Clinica Ginecologica
Clinica Terapeutica
Cliniche Moderne; Bimestrale di Tecnica Clinico Ospedaliera
Cliniques Radiologiques
Cor et Vasa; International
Corse Medicale
Crianca Surda
Criminologia; Revista de Policia Cientifica

Part I (continued)

Cuadernos de Historia Sanitaria
Culegere de Studii si Monografii de Neurologii
Cultura Medica
Cures
Current Medical Practice
Current Work in the History of Medicine
Cybernetica
Czasopismo Stomatologiczne
Dermatologia Venezolana
Dermato-Venerologie
Deutsche Zeitschrift fur Akupunktur
ACTA Physiologica et Pharmacologica Neerlandica (Bulletin)

Part II: Examples of Serials Born After 1950 (U.S.A.)

Journal of Abdominal Surgery
Journal of the Albert Einstein Medical Center
J. of the American Academy of Gold Foil Operators
J. of the American Association for Social Psychiatry
J. of the American Geriatrics Society
J. of the American Psychoanalytic Association
J. of the American Radiography Technologists
J. of Biochemical and Microbiological Technology and Engineering
J. of Chronic Diseases
J. of Existential Psychiatry
J. of the Florida Academy of General Practice
J. of Health and Human Behavior
J. of the Hillside Hospital
J. of Histochemistry and Cytochemistry
J. of Implant Dentistry
J. of Insect Pathology
J. of Lipid Research
J. of Maryland Optometric Association
J. of the Maryland State Dental Association
J. of Medicinal and Pharmaceutical Chemistry
J. of Molecular Biology
J. of Neuropsychiatry
J. of Nuclear Medicine
J. of Occupational Medicine
J. of Prosthetic Dentistry
J. of Protozoology
J. of the Society for Dental Research of the N.Y. University College of Dentistry
J. of the Western Society of Periodontology
Cancer Cytology
Carney Hospital Journal
Chronic Diseases and Geriatrics Monograph
Circulation Research
Clinical Obstetrics and Gynecology
Clinical Orthopaedics
Clinical Pharmacology and Therapeutics

Part II (continued)

- Clinical Physiology
- Colorado Journal of Pharmacy
- Comparative Biochemistry and Physiology
- Comprehensive Psychiatry
- Current Anthropology
- Current Chemical Papers
- Current Studies on the Nature of Brain Function
- Current Therapeutic Research, Clinical and Experimental
- Cancer
- Cancer Chemotherapy Abstracts
- Current Scientific Literature Review; Cancer Immunology Abstracts
- Current Scientific Literature Review; Gastro-Intestinal Abstracts
- Chemical Titles
- Cholesterol as Related to Atherosclerosis; A Review of the Literature
- CIBA Lectures in Microbial Biochemistry
- Clinical Periodontology Monograph Series
- Cooperative Nutritional Status Studies in the Western Region (Bulletin)
- Copnip List
- Current Contents of Pharmaco-Medical Publications
- Current Literature, Arthritis and Related Diseases
- Current Literature: Congenital Anomalies
- Current References to Medical Literature
- Current Theory and Research in Motivation (Symposium)
- Developments in Industrial Microbiology (Symposium)

Part III: Examples of Serials That Died Between 1951 and 1960 (Foreign)

- J. Brasileiro de Neurologia (Rio de Janeiro)
- Anadolu Klinigi (Istanbul)
- J. de Medicina de Pernambuco (Recife) Portuguese, Spanish & English
- J. Odonotologico (Rio de Janeiro)
- J. All-India Inst. Mental Health
- J. Association of Medical Women in India
- J. Ayurveda
- J. Int'l Cath. Ctr. for Assistance to the Hansenians
- J. Int'l de Chirurgie du Thorax
- J. Int'l Coll. of Surgeons of Thailand
- J. of J.J. Group of Hosp. & Grant Medical College (Bombay)
- J. of Japanese Obstetrical & Gynecological Society
- J. M.P. Homoeopathic Board
- J. Medical Syndicate of Egypt
- J. of Mysore Medical Association
- J. Nair Hospital Dental College
- J. Nat'l Association of Opticians
- J. Scientific Research
- J. Sex Education
- J. Shinshu University

Part III (continued)

J. Stanley Medical College
J. de Therapeutique Francais
J. Univ. of Malaya Dental Soc.
Journees Medicales de la Faculte Francaise de Medecine
Juventud Odontologica
Jornal de estomatologia
Canadian J. of Botany
Canadian J. of Chemistry
Canadian J. of Physics
Canadian J. of Zoology
Cancer Progress (London)
Cancerologie
Casistica Chirurgica
Casopis Ceskoslovenskych Veterinaru
Centrul de Educatie Sanitara
¢ercetari de Ftiziologie
Ceskoslovenska Biologie
Ceskoslovenska Hygiena, Epidemiologie, Mikrobiologie
Ceskoslovenska Nemocnice
Ceskoslovenska Psychologie
Ceylon Health Topics
Chemical & Phar. Bull. (Tokyo)
Chen Chiu Tsa Chih
Acta Anatomica Sinica (Chieh, etc.)
Chieh P'ou Hsueh Wen Chai (Anatomy abstracts)
Chimica e Biochimica.
Chirurgia Suppl.
Chung, etc. (Chinese J. of Tuberculosis)
Chung, etc. (Chinese Medicine)
Ciba-Journalen
Ciencia Medica
Ciencia, etc.
Ciklus, etc.
Clinica
Clinica, Higiene e Hidrologia
Clinica, Latina
Clinica Odonto Protesica
Clinica e Terapia Dei Tumori
Clinica Vargas
Clinical Journal (London)
Colombia Odontologica
Cuadernos de Historia Sanitaria
Corso di Aggiornamento per Medici Pratici
Cuaderno Cientifico
Cuadernos de Educacion Fundamental
Cuadernos de Psicoterapia Cultural

Part IV: Examples of Serials That Died Between 1951 and 1960 (U.S.A.)

J. Amer. Osteopathic Soc. of Proctology

Part IV (continued)

J. Child Psychiatry
J. Creighton U. Sch. of Medicine
J. Experimental Analysis of Behavior
J. Family Relations
J. Federation of Chiropractors
J. Florida State Dental Soc.
J. General Physiology
J. Hypnosis & Psychology in Dentistry
J. Micro-Dynameter Research
J. Nat'l Medical Soc., Washington, D.C.
J. Neuropathology and Clinical Neurology
J. Philadelphia Gen. Hosp.
J. Phil. Psychiatric Hosp.
J. Psychotherapy as a Religious Process
J. Small Animal Medicine
J. Social Hygiene
A. Jrnl. of Individual Psychology (Amer.)
Amer. Ind. Hygiene Assn.Qtrly
Amer. J. Roentgenology & Radium Therapy
Amer. J. Syphilis, Gonorrhea & Veneral Diseases
Amer. Medicine
Amer. Naturopath
Apothecary
Artificial Limbs
Cancer Control in Pub. Health; papers presented at annual meeting of Public Health Cancer Assn. of America, N. Y. (1944?)
Cancer Morbidity Series
Cancer Research - Supplement, Chicago
Child Study
Chronicle of Occupational Briefs
Core
Cornell Med. J.
Cosmetic Surgery
Crippled Child
Current Medicine
Current Medicine for Attorneys
Current Research and Development in Scientific Documentation

APPENDIX V-B

THICKNESS OF A YEAR'S PUBLICATION OF VARIOUS BIOMEDICAL JOURNALS, cm.

Journal	1941	1946	1951	1956	1961
Acta Chirurgica Scandinavica	3.2	2.8	2.6	3.2	2.8
Acta Obstetrica et Gynecologica Scandinavica	2.7	4.0	4.1	4.1	5.1
Acta Ophthalmologica, Supplementum	1.5	2.0	.4	.1	2.7
Acta Oto-Laryngologica	2.8	4.0	2.6	2.6	3.3
Acta Paediatrica, Supplementum	7.2	6.0	2.4	2.0	3.0
Acta Physiologica Scandinavica	2.1	2.0	3.7	3.5	3.8
Acta Radiologica, Supplementum	2.5	3.0	.8	3.6	4.1
Aerospace Medicine	1.4	1.6	2.1	2.0	5.0
American Chemical Society Journal	8.0	8.5	13.1	20.8	17.6
American Dietetic Association Journal	5.4	5.7	4.7	5.1	5.1
American Journal of Anatomy	5.3	4.8	5.6	5.4	1.9
American Journal of Diseases of Children	11.8	6.8	6.5	5.7	8.0
American Journal of Medical Technology	1.9	4.2	1.7	2.3	1.9
American Journal of Ophthalmology	6.5	6.0	8.0	9.7	10.2
American Journal of Physical Medicine	3.0	2.5	3.4	2.7	1.8
American Journal of Public Health and the Nation's Health	5.0	8.7	6.8	7.0	7.8
American Journal of the Medical Sciences	6.6	5.6	5.4	5.4	6.1
American Medical Association Journal	26.0	26.9	22.9	21.2	18.7
American Surgeon	4.5	4.7	5.1	6.0	3.8
Anatomical Record	10.4	9.8	11.0	10.5	6.6
Anesthesiology	3.5	3.0	3.7	3.8	4.6
Annales de Dermatologie et de Syphiligraphie	3.5	3.9	5.3	5.2	4.2
Annals of Biochemistry and Experimental Medicine	1.4	.5	1.2	1.0	2.2
Annals of Otology, Rhinology and Laryngology	6.0	4.4	5.8	5.2	5.5
Annals of Tropical Medicine and Parasitology	2.0	3.3	2.4	2.4	2.4
Archiv fuer Hygiene und Bakteriologie	1.5	1.7	3.3	3.4	3.4
Archiv fuer Kreislaufforschung	3.7	1.9	1.6	2.0	2.6
Archives d'Anatomie, d'Histologie et d'Embryologie	1.5	2.0	1.3	1.0	2.5

Journal	1941	1946	1951	1956	1961
Archives des Maladies du Coeur et des Vaisseaux	1.0	3.0	6.5	6.3	7.4
Archives of Diseases in Childhood	1.7	1.6	4.3	3.1	3.6
Archives of Otolaryngology	5.0	7.1	6.5	4.8	5.8
Archives of Physical Medicine and Rehabilitation	3.3	2.5	2.5	2.5	3.7
Archivo Italiano di Anatomia e di Embriologia	4.0	1.0	2.1	2.0	2.2
Australian Journal of Experimental Biology and Medical Science	1.5	2.5	3.6	3.7	5.3
Beitraege zur Klinik der Tuberkulose und Spezifischen Tuberkulose-Forschung	3.8	3.7	3.1	3.6	2.4
Bibliotheca Opthalmologica	.5	.7	1.7	3.7	1.6
Biological Bulletin	5.7	6.0	3.8	3.8	4.5
Brain	2.6	2.0	2.6	3.8	4.3
British Journal of Dermatology	2.0	3.1	2.7	2.4	2.5
British Journal of Ophthalmology	3.2	4.0	3.1	3.4	3.3
British Journal of Urology	1.5	1.5	2.2	2.5	2.7
Brun's Beitraege zur Klinischen Chirurgie	4.9	4.1	4.6	4.4	4.6
California Medicine	5.4	6.9	3.4	3.8	3.4
Canadian Medical Association Journal	6.2	6.5	4.9	7.4	12.3
Cellule	2.1	1.9	2.1	2.0	2.4
Chromosoma	1.3	1.5	1.4	1.0	3.1
Dermatologica	4.1	2.5	4.2	5.4	5.1
Deutsche Gesellschaft fuer Innere Medizin Berhandlungen	2.8	1.8	2.3	3.0	4.2
Deutsche Zeitschrift fuer Nervenheilkunde	2.8	2.0	2.6	2.4	4.2
Diseases of the Nervous System	2.4	1.5	1.4	1.6	2.2
Endokrinologie	3.8	2.0	2.1	2.3	3.0
Folia Haematologica, Leipzig	2.0	1.5	2.4	2.9	2.0
Gastroenterologica	1.7	2.6	2.9	6.0	4.8
Growth	3.4	2.5	1.4	1.5	2.0
Hawaii Medical Journal	2.1	2.4	2.0	2.7	2.4
Helvetica Medica Acta	3.9	3.3	3.1	3.1	3.6
Human Biology	4.8	1.5	2.7	3.0	3.0
Indiana State Medical Association Journal	3.0	6.6	5.4	9.3	6.8
International College of Surgeons Journal	2.2	3.1	10.2	11.3	12.1
Iowa State Medical Society Journal	2.7	4.6	2.3	3.2	4.0
Journal de Physiologie	.7	.5	4.1	5.0	5.4
Journal of Anatomy	3.7	1.7	3.2	4.0	4.4

Journal	1941	1946	1951	1956	1961
Journal of Biological Chemistry	20.5	16.3	25.4	31.3	17.6
Journal of Cellular and Comparative Physiology	2.0	4.6	7.3	7.1	4.0
Journal of Comparative Neurology	6.0	5.5	5.3	8.8	4.4
Journal of Food Science	3.4	2.5	2.8	3.6	3.0
Journal of Immunology	8.4	7.2	8.7	6.4	8.4
Journal of Laboratory and Clinical Medicine	8.5	7.0	9.0	8.6	10.3
Journal of Mental Science	2.1	4.7	4.3	4.2	4.7
Journal of Neurology, Neurosurgery, and Psychiatry	1.3	2.0	2.0	1.7	2.0
Journal of Obstetrics and Gynaecology of the British Commonwealth	4.6	4.8	7.0	6.4	6.6
Journal of Pediatrics	7.4	9.4	6.9	6.6	8.2
Journal of Thoracic and Cardiovascular Surgery	3.7	2.0	5.8	6.9	7.4
Klinische Monatsblaetter fuer Augenheilkunde	2.3	5.9	6.9	7.8	7.5
Langenbeck's Archiv fuer Klinische Chirurgie	3.0	2.0	10.4	4.3	9.8
Los Angeles Neurological Society Bulletin	1.3	1.0	2.0	1.2	1.4
Mayo Clinic, Bulletin	4.1	2.8	2.5	3.0	3.5
Medical Economics	7.9	7.5	7.5	6.8	7.9
Medical Library Association, Bulletin	3.6	2.0	2.3	3.1	3.6
Medicine (Baltimore)	3.0	3.0	3.1	3.0	3.0
Michigan State Medical Society Journal	3.9	6.4	5.2	6.5	4.6
Modern Concepts of Cardiovascular Disease	.5	.5	.6	.4	.5
Monatsschrift fuer Ohrenheilkunde und Laryngo-Rhinologie	2.6	2.8	1.4	1.7	3.0
Naunyn-Schmiedeberg's Archiv fuer Experimentale Pathologie und Pharmakologie	8.5	6.4	4.1	6.1	5.8
New England Journal of Medicine	11.3	11.3	9.2	10.6	10.8
New York State Journal of Medicine	5.0	5.0	14.1	12.8	12.0
Northwestern University School of Medicine Quarterly Bulletin	3.0	2.1	2.0	2.1	2.0
Ophthalmological Society of the United Kingdom Transactions	2.1	3.4	4.7	4.9	4.5
Parasitology	2.8	1.3	2.0	2.7	3.0

Journal	1941	1946	1951	1956	1961
Physiological Reviews	3.7	2.8	2.3	3.6	3.1
Psychiatria et Neurologia	1.4	1.8	4.3	4.3	5.2
Psychoanalysis and the Psychoanalytic Review	4.3	4.1	2.6	4.2	4.6
Quarterly Journal of Microscopical Science	2.0	2.6	2.8	3.8	3.6
Radiography	.9	1.4	1.4	2.3	3.5
Revue de Chirurgie Orthopedique et Reparatrice de l'Appareil Moteur	1.6	1.9	3.3	5.0	3.8
Rio de Janeiro Instituto Oswaldo Cruz, Memorias	4.5	4.6	4.0	3.8	2.5
Royal Society of Medicine (London), Proceedings	6.3	6.0	4.7	5.2	4.8
Scwheizer Archiv fuer Neurologie, Neurochirurgie und Psychiatrie	4.1	2.3	4.2	4.4	4.4
Societe de Biologie, Comptes Rendus Hebdomadaires des Seances et Memoires	8.3	7.5	8.8	10.1	11.2
South Carolina Medical Association Journal	2.9	3.4	2.3	2.3	2.1
Strahlentherapie	3.5	3.3	7.1	5.8	9.1
Surgical Clinics of North America	8.7	7.3	8.4	7.5	7.8
Virchows Archiv fuer Pathologische Anatomie und Physiologie und fuer Klinische Medizin	4.1	3.0	3.9	4.3	2.6
Western Journal of Surgery, Obstetrics and Gynecology	4.2	2.8	3.7	3.8	2.1
Wisconsin Medical Journal	4.4	6.2	5.4	5.6	3.1
Zeitschrift fuer die Gesamte Experimentelle Medizin	3.1	3.2	4.8	4.9	2.6
Zeitschrift fuer Immunitaetsforschung und Experimentalle Therapie	3.5	3.0	2.8	1.5	4.6
Zeitschrift fuer Kreislaufforschung	4.0	3.1	4.5	4.6	6.5
Zeitschrift fuer Orthopaedie und Ihre Grenzgebiete	2.1	2.6	5.2	4.5	6.0
Zeitschrift fuer Zellforschung und Mikroskopische Anatomie	2.3	2.3	2.4	6.1	11.3
Totals	432.0	444.6	502.2	527.5	555.0

APPENDIX V-C

PUBLICATIONS MOST OFTEN REFERRED TO IN THE NIH GRANTS INDEX FOR FISCAL YEAR 1962 AND IN THE NIH STAFF BIBLIOGRAPHY FOR 1961

The following is a composite list of the 100 publications most often referred to in the NIH Research Grants Index for fiscal year 1962 and the 111 publications (including ties) most often referred to in the NIH staff bibliography for 1961. The publications are ranked in order of reference frequency (1, most frequent; 2, next; etc.). Most of the publications are indexed by Index Medicus; those not listed in the January 1963 issue are indicated by an asterisk (*).

Publication	Rank (by frequency of reference) Grants Index	Rank (by frequency of reference) Staff Bibliography	Number of References Grants Index	Number of References Staff Bibliography
Federation Proceedings	1	43	1064	7
Proceedings of the Society for Experimental Biology and Medicine	2	5	475	40
Journal of Biological Chemistry	3	1	429	62
Biochimica et Biophysica Acta	4	2	399	46
Nature	5	3	387	43
American Journal of Physiology	6	9	296	26
Journal of Clinical Investigation	7	6	241	34
Clinical Research*	8	--	187	--
Endocrinology	9	38	182	8
Biochemical and Biophysical Research Communications	10	11	178	25
Science	10	12	178	23
Circulation: Journal of the American Heart Association	12	24	177	12
Journal of Organic Chemistry*	13	7	167	29
Anatomical Record	14	--	165	--
Archives of Biochemistry and Biophysics	15	15	164	19
Proceedings of the National Academy of Sciences (USA)	16	43	153	7
Circulation Research	17	22	135	13
Journal of Laboratory and Clinical Medicine	17	28	135	10

Publication	Rank (by frequency of reference)		Number of References	
	Grants Index	Staff Bibliography	Grants Index	Staff Bibliography
Journal of the American Medical Association	19	24	134	12
Bacteriological Proceedings*	20	--	131	--
Journal of Experimental Medicine	21	24	122	12
Virology	22	22	117	13
New England Journal of Medicine	23	28	113	10
Surgical Forum	24	56	112	5
Journal of Bacteriology	25	38	108	8
Journal of Pharmacology and Experimental Therapeutics	25	15	108	19
Biochemical Journal	27	--	106	--
Journal of Clinical Endocrinology and Metabolism	28	90	98	3
Journal of Immunology	29	28	97	10
Cancer Research	30	13	96	22
Physiologist	31	--	95	--
American Journal of Cardiology	32	--	92	--
American Zoologist*	32	--	92	--
Blood	34	38	87	8
Surgery	35	73	85	4
Journal of Biophysical and Biochemical Cytology	36	--	83	--
Annals of the New York Academy of Sciences	37	28	80	10
Journal of Parasitology	38	35	79	9
Journal of Cell Biology	39	--	78	--
Gastroenterology	40	--	77	--
Biochemical Pharmacology	41	35	76	9
Biochemistry	42	--	75	--
Excerpta Medica	42	--	75	--
Annals of Surgery	44	90	73	3
American Journal of Diseases of Children	45	--	72	--
Experimental Cell Research	45	--	72	--
American Heart Journal	47	56	70	5
American Journal of Pathology	48	90	69	3
Laboratory Investigation	48	--	69	--
Journal of Nutrition	50	73	67	4

Publication	Rank (by frequency of reference) Grants Index	Rank (by frequency of reference) Staff Bibliography	Number of References Grants Index	Number of References Staff Bibliography
Journal of the National Cancer Institute	50	4	67	41
Lancet	50	56	67	5
Journal of Investigative Dermatology	53	56	63	5
Metabolism	53	56	63	5
American Journal of Medicine	55	50	62	6
Journal of Thoracic and Cardiovascular Surgery	55	--	62	--
Pediatrics	55	--	62	--
Archives of Pathology	58	73	61	4
Archives of Internal Medicine	59	--	59	--
Cancer Chemotherapy Reports	60	9	58	26
Journal of Comparative and Physiological Psychology	61	--	57	--
Journal of Histochemistry and Cytochemistry	62	20	56	14
Journal of Dental Research	63	24	55	12
Surgery, Gynecology, and Obstetrics	64	73	54	4
Proceedings of the American Society for Cancer Research*	65	--	53	--
Journal of Pediatrics	66	--	52	--
Annals of Internal Medicine	67	43	51	7
Journal of Molecular Biology	67	--	51	--
Arthritis and Rheumatism	69	73	49	4
Genetics	69	--	49	--
Biological Bulletin*	71	--	46	--
Journal of Cellular and Comparative Physiology	71	50	46	6
American Journal of Veterinary Research	73	--	45	--
Journal of General Physiology	73	73	45	4
Radiation Research	73	--	45	--
American Journal of Clinical Nutrition	76	56	44	5
Archives of Surgery	76	--	44	--
Journal of Lipid Research	76	50	44	6
American Journal of Ophthalmology	79	--	43	--
Analytical Biochemistry	79	28	43	10

Publication	Rank (by frequency of reference)		Number of References	
	Grants Index	Staff Bibliography	Grants Index	Staff Bibliography
Proceedings of the 5th International Congress in Biochemistry*	79	--	43	--
American Journal of Obstetrics and Gynecology	82	--	42	--
Pharmacologist*	83	--	41	--
American Review of Respiratory Diseases	84	28	40	10
Archives of Neurology	85	56	39	5
General and Comparative Endocrinology	86	--	37	--
Psychological Reports*	86	73	37	4
Analytical Chemistry*	88	50	36	6
Journal of Physiology	88	56	36	5
Experimental Neurology	90	18	35	17
Investigative Ophthalmology	90	--	35	--
American Journal of Surgery	92	--	33	--
Cancer	92	20	33	14
Perceptual and Motor Skills	92	--	33	--
Acta Endocrinologica	95	--	32	--
Electroencephalography and Clinical Neurophysiology	95	50	32	6
Journal of Neurophysiology	95	38	32	8
Journal of Protozoology	95	--	32	--
Journal of Surgical Research	95	--	32	--
Experientia (Basel)	100	73	31	4
Journal of the American Chemical Society*	--	8	--	28
American Journal of Hygiene	--	14	--	20
American Journal of Tropical Medicine and Hygiene	--	17	--	18
Public Health Reports	--	19	--	15
Archives of General Psychiatry	--	28	--	10
Archives of Ophthalmology	--	35	--	9
Journal of Abnormal and Social Psychology	--	38	--	8
Biochemical Preparations*	--	43	--	7
Enzymes*	--	43	--	7
Journal of Applied Physiology	--	43	--	7
Journal of Infectious Diseases	--	43	--	7
American Journal of Public Health	--	50	--	6

Publication	Rank (by frequency of reference) Grants Index	Rank (by frequency of reference) Staff Bibliography	Number of References Grants Index	Number of References Staff Bibliography
American Journal of Clinical Pathology	--	56	--	5
American Journal of Hospital Pharmacy*	--	56	--	5
American Journal of Nursing	--	56	--	5
Bacteriological Review	--	56	--	5
Biophysical Journal	--	56	--	5
Experimental Parasitology	--	56	--	5
Journal of Chronic Diseases	--	56	--	5
Journal of General Microbiology	--	56	--	5
Oral Surgery, Oral Medicine and Oral Pathology	--	56	--	5
Anesthesiology	--	73	--	4
Atti del X Congresso della Lega Internazionale Contro il Rheumatism*	--	73	--	4
Epilepsia	--	73	--	4
Journal of Consulting Psychology	--	73	--	4
Journal of Gerontology	--	73	--	4
Journal of Psychiatric Research	--	73	--	4
Medical Clinics of North America	--	73	--	4
Neurology	--	73	--	4
Pathologie et Biologie	--	73	--	4
Acta; Unio Internationalis contra Cancrum	--	90	--	3
American Journal of Human Genetics	--	90	--	3
Annual Review of Medicine	--	90	--	3
Annual Review of Pharmacology*	--	90	--	3
Antimicrobial Agents Annual	--	90	--	3
Archives of Oral Biology	--	90	--	3
Child Development	--	90	--	3
Clinical Pharmacology and Therapeutics	--	90	--	3
Gerontologist*	--	90	--	3
Hospitals	--	90	--	3
International Bulletin of Bacteriological Nomenclature and Taxonomy*	--	90	--	3

Publication	Rank (by frequency of reference)		Number of References	
	Grants Index	Staff Bibliography	Grants Index	Staff Bibliography
Journal of Neurochemistry	--	90	--	3
Journal of Neuropathology and Experimental Neurology	--	90	--	3
Journal of Periodontology*	--	90	--	3
Mental Hygiene	--	90	--	3
Radiology	--	90	--	3
Stain Technology	--	90	--	3
Transactions of the New York Academy of Sciences	--	90	--	3
Transfusion	--	90	--	3

June 11, 1963
(Revised November, 1963)

NAS-NRC Study of Communication Problems in Biomedical Research

Staff Paper No. VI

SECONDARY DISTRIBUTION OF BIOMEDICAL DOCUMENTS*

INTRODUCTION

The term "information retrieval" is currently used loosely to apply to any service or device for performing one or more of the following functions: (1) finding references to documents that may contain the information desired by the user; (2) supplying documents for which references are known; and (3) providing the specific information required to answer a given question. In the literal sense, only the last function constitutes true information retrieval. The first function is better called reference retrieval, and the second should be referred to as document retrieval, or secondary distribution of documents, to distinguish it from primary distribution, such as a publisher provides by automatic distribution to journal subscribers.

Although, to the scientist-user, reference retrieval is useful only as a preliminary to document retrieval, the fact that these two functions must be closely coupled is often ignored in proposed "solutions" to the information problems of scientists. A machine or "system" that supplies the scientist with a list of references within minutes represents little in the way of a practical advance if the documents referred to cannot be obtained with ease and speed. Despite the obvious interdependence of these two functions, current attention is focussed largely on ways to provide new and improved reference retrieval services, and improvements in document retrieval services are either ignored or assumed unnecessary.

The general aims of this working paper are to explore the question of how improved reference-retrieval services will increase and change demands for delivery of documents, and to examine the adequacy of present means for meeting these demands. We assume that within two years certain plans for major improvements in reference services for biomedical scientists will be realized and that these services will be utilized. In particular, we postulate full operation of the MEDLARS program (1) of the National Library of Medicine (NLM).

APPROACH

The specific objectives of this facet of the over-all study were:

(1) to analyze the institutionalized and personal sources on which the biomedical scientist calls to obtain a document, once he has a reference to it;

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*Not for publication or publication reference.

(2) to assess the relative importance of these sources;
(3) to describe the major institutionalized sources (medical libraries) as a national "system" for the secondary distribution of documents, i.e., for delivering documents on demand;
(4) to determine past trends in demands for document delivery and to estimate the capacity of the present medical library system;
(5) to predict the probable quantitative and qualitative changes in the demands for document delivery that will result from new reference retrieval services; and
(6) to compare the capacity of the present system with the probable demands in 1965.

Previous studies were reviewed; however, few were helpful in developing this approach. Some biomedical libraries publish annual reports, and these were useful when they provided data on the number of documents borrowed from, or loaned to, other libraries. To supplement the meager data available, we conducted a modest survey, which is described in the addendum to this paper.

RESULTS AND DISCUSSION

Scientists' Sources of Documents

Faced with a need for a document that he has identified, for example, through a reference in an article, a scientist has six possible sources from which to choose: he can

(1) sometimes find it in his personal collection of reprints, journals, and books;
(2) ask a colleague who may have it, or he can write to the author for a reprint;
(3) request a copy from the organization or company that published the document, or from various types of special services, for example, book dealers, the Office of Technical Services of the Department of Commerce (for technical reports of research supported by government contract), or the Excerpta Medica Foundation and the Institute for Scientific Information (for articles listed by their respective reference services, Excerpta Medica and Current Contents);
(4) turn to the library in his "working unit" (his department or laboratory) if it has one;
(5) call on the resources of the main libraries of his institution; or
(6) utilize a local library outside his institution.

The first two possibilities are personal or informal sources. The last four represent services set up expressly to deliver documents on demand and may be considered institutionalized or formal sources.

A scientist's strategy for deciding on the order in which he tries the different sources depends on many variables, including the nature and age of the document, the relative effort involved, the cost, the urgency of his need, his knowledge of the resources of a given source, and his experience in using particular sources.

Relative Importance of Sources

Very little objective evidence is available that bears directly on the relative quantitative importance of various sources, i.e., the percentages of a biomedical scientist's needs for specific documents that are filled by the difference sources. The relevant literature consists largely of more-or-less educated guesses. About all that can be said with certainty is that local services -- his "working unit" library and the other libraries of his institution -- are the major sources to which he turns for needs not satisfied by his informal sources.

Description of the National Biomedical Library System

These local services are part of a functional national system of biomedical libraries that can be considered as having two levels: a "national level" and a "local level." All biomedical libraries whose primary function is to serve local or regional communities are considered local-level components of the system, whereas NLM, whose primary mission is to serve the entire nation, is the sole national-level component. At the national level the flow of documents is one-way (from NLM to local-level libraries); some representative figures for such loans are given in Table VI-1. At the local level a given library may send documents to, and receive them from, any other local library. This is a simplification of the system's operation, but it is useful for the present type of analysis.

The research worker interacts directly only with the local level of the system. The services of NLM are available to him only through local-level libraries. It does not matter to him whether his request is met from his own institutional library or by loan from the libraries of other institutions or from NLM. His only concern is that his needs be met appropriately and quickly.

Table VI-2 shows the total resources of the biomedical library system in terms of numbers and types of libraries and document collections. One-fourth of the local-level libraries are in academic institutions. These academic libraries account for one-half of all the volumes in biomedical collections. The geographical distribution of biomedical libraries is given in Appendix VI-A.

TABLE VI-1

LOANS
BY
THE NATIONAL LIBRARY OF MEDICINE

Type of Borrowing Libraries	Number of Documents Loaned by NLM in 1959
Federal	17,249
Hospital	15,456
Medical School	8,284
Industrial and Foundation	7,708
Academic (excluding medical schools)	2,521
Professional	2,119
Public	1,465

Source: For volume of NLM loans in 1959 -- William H. Kurth. Survey of the Interlibrary Loan Operation of the National Library of Medicine. U.S. Public Health Service. April 1962. Insofar as possible, the data from this source were adapted to the classification of biomedical libraries used in Table VI-2.

TABLE VI-2

THE RESOURCES OF THE NATIONAL BIOMEDICAL LIBRARY SYSTEM

Type of Institution	(1) No. Libraries	(2) % of Total Libraries	(3) No. Volumes Held	(4) % of Total Volumes	(5) Average No. Vol./Library
Academic*	143	26.7	6,129,400	50.1	43,000
Federal (other than hospitals)	39**	7.3	2,012,900**	16.4	26,000†
Professional††	53	9.9	1,855,300	15.2	35,000
Hospital#	241	45.0	1,558,100	12.7	6,500
Industrial	44	8.2	414,900	3.4	9,400
Public##	7	1.3	197,600	1.6	28,000
Foundation	8	1.5	71,400	0.6	8,900
Total	535		12,239,600		

Sources for columns 1 and 3: L. Ash. Subject Collections. New York, Bowker, 1961, 2nd ed. and Medical Library Association. Directory. 1959.

Note: Only libraries listed in these two sources were included, the assumption being that a library not listed was either not sufficiently organized to provide "professional" service, or too restricted in its use to be considered as part of the biomedical library system.

* Certain types of university libraries, e.g., biology and biochemistry department libraries, although classifiable as biomedical, were excluded because consistent or complete information was not obtainable. Department libraries that are identifiable as medical, dental, or pharmaceutical are, however, included.

** Includes the National Library of Medicine, whose holdings approached 1,000,000 volumes in 1961

† Excluding NLM

†† Operated presently by a professional society or originally established to serve the medical profession

Private and governmental, including federal hospitals such as those of the Veterans Administration

Libraries whose funds are derived from local taxes or which have defined their function as serving the general public

TABLE VI-3

INTERLIBRARY TRANSACTIONS OF WAYNE STATE UNIVERSITY COLLEGE OF MEDICINE LIBRARY (JUNE 1962 - MAY 1963)

Types of Libraries	Libraries Lending to Wayne State		Libraries Borrowing from Wayne State	
	No. of Libraries	No. of Documents	No. of Libraries	No. of Documents
NLM	1	67	--	--
Hospital	3	38	29	4,030
Academic	9	35	16	36
Public	1	18	3	3
Professional	1	4	1	2
Industrial	1	4	20	470
Federal	2	3	--	--
Governmental	--	--	2	153
Foundation	--	--	1	15

Note: Libraries are classified here in the same general way as Table VI-2, except for the category "governmental" among borrowing libraries, in which nonhospital municipal, as well as Federal, establishments are included.

How the system handles a request and delivers a document can be illustrated by a series of schematics. Figure VI-1 is a flow chart that illustrates in selected detail the large number of operations that a scientist's request for a document may initiate. It emphasizes the intra- and interlibrary operations entailed when his request cannot be filled by his local library (the "borrowing library"), and another local-level library or NLM (the "lending library") is asked to provide the document either as an "original" or as a photocopy. Of course, his local library can obtain certain types of documents from publishers; but borrowing from another library is much more common. The interlibrary loan transaction is summarized in Figure VI-2. The transaction is much the same whether an original document or a photocopy is obtained, except that the former must be returned, and securing the latter may require processing an invoice for charges to cover the "lending" library's photocopying costs. Table VI-3 shows the relations of one academic library (Wayne State University College of Medicine Library) with other local-level libraries and with NLM. In one year, this library borrowed 102 documents from 17 other local-level libraries, largely in the Mid-West, and 67 documents from NLM. The total number of documents borrowed (169) is small compared with the total number it loaned to 72 other local-level libraries (4,709). (See Appendix VI-B for a list of all the libraries with which it dealt and for the volume of these transactions.)

As would be expected, the libraries with larger collections, in general, borrow relatively little and are primarily lenders, whereas the opposite is true of the libraries with smaller collections. The data for Wayne State University illustrate this phenomenon, which is important for understanding the problems of the system; the number of documents Wayne State loaned to each of six smaller libraries exceeded the total of its own borrowing.

Volume of Interlibrary Document Flow in the System

Table VI-4 gives the total number of documents loaned by six local-level libraries that reported this statistic for the years 1958-1961, and cites the corresponding figures for NLM. If one knew either the number of documents loaned or the number borrowed by each of the 534 local-level biomedical libraries in the U.S., it would be possible to determine the total flow of documents among all local-level libraries (the total interlibrary flow minus NLM loans, which are known). Such figures are not presently available; however, on the basis of Table VI-4, it can be seen that the total flow at the local level of the system must be greater than that at the national level. In 1961, the College of Physicians of Philadelphia Library alone made more than one-seventh as many loans (16,035) as NLM (109,258).

The total local-level flow can be roughly estimated from the number of NLM loans* if a ratio of national to local-level flow is assumed. From the little evidence presently available, a ratio of

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*The published information on NLM loans (7) does not identify individual libraries, but the categorical breakdown indicates that at least 75 percent of its loans in 1959 were to U.S. biomedical libraries.

Fig. VI-1. SIMPLIFIED FLOW CHART OF INTRA- AND INTERLIBRARY OPERATIONS REQUIRED TO DELIVER DOCUMENTS

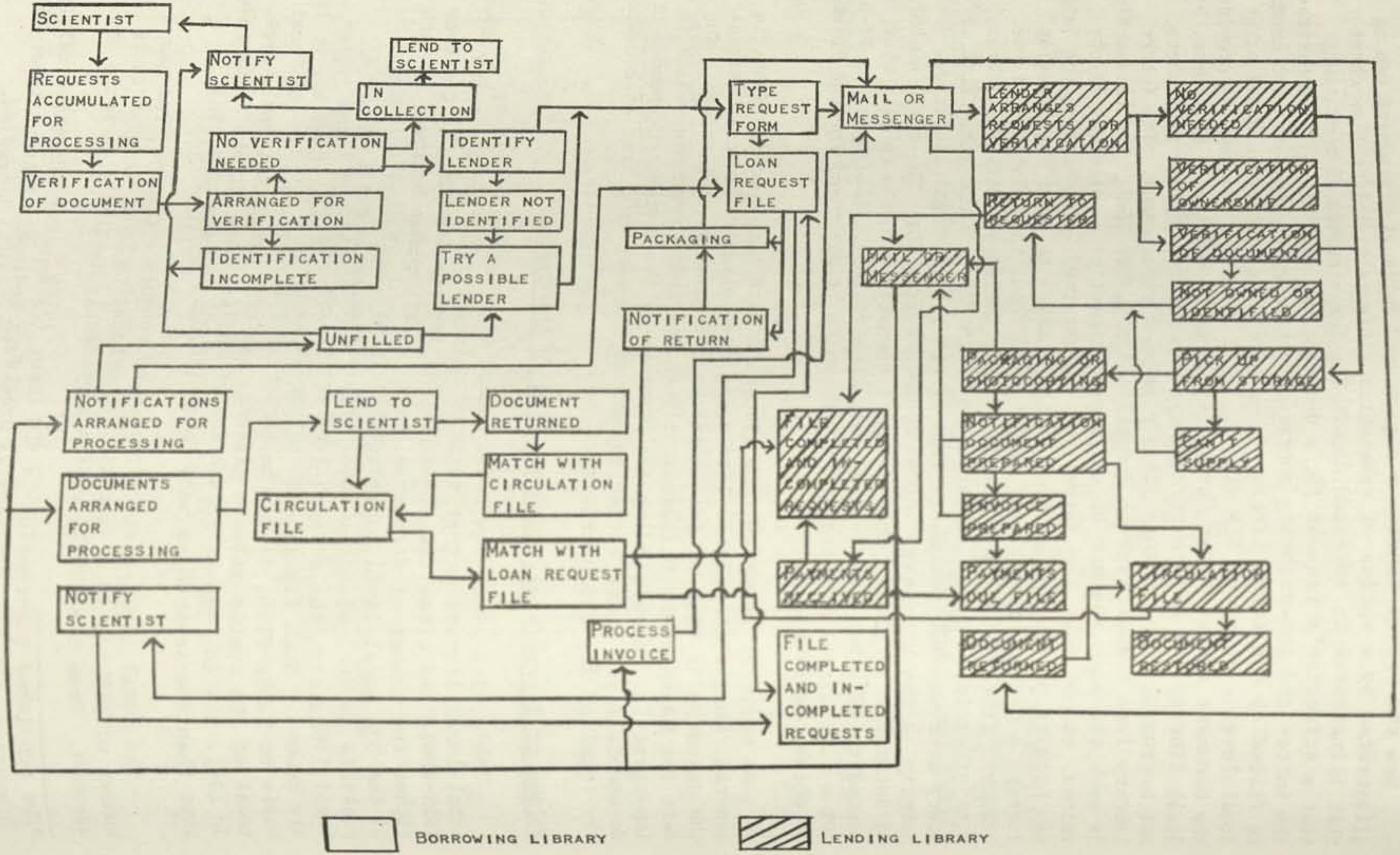
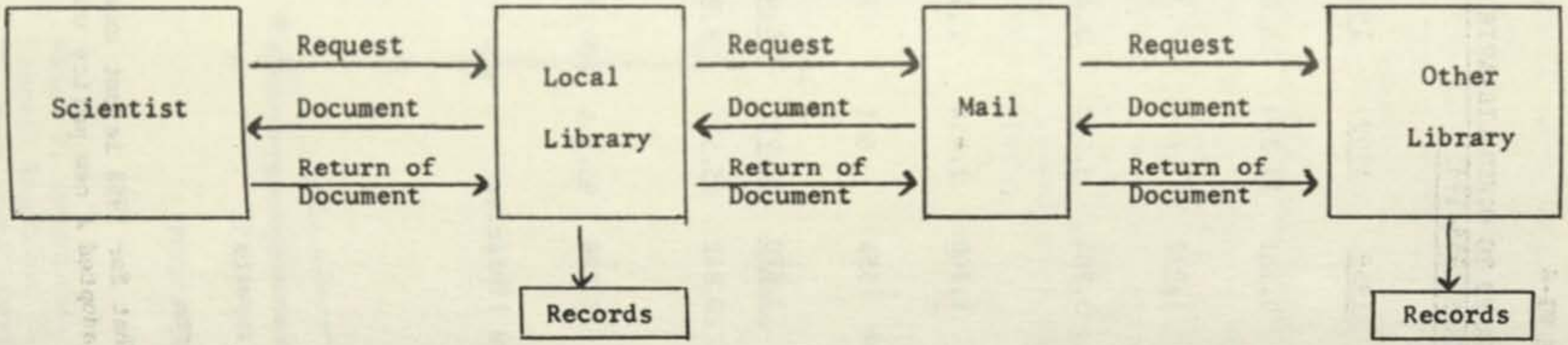


Fig. VI-2. The Interlibrary "Loan" Transaction

Borrowing Original Documents



Securing Photocopies

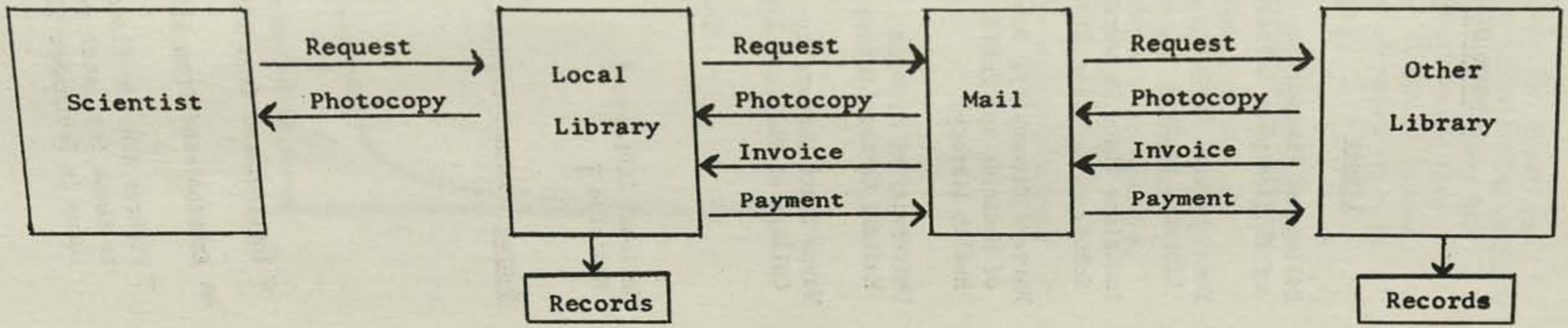


TABLE VI-4

NUMBER OF DOCUMENTS LOANED TO OTHER LIBRARIES DURING THE YEARS 1958-1961

Lender	1958	1959	1960	1961	1958-1961 Increase,%
College of Physicians of Philadelphia Library	6,926	9,161	13,359	16,035	132
Texas Medical Center Library, Houston	1,683	1,973	1,746	2,374*	40
Louisiana State University, School of Medicine Library	2,987	3,584	3,520	3,442	15
Harvard University, School of Medicine and Public Health Library	1,881	1,700	2,454	1,903	1
University of Alabama Medical Center Library	490**	554	601	724	48
Wayne State University College of Medicine Library	3,247	3,870	3,912	4,412	36
Total	17,214	20,842	25,592	28,890	68
National Library of Medicine †	59,946	72,728	95,595	109,258	82

Source: Annual reports of the given libraries

* Interpolated from 1960 and 1962 reports

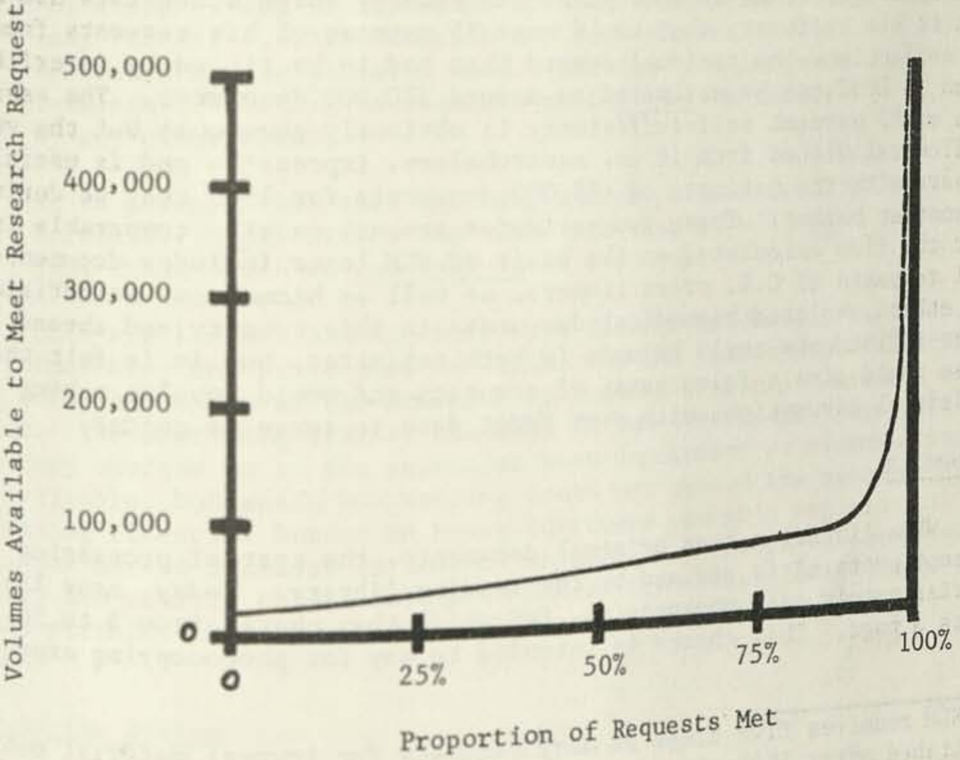
** Extrapolated from 1959-1961 reports

† Figures are for fiscal years. That for 1958 is not exactly comparable to those for later years as NLM adopted a new policy on interlibrary loans in September 1957.

one loan from NLM to every three by local-level libraries seems conservative. At this ratio, the calculated total local-level flow would be about 290,000 documents for 1960 and 330,000 for 1962 [when NLM loans exceeded 110,000 (3)] , making the total interlibrary flow 380,000 and 440,000 for these years, respectively. A modest survey of libraries that borrowed from NLM was an attempt to establish this ratio, and is reported in the Addendum to this paper.

Relation of Total Demands on Libraries to Interlibrary Loan Traffic

The total interlibrary flow of documents represents only the residual demand that could not be filled by the collections of local-level libraries. Very few of these libraries have any data on the proportion of document requests they meet from their own collections. This proportion may be called the "self-sufficiency" quotient. Esterquest (4) has proposed the following curve for the relation between the size of a biomedical collection and its self-sufficiency in serving research workers.



Source: Ralph T. Esterquest. Strengthening Medical Library Resources in New York State. The New York State Library, Albany, 1963.

There are few data to test this curve, especially through its critical mid-portion, where most biomedical libraries lie (95 percent of biomedical libraries have fewer than 100,000 volumes). In addition, factors other than mere numbers of volumes must also determine a library's self-sufficiency, e.g., other characteristics of the collection (the relative emphasis on journals vs. books, the proportion of old material to new, etc.) and the nature of the scientific population served. It seems unlikely that the proposed curve is valid for other than university libraries or even within this category of libraries, for collections that have been established fairly recently and have concentrated on building a file of the last 10 years' issues of the most frequently used biomedical journals. Such collections would undoubtedly meet a much higher proportion of requests than those of equal size but containing more relatively old monographs, text books, and journal material.*

In the absence of data on how many documents biomedical scientists request of libraries, an extrapolation may be attempted from the experience of a single academic community. Quatman found that the average faculty member requested 134 items per year** from Purdue's libraries (5). If one assumes that the average biomedical research scientist uses a library as much as the average faculty member at Purdue, the 40,000 U.S. biomedical scientists estimated for 1960 (6) requested 5,360,000 documents from their libraries in that year. If each of these scientists had available to him a library that could meet 95 percent of his requests from its own collection, the residual demand that had to be filled by interlibrary loans in 1960 can be estimated as around 270,000 documents. The assumption of 95 percent self-sufficiency is obviously generous; but the volume of flow calculated from it is, nevertheless, impressive and is useful to compare with the estimate of 490,000 documents for 1960 that we derived in another manner. These two estimates are not exactly comparable in that the flow calculated on the basis of NLM loans includes documents to fill requests of U.S. practitioners, as well as biomedical scientists and others who need biomedical documents in this country and abroad. Minor refinements could be made in both estimates, but it is felt that these would give a false sense of accuracy and would involve making additional assumptions with even fewer data to serve as guides.

Economics

When libraries loan original documents, the cost of processing (except postage) is assumed by the lending library. Today, many libraries supply only photocopies, for which they charge from 5 to 50 cents a page. This charge is intended to pay for photocopying expenses,

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* NLM receives five times as many requests for journal material published after 1945 than for material published in 1945 or earlier, even though it has twice as many volumes of the latter age (3).

** This figure does not include the documents read in the library that did not require making a request of a librarian.

but the over-all or operational cost of the service is not covered. Also, the added expenses of billing and bookkeeping may, in themselves, exceed the revenue from photocopy charges. If each library borrowed as many documents as it loaned, the result could be described as a kind of barter system. However, as has been pointed out, big borrowers are not big lenders.

It is an age-old library tradition that the scientific record should be freely available; and by "agreement," interlibrary loans have been made according to the socialistic principle, "from each according to his ability, to each according to his need." "Courtesy" is the main motivation, except for a few institutions whose responsibilities have been defined legally or administratively to include lending to other libraries, e.g., NLM. That this courtesy has been strained by demands in recent years is evidenced by the restrictions imposed on the traditional agreement by the General Interlibrary Code of 1952 (2):

> "The purpose of interlibrary loans is to make available for research and for serious study library materials not in a given library, <u>with due provisions made by the lending library for the rights of its clientele</u>.
>
> "Interlibrary loan service is a <u>courtesy and a privilege</u>, not a right, and is dependent upon the cooperation of many libraries...the interlibrary loan service should be restricted (especially when borrowing from large research libraries) to requests that <u>cannot</u> be filled by any other means.
>
> "It is assumed that the borrowing library will carefully screen all applications for loans and that it will <u>reject</u> those which do <u>not conform</u> to the Code."

Both big lenders and big borrowers incur considerable expenses. The former bear the basic cost of loans, and the latter pay a mounting bill for photocopies as the practice of loaning original documents declines. The borrowing library can and, in some instances, does pass photocopy charges on to the scientist when department or research funds are available; but again bookkeeping costs may exceed the revenue. The increasing financial burden on heavy borrowers probably explains, in part, the marked increase in demands on NLM (3). Though a biomedical library can usually obtain documents faster from other local libraries in its vicinity than from NLM, the latter does not charge for photocopies.

<u>Cost of the System</u>

Statistics on the total cost of maintaining U.S. biomedical libraries are few and conflicting. For college and university libraries in general, however, the annual cost per volume averages around $1.00 (8). With 12,239,600 volumes in biomedical collections (Table VI-1), the total cost of maintaining U.S. biomedical libraries can be estimated as at least $12,000,000 per year. This cost, of course, covers functions other than secondary distribution of documents, as we have defined this term, and serves populations other than the biomedical research community.

Very few libraries have the type of cost accounting required to determine the true cost of borrowing or lending documents to other libraries; however, the general consensus seems to be that it costs most local libraries about $2.00 to borrow a document and the same amount to lend one, making the cost of a complete interlibrary loan transaction $4.00. Libraries that handle a large volume of transactions may have lower unit costs.* On the basis of the total document flow previously estimated for 1962 (550,000), the total cost of transactions in that year exceeded $2,000,000.

Performance

From the user's viewpoint, the performance of the national biomedical library system can be assessed in terms of the proportion of his requests for documents that are filled and the speed of fulfillment. The resources of the entire system can meet practically all his requests for journal and book literature in the biomedical field and, by calling on non-biomedical libraries, can supply documents in other fields relevant to his work. The time required to fill his request, however, depends on the resources and location of the local library, and on the nature and age of the document he desires. Any individual library's performance may be judged by the percentage of the requests of its clientele that can be met (a) in minutes (own collection), (b) in 1 to 3 days (loans from immediate vicinity), (c) in 3 days to 2 weeks (loans from distant libraries or NLM), (d) in a longer period (items difficult to locate, e.g., theses, historical material, etc.), and (3) never. Unfortunately, data of this type are not available for a single library.

The total time required to fill a scientist's request by interlibrary loan depends on four variables: (a) the time required by the scientist's local library to process the request, including locating a lender and sending out the request; (b) the time required by the lender to process the request and send out the desired document; (c) the transit times between the borrower and lender for both the request and the document; and (d) the time required by the local library to process the incoming document and to notify the scientist or deliver the document. Geography has a considerable influence on transit time. Libraries near large metropolitan centers with many medical resources, e.g., New York, Chicago, Boston, and Philadelphia, have a number of libraries from which they can obtain loans quickly. Airmail is seldom used for interlibrary loans; hence libraries in the Western states are at a disadvantage, especially with regard to NLM loans.

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* Although the published budgets of NLM do not permit one to calculate directly the cost of its loan service, this appears to fall somewhere between $1.00 and $2.00 per loan.

For the Medical Library of Wayne State University (Detroit), the total time required to fill a scientist's request breaks down as follows for documents other than those difficult to borrow:

	Average no. days for loans within city*	Average no. days for loans outside city
Processing request	½	1
Lender processing	1	8
Transit times	1	4
Processing incoming document and notification	½	1
Totals	3	14

Capacity of Present System

In the past decade the system has accommodated a large increase in traffic. Assuming that the ratio of NLM loans to loans among local-level libraries has remained constant, the total flow of documents has increased by 82 percent over the 3-year period 1958-1961 (see Table VI-4). During the same period, the over-all increase in loans by six local-level libraries was 68 percent, with the largest lender (College of Physicians and Surgeons of Philadelphia Library) showing a 132-percent increase. Signs of overload are, however, accumulating and indicate that the system's capacity is being strained.

As the volume of requests increased, many libraries found that lending bound volumes of journals to other libraries began to affect their ability to meet the demands of their own clientele.** Of the 291 libraries old enough to be listed in both the 1943 edition of the Union List of Serials and the 1961 volume of New Serial Titles, almost half (135) no longer lend journals as original documents. Since borrowers try to avoid the expense of purchasing photocopies, when one major lender restricts its loans in this way, the load shifts to other lenders, with the effect of accelerating the trend toward restricting loans to photocopies.

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* Informal arrangements with other libraries in the city and telephone calls speed operations within both the borrowing and lending libraries. Use of telephone and messengers, rather than mail, reduces transit times.

** NLM, in September, 1957, restricted loans of original documents and instituted its present policy of furnishing photocopies to libraries without charge.

This trend, in turn, started another vicious cycle. Requests for photocopies mounted until the operation threatened to disrupt the local services of some libraries, which then decided either to restrict "loaning" even photocopies or to organize the operation and attempt to make it pay for itself by increasing the charges for photocopies. The expenses of billing and accounting, which have been discussed previously, complicated the problem of making the charges adequate but not prohibitive. On the borrowing end, mounting expenses for the purchase of photocopies strained already inadequate budgets, aggravating the chronic and serious financial plight of medical libraries, which has been described by Adams (9). Some attempted to pass these expenses on to the user; but, for the reasons mentioned previously, the net benefit has generally been disappointing. Others, faced with the prospect of curtailing purchasing of journals and books in order to pay photocopy charges, concentrated on using the most economical sources for loans, even if this meant delays in filling users' requests. The "snow-balling" effects of these actions by lenders and borrowers are obvious.

These signs of overload make it reasonable to conclude that the system, as presently operated and financed, has about reached its maximum capacity. It is true that more and more of the total load might be shifted to NLM, provided its budget continues to be adequate for supplying photocopies on request to any U.S. biomedical library; but this would mean that the average time to obtain a document by interlibrary loan would increase considerably. (Compare the time for loans filled locally with that for NLM loans).

Probable Demands in 1965

Much of the increase in the flow of biomedical documents during the past decade has resulted from the increase in the number of biomedical research workers. This population has grown more rapidly than the others served by biomedical libraries (practitioners and students) and also needs a greater number and variety of documents. In addition, since scientists' demands for documents are influenced by the extent to which they know of the existence of documents relevant to their work, i.e., by the efficiency of the methods they use for reference retrieval, the recent improvement in reference-retrieval services has undoubtedly also increased the demands on the system.

The MEDLARS program promises to constitute a major expansion in reference retrieval services. Not only will the coverage of Index Medicus be increased from the present 2,200 journals to 3,500 in 1965 (1), but books will be added to its coverage (5,000 annually by 1965). This general reference-retrieval tool will be supplemented by many specialized tools and services, including monthly issues of current bibliographies tailored for special interest groups and on-demand searches by computer of all the articles and books indexed after January 1, 1963. If the demand for these searches exceeds the capacity of NLM's computer, copies of the magnetic-tape files will be made available for searching on other computers. In addition to the services of the MEDLARS program, by 1965 other important new reference-retrieval services, currently getting under way or being planned (e.g., citation indexes), will undoubtedly be available to the biomedical community.

One indication of the impact of all these new services on the system for delivering documents is provided by an on-going study of an experimental bibliographic tool for workers in cerebrovascular research (10). This periodical lists references likely to be of interest to this special group and is a prototype of the 50 monthly bibliographies MEDLARS will be able to produce. The population on which this experimental tool is being tested consists of leading investigators who are well-read by present standards. Although the references listed in this bibliography were, on the average, over 6 months old, these investigators found that over 85 percent of all references whose titles indicated relevance to their work were new to them. If these scientists request from their local libraries a significant fraction of the new references that have been brought to their attention, it will mean a large increase over their previous levels of demand.

Not only will the expanded and new reference-retrieval services result in a marked increase in the demand for documents, but these will create new demands for articles from the more obscure journals that are received by few libraries. Outside of NLM, only three biomedical libraries currently receive 2,200 journals; and as the coverage of Index Medicus increases, it is doubtful if any local library can keep up. Superimposed upon the present rapid growth of demand, the effect of new reference-retrieval services could be to double interlibrary loans within a few years. A total load of over a million transactions is a reasonable estimate for 1965. The capacity of the national biomedical interlibrary loan system, as presently operated and financed, appears inadequate to handle this load. In the near future, biomedical scientists may have the means to find every reference in the world literature that is pertinent to their work; but if they cannot readily obtain the documents referred to, they may well consider themselves worse off than before.

CONCLUSIONS

(1) The implications of present efforts to provide biomedical scientists with improved reference-retrieval services have not been fully appreciated.

(2) Such services must be matched by improvement in the system for delivering documents.

(3) The present system will require radical strengthening to meet the new demands that will be placed on it.

(4) The data essential for intelligent planning of an improved system for document delivery are not presently available.

ADDENDUM TO STAFF PAPER NO. VI

In an effort to test the assumptions made in estimating interlibrary loans, and to obtain a better idea of the general rate of increase in interlibrary loan traffic, a modest survey was conducted. After excluding foreign libraries, U.S. government libraries abroad, public libraries (unless exclusively biomedical), college and university libraries other than biomedical libraries, and elementary and secondary school libraries, every tenth library on the list of institutions to which NLM loaned documents in 1959 was sent a simple postcard questionnaire asking how many documents (originals or photocopies) it borrowed from all sources in 1959 and in 1962. Of the 104 questionnaires mailed, 78 were returned in time to be included in the analysis. Of these, 50 supplied usable information, which is given in Table VI-5.

TABLE VI-5

"BORROWING" BY SAMPLE* OF U.S. BIOMEDICAL LIBRARIES

		All Documents Borrowed			Documents Borrowed from NLM 1959†	
Institution**	No. in Sample	1959	1962	% Increase	No.	% of All Documents Borrowed in 1959
Academic	6(12%)	3,960	5,687	44	954	24
Federal (other than hospitals)	4(8%)	672	1,343	100	213	32
Professional	4(8%)	883	982	11	42	5
Hospital	21(42%)	8,123	10,487	29	1,208	15
Industrial††	11(22%)	3,005	4,053	35	100	3
Foundation	2(4%)	634	644	2	112	18
Other	2(4%)	503	683	36	19	4
Total	50	17,780	23,879	34	2,648	15

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* Sample derived from list of libraries borrowing from NLM in 1959. See text for sampling method.

** The classification used here is the same as in Tables VI-2 and VI-4.

† The number of documents borrowed from NLM by each of the libraries in the sample was determined from NLM records for 1959.

†† Because of the sampling method, a few industrial libraries that would not be considered strictly "biomedical" were included in this sample.

The total borrowing reported by the 50 libraries in the sample is plotted in Figure VI-3 along with data on NLM loans during the period 1958-1963 and with the total number of loans by six academic and professional libraries (taken from Table VI-4).

If one assumes that the respondents to this questionnaire are a representative sample of U.S. biomedical libraries, the total amount of borrowing through the national interlibrary loan network, hence the total interlibrary flow of documents, has increased by about 10 percent a year during the period 1959-1962. This increase is close to that for biomedical research manpower from 1958-1960 [9 percent per year in full-time equivalents (6)]. For this sample of libraries, about 15 percent of all borrowing in 1959 was from NLM. Using this ratio of 15 percent rather than the 25 percent originally assumed to arrive at a conservative estimate (see pages VI-7 and VI-11), the flow in the system (ignoring return of original documents to the lending institution) can be calculated to be about 490,000 documents in 1959. A 10-percent annual increment would mean that the total flow approximated 640,000 documents in 1962 (see —— . —— line, Fig. VI-3). On the other hand, if one assumes that the ratio of borrowing from NLM to all borrowing remained the same in 1962 as in 1959 (15%), the total flow for 1962 would be around 730,000 documents (see —— —— line, Fig. VI-3).

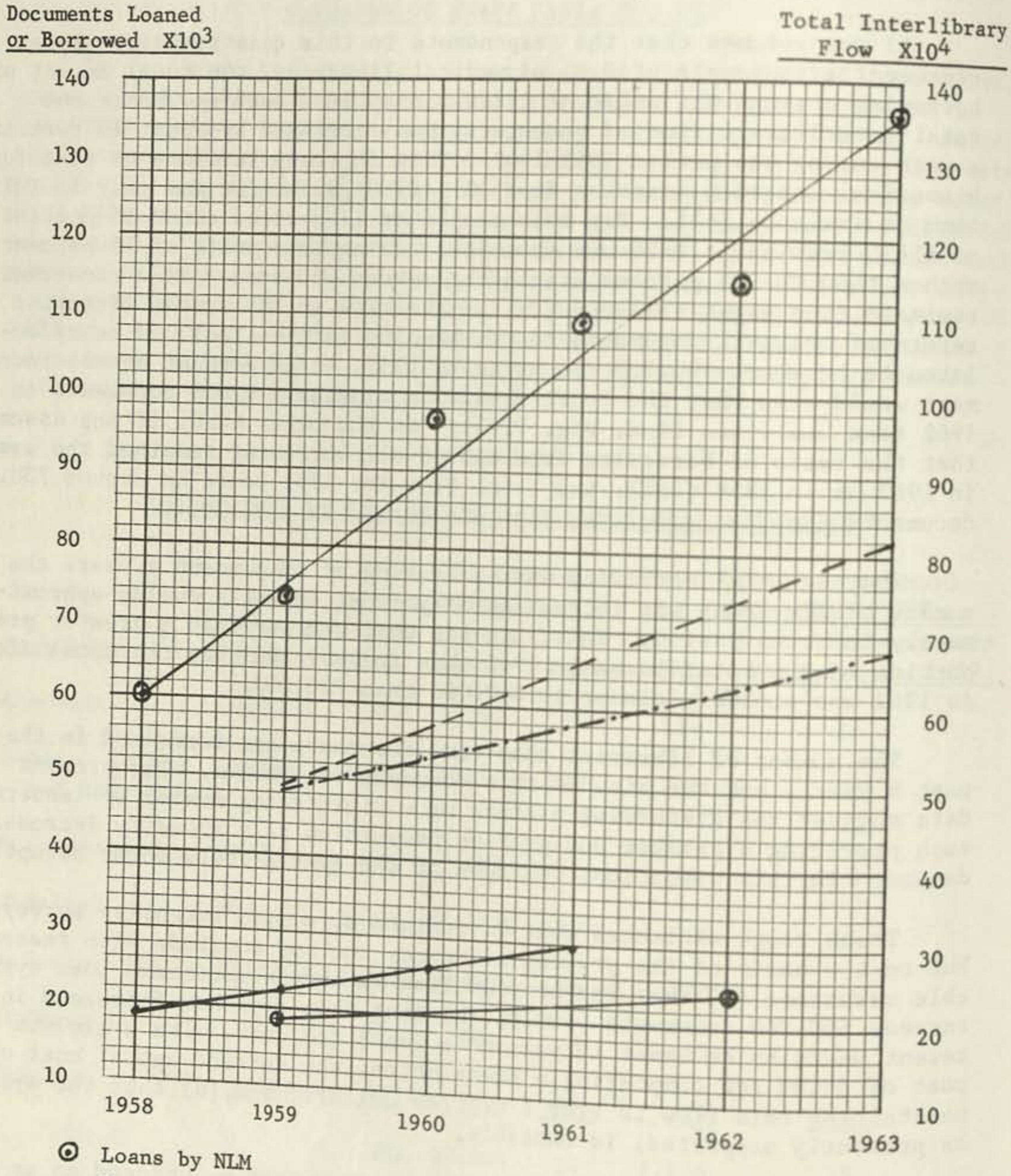
Whereas total borrowing was increasing at 10 percent a year, the number of NLM loans was increasing 25 percent annually during approximately the same period. This suggests that NLM provided a greater proportion of the total loans in 1962 than in 1959 and that the total flow in 1962 was probably closer to 640,000 than 730,000.

The number of libraries that lend documents has decreased in the past 5 years, but the size of this decrease is unknown. The present data suggest the disturbing picture of a diminishing number of lenders, each providing a greater and greater proportion of a steadily increasing demand. In this situation, collapse of the system could occur abruptly.

These rough estimates must be refined by a more extensive survey; but on the basis of the present evidence, one may conclude with reasonable assurance (a) that the present flow in the interlibrary loan system exceeds 600,000 documents yearly; (b) that this flow has increased in recent years by at least 10 percent a year; (c) that, with a minimum cost of $4.00 for completing a transaction, the current annual cost of maintaining this flow is over 2 million dollars; and (d) that the system, as presently supported, is unstable.

In thinking about how the present system might be changed so as to accommodate the loads that can be expected in the next decade, and also to improve document delivery services for biomedical scientists, three major alternatives suggest themselves. First, NLM's capacity might be increased to the point where it could, if necessary, handle the entire demand for interlibrary loans. Unless provisions were made for transmitting requests and documents by some means more rapid than mail, this alternative would mean an increase in the average time required for the

Fig. VI-3. Trends in Interlibrary Transactions



⊙ Loans by NLM

• Loans by six academic and professional biomedical libraries

⊕ Total borrowing by sample of local biomedical libraries

— — — Estimated total interlibrary flow based on fixed ratio (15%) of NLM loans to total borrowing of local biomedical libraries

—·—·— Estimated total interlibrary flow based on annual increment of 10% over 1958 figure

Sources: See Tables VI-4 and VI-5, NLM loans for fiscal year 1963 taken from its annual report for that year.

scientist to obtain a document by interlibrary loan. Second, certain large libraries might be designated as regional interlibrary loan centers and subsidized to provide service for their respective regions. If the regions were small enough to facilitate quick delivery by mail, in some cases it would be necessary to enlarge greatly the collection of the largest existing library before it could meet regional demands. This alternative, therefore, can be considered as equivalent to developing an unknown number of smaller versions of NLM. Third, the collections of all biomedical libraries might be developed to the point where they are largely self-sufficient.

It is beyond the scope of the present inquiry to evaluate the relative merits of these alternatives. Each would entail an initial expenditure at least several times larger than the total annual cost of the present interlibrary loan system and entail problems that would require considerable time to overcome. The most efficient of the alternatives can be determined only by a systematic and detailed systems study. If such a study were begun tomorrow, it seems unlikely that the course of action selected could be implemented in less than three years.

NLM has recently expressed concern about its ability to handle the rapidly increasing demands, and about the prospects of increasing centralization of interlibrary loan service (3). In view of NLM's limited capacity, the instability of the system, and the likelihood of a rapid increase in demand in the next few years, it would appear that some mechanism to provide short-term insurance against collapse should be developed quickly while long-term solutions are being studied and implemented.

REFERENCES

(See footnotes to tables, appendixes, and figures for additional data sources)

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APPENDIX VI-A

GEOGRAPHICAL DISTRIBUTION OF BIOMEDICAL LIBRARIES
(all volumes are in hundreds)

	Academic		Hospital		Gov't		Professional		Industrial		Public		Foundation		Total	
State	No.	Volumes	No.	Volumes	No.	Volumes	No.	Volumes	No.	Volumes	No.	Volumes	No.	Volumes	No.	Volumes
Alaska	---	---	---	---	1	20	---	---	---	---	---	---	---	---	1	20
Ala.	1	670	3	107	---	---	---	---	---	---	---	---	---	---	4	777
Ariz.	---	---	---	---	---	---	1	100	---	---	---	---	---	---	1	100
Ark.	1	430	2	78	---	---	---	---	---	---	---	---	---	---	3	508
Calif.	12	4766	27	1421	4	285	9	1551	3	216	1	220	---	---	56	8459
Colo.	1	653	4	386	---	---	2	457	---	---	1	48	---	---	8	1544
Conn.	1	3013	10	359	2	228	1	256	---	---	---	---	2	240	16	4096
Del.	---	---	---	---	---	---	1	70	2	490	---	---	---	---	3	560
D.C.	3	714	---	---	8	15985	1	110	---	---	---	---	1	12	13	16821
Fla.	3	1237	5	169	2	210	---	---	---	---	---	---	---	---	10	1616
Ga.	4	1004	4	118	2	350	---	---	---	---	---	---	---	---	10	1472
Hawaii	---	---	2	82	---	---	1	240	---	---	---	---	---	---	3	322
Idaho	1	280	---	---	---	---	---	---	---	---	---	---	---	---	1	280
Ill.	7	3585	11	839	1	24	---	---	2	330	1	1500	---	---	22	6278
Ind.	5	1375	8	298	---	---	1	50	4	665	---	---	---	---	18	2388
Iowa	4	3306	3	95	---	---	---	---	1	65	---	---	---	---	8	3466
Kan.	3	770	5	393	1	43	1	3	---	---	2	100	---	---	12	1309
Ky.	3	900	1	78	---	---	---	---	---	---	---	---	---	---	4	978
La.	3	1899	2	102	1	87	---	---	---	---	---	---	---	---	6	2088
Me.	---	---	---	---	---	---	---	---	---	---	---	---	1	55	1	55
Md.	3	2763	7	616	2	840	1	840	---	---	---	---	---	---	13	5059
Mass.	6	2825	17	1248	1	47	1	1200	---	---	---	---	1	40	26	5360
Mich.	5	3094	12	862	1	80	---	---	3	300	---	---	---	---	21	4336
Minn.	1	1382	6	1214	---	---	3	668	---	---	---	---	---	---	10	3264
Miss.	1	311	4	110	1	153	---	---	---	---	---	---	---	---	6	574

	Academic		Hospital		Gov't		Professional		Industrial		Public		Foundation		Total	
State	No.	Volumes	No.	Volumes	No.	Volumes	No.	Volumes	No.	Volumes	No.	Volumes	No.	Volumes	No.	Volumes
Mo.	7	1443	4	175	---	---	2	779	1	6	1	35	---	---	15	2438
Mont.	---	---	1	30	1	270	---	---	---	---	---	---	---	---	2	300
Neb.	2	1556	3	185	---	---	---	---	---	---	---	---	---	---	5	1741
N.H.	1	330	---	---	---	---	---	---	---	---	---	---	---	---	1	330
N.J.	3	265	5	748	---	---	1	330	11	735	---	---	---	---	20	2078
N.M.	---	---	2	130	---	---	1	40	---	---	---	---	---	---	3	170
N.Y.	15	7019	47	2773	5	731	10	6703	11	1102	---	---	2	267	90	18595
N.C.	4	1519	2	63	1	100	2	326	---	---	---	---	---	---	9	2008
N. Dak.	1	200	2	160	---	---	---	---	---	---	---	---	---	---	3	360
Ohio	5	1202	13	1271	---	---	2	981	3	130	---	---	---	---	23	3584
Okla.	1	442	2	66	---	---	1	90	---	---	---	---	---	---	4	598
Oregon	2	758	---	---	1	30	---	---	---	---	---	---	---	---	3	788
Pa.	13	3465	5	415	1	90	4	2478	---	---	---	---	1	100	24	6548
R.I.	---	---	3	79	1	71	1	430	---	---	---	---	---	---	5	580
S.C.	1	297	2	51	---	---	---	---	---	---	---	---	---	---	3	348
S. Dak.	1	135	1	20	---	---	---	---	---	---	---	---	---	---	2	155
Tenn.	3	1254	3	105	---	---	---	---	1	30	1	73	---	---	8	1462
Texas	7	2252	6	420	2	485	3	430	1	68	---	---	---	---	19	3655
Utah	1	400	1	71	---	---	---	---	---	---	---	---	---	---	2	471
Vt.	1	150	---	---	---	---	---	---	---	---	---	---	---	---	1	150
Va.	2	1008	2	117	---	---	1	85	---	---	---	---	---	---	5	1210
Wash.	1	750	1	45	---	---	2	336	1	12	---	---	---	---	5	1143
W. Va.	1	400	1	21	---	---	---	---	---	---	---	---	---	---	2	421
Wis.	3	1472	2	61	---	---	---	---	---	---	---	---	---	---	5	1533
Total	143	61294	241	15581	39	20129	53	18553	44	4149	7	1976	8	714	535	122396

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APPENDIX VI-B

INTERLIBRARY LOAN TRANSACTIONS OF WAYNE STATE UNIVERSITY COLLEGE OF MEDICINE LIBRARY
(JUNE 1962 - MAY 1963)

Borrowing Library (Total: 72)	Number of Documents
Sinai Hospital	930
Grace Hospital	649
Henry Ford Hospital	572
Veterans Administration Hospital, Detroit	345
Childrens Hospital	312
Parke-Davis & Co. Research	261
Harper Hospital	167
Oakwood Hospital	158
Womens Hospital	157
Detroit Department of Health	145
Herman Keifer Hospital	112
Wayne County General Hospital	104
Difco Co.	91
Lafayette Clinic	81
St. Joseph Hospital	78
U.S. Public Health Service Hospital, Detroit	77
Providence Hospital	70
Mt. Carmel Mercy Hospital	64
Beaumont Hospital	51
General Motors Research	35
Metropolitan Hospital	25
Deaconess Hospital	25
St. Joseph Mercy Hospital	23
Michigan Epilepsy Foundation	15
Ethyl Corp.	13
R. P. Scherer Corp.	12
University of Detroit	11
Chrysler Corp.	11
McManus, John & Adams	8
Michigan State University	8
Selfridge A.F.B.	8
Michigan Bell Telephone Co.	8
Plymouth State Home and Training School	7
Detroit Memorial Hospital	6
Detroit Edison Co.	6
Ford Motor Co. Engineering Library	5
Pontiac General Hospital	5
Cottage Hospital	5
General Motors. Public Relations	4
Merrill-Palmer School	3

General Motors. Chevrolet Division Archives	2
Campbell Ewald	2
Jennings Hospital	2
Toledo Medical Library Association	2
Mandell Library, Kalamazoo	2
Texas Medical Center	2
Parke-Davis & Co. Engineering	2
Engineering and Research Library, Minneapolis Honeywell, Denver	2
Northville Hospital	2
Bendix Corp.	2
Blain Hospital	1
General Motors. Engineering Division	1
Holy Cross Hospital	1
Rehabilitation Institute	1
St John Hospital	1
Zieger Corp.	1
Straith Hospital	1
University of Washington	1
Temple University	1
Purdue University	1
University of Louisville	1
Ferris Institute	1
Albuquerque Public Library	1
Jefferson Medical College	1
Washington University. School of Medicine	1
University of Maryland	1
Oregon State University	1
Central Michigan University	1
University of Manitoba Medical Library	1
Toledo Public Library	1
University of Arizona	1
Royal Oak Public Library	1
Total	4709

Lending Library (Total: 18)	Number of Documents
National Library of Medicine	67
Henry Ford Hospital	27
John Crerar Library	18
University of Michigan	12
Harper Hospital	6
Grace Hospital	5
Ohio State University	5
Parke-Davis & Co.	4
New York Academy of Medicine	4
Michigan State University	4
University of Wisconsin	3
University of Chicago	3
Midwest Interlibrary Center	3
University of Minnesota. Bio-medical Library	3
National Institutes of Health Library	2
Western Reserve School of Medicine Library	1
U.S. Army Medical Research Laboratory, Fort Knox, Ky.	1
University of Kentucky Medical Center	1
Total	169

Libraries That Both Loaned and Borrowed (Total: 5)	No. Documents Borrowed from Wayne State	No. Documents Loaned to Wayne State
Grace Hospital	649	5
Henry Ford Hospital	572	27
Parke-Davis & Co.	261	4
Harper Hospital	167	6
Michigan State University	8	4
Totals	1657	46

November 1963

NAS-NRC Study of Communication Problems in Biomedical Research

Staff Paper No. VII

TECHNICAL REPORT LITERATURE IN BIOMEDICINE*

INTRODUCTION

A technical report may be defined broadly as an investigator's account of research findings that is issued and distributed as a separate document by the source of his support.** Although this method of disseminating the results of research has been practiced for centuries by both private and governmental institutions engaged in research, not until the past few decades has the term, "report literature," come into common use to differentiate this type of publication from the periodical literature and from non-periodic forms of literature (monographs, proceedings, etc.) issued and distributed by professional societies and by non-profit and commercial organizations set up as publishers. During this period, research by scientists employed by government, or working in private institutions under government contract, expanded markedly. For various reasons, which will not be reviewed here, the results of much of this government-sponsored research, particularly that supported by agencies*** engaged in the defense effort, have appeared as technical reports distributed largely through governmental channels. Although numerous private organizations publish technical reports of research they themselves have supported, the predominance of government in generating documents of this type has led many to define technical reports more narrowly to include only documents issued and distributed by governmental agencies and to distinguish technical reports from other government publications; technical reports are original reports of research and development, rather than educational material, reports of administrative activities, etc. This paper is concerned primarily with technical reports in this restricted sense.

A number of governmental services announce, distribute, store and retrieve this form of literature. The issuing agencies and these services constitute a loosely organized system performing for the technical report much the same functions as the complex of traditional publishers, abstracting-indexing services, and libraries perform for other types of literature. In the main, these two parallel "systems" have operated in relative isolation from each other.

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* Not for publication or publication reference.

** "Internal" reports for use only within the investigator's organization.

***The term, "agencies," in this paper refers to governmental units of all sizes.

As one of the facets in the NAS-NRC study of scientist-to-scientist communication in biomedicine, the technical-report literature and its processing services were assessed. The aims of this paper are to present a general review of the generation, processing, and use of technical reports; to summarize our findings relating to the volume, origin, and distribution of technical reports useful to biomedical scientists; and to estimate their current and potential importance to the biomedical research community.

METHODS AND SOURCES

In addition to reviewing previous studies of the technical-report literature, expressions of scientists' opinions, and the policies and practices of governmental agencies and information services, the staff collected and analyzed some original data.

All 1962 issues of the following periodicals, which announce technical reports, were examined for reports of biomedical research: Technical Abstract Bulletin (TAB) [issued by the Defense Documentation Center (DDC) formerly the Armed Services Technical Information Agency (ASTIA)], Nuclear Science Abstracts (NSA)* [Atomic Energy Commission (AEC)], Technical Publications Announcements (TPA)* [National Aeronautics and Space Administration (NASA)], and U.S. Government Research Reports (GRR)* [Office of Technical Services (OTS) of the Department of Commerce]. In one issue of GRR (January 1962, Vol. 37, No. 1), the price and the number of pages of each biomedical report were recorded. Theses, journal articles, reports of foreign work, and governmental publications other than original reports of research were excluded in counting technical reports. In TAB, any stated limitations on the distribution of documents were noted.

Each of these announcement periodicals arranges entries by subject matter. Only reports found, or referred to, under the following headings were considered to be "biomedical":

Technical Abstract Bulletin: Sections 16 ("Medical Science") and 28 ("Psychology and Human Engineering");

Nuclear Science Abstracts: sections entitled "Biology and Medicine" and "Health and Safety";

Technical Publications Announcements: the section, "Life Sciences and Life Support Systems," which includes physiology, medicine, biology, piloting, human engineering, human factors, and radiation effects on man; and

U.S. Government Research Reports: Divisions 16 ("Medical Sciences") and 28 ("Psychology and Human Engineering"), and the categories of behavioral sciences, human engineering, and biological sciences (anatomy, physiology, biochemistry, pharmacology, toxicology, medical specialties, radiobiology, and surgery) in the section, "Nonmilitary Research Reports."

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* Covers only non-classified documents.

GENERAL REVIEW

General Pattern for Processing Technical Reports

Practices and polices differ somewhat from one governmental agency to another, but a general pattern for handling technical reports can be described. The investigator, whether a government employee or a contractor, submits a draft of his report to the sponsoring agency for review of content and of any restrictions on distribution indicated by security or other considerations. After approval of the draft, copies are reproduced* and distributed according to standard lists. This primary distribution includes one or more depositories. The main depository then abstracts the report (if the investigator himself was not required to furnish an abstract), categorizes the document, and announces its availability in a periodical covering documents generated by, or of interest to, scientists supported by the given agency. Eligible parties may, without charge, obtain copies of specific reports on request (secondary distribution) and may also request searches of the depository's files for documents relevant to specific questions.

Description of Major Report Services**

Three "agencies" account for the bulk of technical reports generated and distributed by the government: DOD, AEC, and NASA. Each of these agencies has established large, centralized services for handling technical reports and other documents containing the results of research and development. These systems evolved independently and are oriented to the missions of their respective agencies. In addition, OTS maintains a service that handles selected technical reports of work sponsored by these three agencies and others.

Defense Documentation Center. The primary mission of DDC, formerly known as ASTIA, is to receive, store, and disseminate information of a scientific and technical nature to agencies and contractors of DOD. In theory, DDC receives copies of all technical reports generated by DOD support; however, in 1962, although it received some 27,000 reports, these represented only about 20 percent of the total number of such reports (2). Some 35 percent of these reports were by government-employed scientists and about 60 percent by government contractors. Approximately one-quarter were classified for security reasons.

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* In most government research contracts, the reporting requirements are specified, including the format and numbers of copies to be furnished to the sponsoring agency and otherwise distributed by the investigator's institution. Reporting requirements for work supported by grants are generally more loosely defined.

**The source for the specific information in this section is a report entitled "Study of the Federal Government's System for Distributing Its Unclassified R & D Reports"(1), dated June 30, 1962.

The Technical Abstract Bulletin announces the acquisition of documents by DDC. TAB is issued semimonthly (circulation approximately 3,500) and distributed without charge to DOD activities and their contractors and also to authorized Federal agencies, grantees, and contractors. In each issue abstracts of newly acquired documents are arranged into 33 subject divisions, and a subject index is included. "Unlimited" documents (those whose distribution is unrestricted) and "limited" documents are listed separately. During 1960 and 1961, the interval between the dates on documents and the dates on which they were received by DDC averaged about 4 months; approximately 50 additional calendar days elapsed before they were announced in TAB, making the total lag from publication to announcement almost 6 months.

Private and governmental activities that have established eligibility for DDC service and have filed a "Field of Interest Register" may request copies of the documents announced in TAB for support of active government-sponsored projects, within the limitations of security and other restrictions on distribution. In 1962, the service supplied over 3,000 reports on each working day, or approximately 750,000. About 60 percent of these documents were supplied as Xerox copies from microfilmed masters. Eligible parties may also request searches of the DDC collection for documents containing information they need and may ask that bibliographies be prepared on specific subjects. DDC staff uses a large computer to assist in answering an average of 23 requests for searches per working day and in preparing some 500 bibliographies per year. The annual budget in fiscal 1962 was $3 million. At present, DDC's services are being expanded and improved, and more complete coverage of documents generated by DOD support is anticipated (2).

Division of Technical Information of AEC. The Division of Technical Information Extension (DTI) supervises the operations of the AEC's information system and acts as a center for collecting, reproducing, and disseminating documents generated by, or of interest to, AEC-supported research and development. In 1961-1962, it received about 35,000 nonclassified documents* a year from AEC activities, contractors, and grantees, from other governmental agencies and contractors, and from foreign countries and miscellaneous contributors. Of the documents retained in the collection, over 60 per cent were journal articles, about one-third were technical reports, and the remainder were of miscellaneous types (patents, translations, etc.).

DTI announces all non-classfied documents retained in its collection to AEC personnel and contractors through a weekly periodical. It also publishes, for wider distribution (about 8,000 copies), the semimonthly NSA, which contains abstracts** of documents selected for current interest. In each issue of NSA, the abstracts are arranged by subject categories and are indexed. New acquisitions are announced within 8 weeks of receipt.

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* Of all the documents received, about 80 percent were non-classfied.
**Only titles, and not abstracts, of AEC reports are published.

Eligible users may request documents announced in NSA. They receive microform copies (microcards) unless they request full-sized copies. In 1961, the service answered 100,000 requests for documents and produced 3,500,000 microcards and 650,000 pages of full-sized copy (largely Xerox copies from microform masters). Searches of the DTI collection may also be requested.

Office of Scientific and Technical Information of NASA. NASA supports by contract a Scientific and Technical Information Facility, which collects and disseminates information generated by, or of interest to, NASA-supported research and development. It acquires about 20,000 documents a year (1961-1962) from its facilities, contractors, and grantees; from other governmental agencies; and by exchange with domestic and foreign organizations. These are reviewed for relevance to NASA interests and analyzed for announcement and retrieval. Abstracts of all non-classified technical reports are published biweekly in Scientific and Technical Aerospace Reports (STAR)*. Abstracts are arranged by subject and indexed. Documents are announced within 6 weeks of receipt. Classified material is announced in a similar periodical.

Eligible parties may obtain copies of specific documents listed in STAR,** either in microform or full-size. In addition, searches for documents bearing on a given subject are made on request, and factual answers (as contrasted to bibliographic citations) are provided when desired and feasible.

Office of Technical Services of Department of Commerce. The primary mission of OTS is to make available to any individual the non-classified and otherwise unrestricted information resulting from research and develment sponsored by the U.S. Government. "Releasable" technical reports are supplied to OTS by many governmental agencies. In 1961, OTS received some 25,000 such reports, of which about one-fifth described work at governmental facilities and two-thirds related to work of government contractors. Abstracts of these reports are published in the semimonthly GRR, which has a circulation of 4,200 (1961). Each issue of GRR has two sections: the first is a duplicate of the "unlimited"-document section of TAB; the second ("Non-Military Research Reports") contains older military reports that have been declassified and reports generated by non-military agencies. Each issue is indexed. In 1961, excluding the section duplicated from TAB, the average lag between the date of a document and its appearance in GRR was over 9 months, of which 7 weeks were required for processing by OTS.

Any individual may purchase a subscription to GRR and microform or full-sized copies of the documents it announces. Searches may also be obtained for a fee. OTS distributed 350,000 documents annually in 1961-1962.

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* NASA supports the publication by a private organization, the American Institute of Aeronautics and Astronautics, of IAS Abstracts, a periodical covering all the journal articles collected by the NASA information facility (3).

**Only documents generated by NASA support are supplied to individuals other than employees of NASA or its contractors.

Eligibility for Services. At present, all those engaged in government-supported research are eligible for the services provided by DOD, AEC, and NASA. In the past, however, the eligibility of grantees of the U.S. Public Health Service has not always been recognized, particularly with regard to DDC services. A recent directive (4) has clearly defined their eligibility.

Comparison of Technical Reports with Journal Articles

Content. Technical reports are usually labeled as either final or interim reports; most are final (1). For journal articles, no comparable information is available. Technical reports are generally longer than journal articles, present data and methods in detail, use tabular material more extensively, and usually are prefaced by an author abstract (this practice is still relatively uncommon in biomedical journals).

Critical Review. In two respects, there is a clear, general difference in reviewing process between technical reports and journal articles: the review of a technical report does not ordinarily involve a judgment as to whether the report should be disseminated, nor must it consider competition for limited space. In other respects, the difference is not so clear. The care and strickness with which an author's manuscript is reviewed by the sponsoring agency before distribution and the number and competence of the reviewers vary widely from agency to agency, just as they do from journal to journal. Some agencies and governmental laboratories have established rigorous review procedures, using outside experts as well as scientific employees, to examine the accuracy, reliability, and validity of the findings reported and to set forth the changes required in both form and content before the report is accepted and duplicated for distribution. The standards in certain cases are probably as strict as those of journals with high standards. In other cases, there is no review by experts in the subject matter, but this is also true of some biomedical journals. Two recent studies (5,6) have recommended that all governmental agencies institute policies that ensure critical review of reports, and these recommendations are being implemented (7).

Speed of Publication. The interval between submission of a manuscript and publication, which may be called journal-processing time, averages from 6 to 8 months for biomedical journals (8,9). For technical reports, the comparable processing time probably averages only a month or so less (1). However, although the technical report is often considered to be a fast medium for disseminating information, the total time required in some agencies for review and duplication may exceed that taken by journals to publish an article.

Primary Distribution. The average routine distribution of technical reports by the sponsoring agency or the investigator's institution is considerably smaller than the average circulation of biomedical journals. Aside from the copies sent to the depositories to meet later requests, the official distribution of a technical report averages 135 (1). If the report is not classified, the author may have copies sent to colleagues with whom he routinely exchanges publications, just as with journal reprints.

Announcement. New technical reports are announced in special periodicals issued by governmental agencies; journal articles are announced by the conventional abstracting-indexing services. The average lag between publication and announcement for technical reports (1) is probably less than the 4 to 6 months journal articles take to appear in major abstracting-indexing services, such as Index Medicus (IM), Biological Abstracts (BA), and Chemical Abstracts (CA) (see Staff Paper No. VIII).

Although the major report-announcement periodicals cover all journal articles resulting from sponsored work,* as well as technical reports, the major abstracting-indexing services, in general, cover technical reports only selectively. For example, IM, in the section, "Recent United States Publications," lists titles of some technical reports and other government publications with titles of new books. Among the abstracting-indexing services, the Bibliography of Agriculture (BAg) is an exception to the general rule. In addition to covering journal literature, it includes all technical reports of research sponsored by the Department of Agriculture. The Weinberg Report (6) summarizes the current situation as follows: "The documentation community has taken an equivocal attitude toward...reports; in some cases the existence of these reports is acknowledged and their content abstracted in the abstracting journals. In other cases...reports are given no status; they are alleged to be not worth retaining as part of the permanent record unless their contents finally appear in a standard...journal."

Secondary Distribution. Distribution of technical reports in response to requests for copies of specific documents after they have been announced is, in certain respects, similar to that of journal articles, i.e., requests may be directed either to the generator (the author or his institution)** or to the "publisher." In the case of technical reports, the publisher (the sponsoring agency) usually designates one or more depositories from which copies may be obtained, and they are commonly available in local collections of colleagues or libraries.

Some data on secondary distribution of technical reports are provided by DDC experience in answering requests. There are more than 10 requests for only 10 percent of the reports deposited with DDC, from one to 10 requests for 80 percent, and no requests for 10 percent. No figures on the average number of technical reports requested from authors could be found. Because the secondary distribution of journal articles from sources other than authors, who are probably the major source (10),

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* See footnote on page VII-5 for a recent NASA arrangement that constitutes an exception to this general pattern.

**This source of secondary distribution can be used for a technical report when there is no limitation on its dissemination.

is highly decentralized, no figures are available to compare with the DDC experience. Reliable data on the number of requests received by authors for reprints of journal articles are scarce, but one recent study (11) established the median as between 11 and 15.

Fate of Technical Reports

In the field of Physics, Gray and Rosenborg found that about half of what they termed the "publishable" information in these reports appeared in journals within 2 or 3 years (12). Of the 239 biomedical technical reports listed in the Current List of Medical Literature (the predecessor of IM) during a 6-month period, October 1950-April 1951, fewer than one-quarter appeared as journal articles by 1953 (13). The average interval between the date of the report and appearance in a journal was 7 months. No more recent studies of biomedical reports seem to have been performed.

Attitudes of Scientists Toward Technical Reports

Scientists, particularly those engaged in "basic" research in academic institutions, tend to regard technical reports as "second-class" literature. However, in certain fields, e.g., where significant quantities of information are classified or where technological development is of central interest, numerous studies have shown that technical reports are a major medium of communication. From the user's point of view, the primary criticism of technical reports is that quality control is not as strict as for journal literature. On the positive side, the advantage of greater speed of publication is usually assumed. The technical report has also been recognized as a superior source of details of methodology and complete data (14). The latter advantage is obvious when the same research project is published both as a technical report and a journal article.

Few data on biomedical scientists' use of technical reports have been collected, but informal evidence indicates that few biomedical workers are either knowledgeable about technical report literature or make any significant use of it. A number of biomedical journals do not permit authors to cite technical reports.

Attitude of Librarians Toward Technical Reports

The classic attitude of librarians toward report literature is to consider all such material as "ephemera"; but librarians working in fields where there is considerable demand for technical reports have learned to use the special techniques and tools required to handle them. Library schools are now instructing students in these techniques, particularly if they plan to work in libraries associated with research activities. An informal survey by the staff, however, indicates that most academic biomedical libraries do not possess the required bibliographic tools and that many biomedical librarians view the problems of handling technical reports with dismay.

DATA AND DISCUSSION

Volume and Sponsors of Biomedical Technical Reports

Table VII-1 gives the number of sponsors of biomedical reports announced in 1962.

TABLE VII-1

SPONSORSHIP OF
BIOMEDICAL TECHNICAL REPORTS ANNOUNCED IN 1962[*]

Sponsor of Research	No. Reports
DOD[**]	930
AEC[†]	525
NASA[††]	117
Other[‡]	43
Total	1,615

[*] Only non-classified reports are included, except for reports generated by DOD support.

[**] The number of DOD reports was taken as the number listed in both the "unlimited"and "limited" document section of TAB (609 and 321, respectively). Not included are older military reports that were declassified and announced in GRR during 1962.

[†] Only reports announced in NSA and designated as AEC-supported.

[††] Only reports in TPA and designated as NASA-supported.

[‡] Reports announced in GRR that were sponsored by governmental agencies other than DOD, AEC, and NASA, or by private institutions. Included are reports with joint sponsorship, e.g., Armed Forces-NRC, Navy-Public Health Service, and FAA (Federal Aviation Agency)-NASA-Air Force.

No check was made of all the government reports listed by the Government Printing Office to see whether OTS announced all those that qualified as Biomedical Technical Reports. It is therefore possible that some technical reports of biomedical interest sponsored by agencies such as the Bureau of Mines, the Fish and Wildlife Service, and the National Bureau of Standards were missed; however, it seems unlikely that the number of such omissions is large. The Department of Agriculture also supports work of biomedical interest. A few reports of work supported by the Department of Agriculture were announced in the "non-military" section of GRR, but a systematic review of BAg would probably disclose more.

Length and Price of Reports

Of the 45 biomedical reports listed in one issue of GRR, the average length was 43 pages (range two to 273 pages). The average OTS price for these reports was $5.21 (range $0.50 to $17.50) for a full-sized copy, and the average price per page was $0.12 (range $0.02 to $0.55). Microfilm copies cost 4¢ per page for the first 20 pages, and 3¢ for each page over 20.

Restrictions on Distribution of Biomedical Reports

Table VII-2 compares the number of biomedical reports sponsored by DOD, AEC, and NASA and announced in 1962 in the appropriate announcement periodicals with the number of reports listed by OTS in GRR and therefore available to all scientists regardless of their eligibility for special services.

TABLE VII-2

NUMBER OF BIOMEDICAL REPORTS ANNOUNCED IN 1962
BY MEDIUM OF ANNOUNCEMENT

Sponsor of Research	Number of Reports Announced by Sponsoring Agency	Number of Reports Announced by OTS*
DOD	930	983 (609)
AEC	525	193
NASA	117	39
Totals	1,572	1,215 (841)

* Figures in parentheses exclude older military reports that had been declassified in 1962, or that, for other reasons, had not been listed in GRR when they were issued. During 1962, OTS listed several hundred reports of the Naval Medical Research Institute from the 1940's and 1950's. These largely accounted for the 374 older military reports listed in GRR in 1962.

Some of the difference between the number of reports announced by sponsoring agencies and the number listed by OTS may be explained as an artifact, in that the categories included in counting reports in GRR did not correspond exactly with those included in the counts of TAB, NSA, and TPA. The analysis in Table VII-3, however, indicates that at least for DOD reports, the difference is real and reflects restrictions on distribution.

TABLE VII-3

RESTRICTIONS ON DISTRIBUTION OF DOD BIOMEDICAL REPORTS ANNOUNCE IN 1962

(Total number of DOD reports announced in TAB = 930)

No restrictions*	609 (65%)	
Some restrictions**	321 (35%)	
Reasons of security (classified)		14 (2%)
Other reasons		307 (33%)

* Listed in the "unlimited" document section of TAB and therefore available to all scientists through OTS.
**Listed in "limited" document section of TAB

For 25 of the non-classified DOD reports announced in the "limited" document section of TAB, the entry contained such notices as "no automatic release to foreign nationals," indicating restrictions for military reasons. For the remainder of the reports listed in the "limited" document section of TAB, no specific reasons were given. Copyright infringement is seldom a problem with technical reports. Therefore, it must be assumed that other considerations determined the restrictions automatically imposed by not releasing documents to OTS. In an effort to avoid unnecessary restrictions, the criteria for limiting distribution of non-classified DOD reports have recently been clearly stated as follows (4): "When necessary in the interest of security, to protect corporate rights not protected by patents, to protect the proprietary rights of the Government, to minimize the liability of the Government or its employees, or for ethical reasons such as a protection of information regarding the relative merits of commercial products."

Because the biomedical reports announced in NSA and TPA were all non-classified, security considerations cannot explain the restriction on distribution of AEC and NASA reports that is suggested by the relatively small number available through OTS.

If they try to obtain technical reports, biomedical scientists who are not eligible for the services of DDC, AEC, and NASA will find that OTS cannot supply many non-classified documents. In addition, the relatively high cost of reports is a deterrent. Although the title and abstract of a report listed in GRR may look interesting enough to warrant buying it at a price comparable with that of a small book or the subscription rate of some journals, the report may turn out to be of little or no interest; there is no provision for returning an unwanted report for a refund.

CONCLUSIONS

(1) Currently the volume of technical reports of potential interest to biomedical scientists is small, compared with that of journal articles. Only relatively few biomedical scientists probably feel a need to use technical report literature or are familiar with its resources and services. As biomedical research increasingly draws upon the physical sciences, and the space program entails more biomedical research, it is likely that the technical report literature will assume greater importance to biomedical scientists.

(2) Whereas journal literature is a medium of information exchange available to all, use of technical report literature by biomedical scientists has often been characterized by restrictions and other practical difficulties. With the recent clarification of U.S. Public Health Service grantees' eligibility for DDC services, some of these difficulties will disappear, at least for a large proportion of U.S. workers.

(3) Although the technical report literature may be more practically accessible to many biomedical scientists as a result of recent developments, if it is to be exploited effectively, the biomedical community must become better acquainted with this resource and biomedical libraries must acquire the special techniques and tools required to handle it.

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October 2, 1963
(Revised November, 1963)

NAS-NRC Study of Communication Problems in Biomedical Research

Staff Paper No. VIII

ABSTRACTING AND INDEXING SERVICES IN BIOMEDICINE*

INTRODUCTION

As part of our study we endeavored to analyze the functions served by abstracting and indexing services, and to describe qualitatively the present effort to provide these services for biomedical scientists. This paper reviews our findings and suggests the nature and magnitude of some of the problems associated with improving abstracting and indexing services in biomedicine. Services primarily concerned with the "technical report" literature are not considered here.

For the present purpose, we define "abstracting-indexing services" broadly as services issuing for public use, and on a continuing basis, bibliographic guides to the scientific literature consisting of one or more of the following: (1) lists of the titles of documents published elsewhere, (2) abstracts or digests of these documents, and (3) indexes to these documents. Such services may be provided as: (1) serial publications, (2) sets of cards or separate sheets, or (3) special sections in scientific journals devoted primarily to other types of material (original articles, reviews, etc.). All abstracting-indexing services must, of course, include in their product the titles of documents (articles, books, patents, etc.). Some services ("title-listing" services) produce only simple or classified lists of document titles, others provide abstracts, with or without a subject index, and still others ("indexing-only" services) produce indexes but not abstracts.

METHODS

As a first step, we reviewed published and unpublished information relating to the policies, functions, performance, and coordination of abstracting-indexing services. Data on services covering biomedical literature, as traditionally defined, were extracted from the most recent and authoritative source on abstracting-indexing services for science and technology (1).

Since there had been no recent assessment of how abstracting-indexing services were covering biomedical literature in general, we undertook a limited investigation. Some operational definition of what constitutes the literature of biomedicine is required for any attempt to assess how completely or inclusively a given service, or combination of services, covers this universe of documents. (See Staff Paper No. V for a discussion of the difficulties in defining the biomedical literature.) For the

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* Not for publication or publication reference.

present assessment, we defined the literature as all documents generated by research similar to that supported by NIH and used, as a sample of this universe, all journal articles cited in NIH Research Grants Index 1962 as resulting from grantees' work.* Each journal represented in the sample was looked up in a 1962 compilation of the journals covered by 12 major U.S. science abstracting-indexing services, and in a list of the journals covered by Excerpta Medica.**

Citations in the Grants Index were not standardized as regards journal names. This introduced two problems: (1) determining whether some of the publications cited were, in fact, journals by our definition, viz., any scientific or technological periodical issued more than once a year; and (2) ruling out errors caused by treating variants of a given journal's name as representing separate journals. Because of time and manpower limitations, the first difficulty was resolved by including in this sample only citations of publications that could be readily identified as journals in available standard references, or else recognized as journals by individuals familiar with a wide variety of scientific literature. The second was met by considering different journal names synonymous when a trained librarian was reasonably certain of their equivalence. These decisions resulted in a final sample of 14,334 articles in 882 different journals. Fewer than 2 percent of the cited references in the Grants Index that possibly represented journal articles had to be excluded from the sample.

For measuring the coverage of biomedical literature, as we defined it, our procedure has certain limitations: (1) Assessing coverage from lists of journals "covered" by the various services, rather than looking for each article in the product of each of the services, has an inherent limitation that had to be accepted because of limitations on time and manpower. Of the 19 services included in this assessment, only two [Index Medicus (IM) and Bibliography of Agriculture (BAg)] include all the substantive articles in the journals they process regularly. The other services "cover" at least some of the sample journals selectively, i.e., they process only those papers that fall within their sphere of interest. For example, Biological Abstracts (BA) "covers" clinically oriented journals selectively by processing only papers considered to be of interest to "basic" scientists, and Nuclear Science Abstracts (NSA) selects papers relating to radioisotopes, nuclear energy, etc. For the selective services, therefore, the proportion of the sample articles processed can be given only as an upper limit set by the number of sample articles in the journals they process. One can only guess what proportion of this number they actually processed. (2) Limiting the sample to journal articles, and further to articles in journals that can be readily identified, will result in some overestimation of the coverage of all biomedical documents by abstracting-indexing services. (3) Although NIH

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* The output of biomedical research workers, of course, includes other types of published documents, e.g., books, papers published in proceedings volumes, etc.; but journals account for over 90 percent of the references cited in NIH Grants Research Index 1962.

** This service, although technically a foreign service, is one that is widely available to U.S. biomedical scientists.

grantees do publish a significant number of papers in journals of other countries, foreign journals are certainly under-represented in the present sample as compared with a random sample of the output of all biomedical scientists. Because U.S. abstracting-indexing services undoubtedly cover U.S. literature more completely, this sample bias also leads to some overestimation of their coverage of the biomedical literature.

GENERAL REVIEW

Functions

The basic functions of abstracting-indexing services are:

(1) *announcement* -- alerting scientists to the existence of new documents that may interest them and that they may wish to obtain and read, i.e., facilitating "current awareness;" and

(2) *control of the scientific record* -- organizing and identifying the documents comprising the scientific record, to make it possible to find a desired document, or group of related documents, *at any time in the future*, i.e., providing an efficient, permanent tool for "retrospective search."

Services that provide abstracts have an additional function:

(3) *ready reference* -- supplying scientists with a condensed substitute for the original document when the original is inaccessible or in a language foreign to the reader, when the subject is of only peripheral interest to the reader and the abstract suffices for keeping him broadly informed, or when the abstract itself contains the information of greatest value to the reader.

Performance Requirements

The major requirements imposed on abstracting-indexing services are summarized in Table VIII-1 according to the function to be served, and roughly in order of relative importance within a given function. Services that attempt to perform more than one function are often forced to compromise on major requirements. For example, a service that issues a bibliographic guide or "tool" intended for "current awareness," as well as for searching the literature, faces serious problems. The extensive processing needed to meet the requirements for the latter function (inclusiveness, richness and depth of indexing, and consistency) tends to reduce promptness of announcement, hence to decrease the tool's value for current awareness. The requirements for serving as a ready reference generally conflict with the currency so important for the announcement function. Different requirements may conflict even when only one function is to be served, e.g., convenience *vs.* inclusiveness, currency *vs.* inclusiveness or exclusiveness, and breadth of coverage *vs.* inclusiveness. Additional compromises are necessitated by economics and availability of qualified personnel.

TABLE VIII-1

REQUIREMENTS OF ABSTRACTING-INDEXING SERVICES

For announcement

1. Currency -- promptness of announcement of new documents
2. Convenience of use -- manageable size, arrangement suited to user, ease of perusing ("browsability")
3. Inclusiveness or exclusiveness -- either assurance of coverage of "all" relevant references or limitation of coverage to only those representing the "best" by some criterion
4. Specialization -- scope of coverage coincident with, and limited to, interests of users

For control of scientific record

1. Stability -- continuity and dependability of service
2. Inclusiveness
3. Breadth of coverage (the broader the range of subject matter covered, the fewer the different services that must be consulted in searching the scientific record)
4. "Richness" and "depth" of indexing -- permitting search from the multiple points of view natural to various types of users and at different levels of specificity (e.g., both classes of drugs and specific drugs); assurance of minimal "loss" of relevant references that are included in the service
5. Consistency -- control of quality and form of abstracts or index entries, uniformity and completeness of bibliographic entries, and reasonable conservatism in changing indexing terminology or style for citing journals
6. Currency

For ready reference (applies to abstracts only)

1. Understandability -- without recourse to original document
2. Readability
3. "Slanting" -- concentration on the information most "significant" to a particular group of readers

Economics

The cost of processing a document varies widely from one abstracting-indexing service to another and depends on many factors, including the proportion of volunteer to paid personnel, currency, inclusiveness, depth and richness of indexing, quality standards, and form of dissemination. A general economic law for such services seems to be that the cost rises exponentially with attempts to fulfill more completely any of the requirements on performance. Given finite limitations on the funds and manpower available to a service, it is apparent that compromises and "trade-offs" are inevitable.

Sponsors

The traditional sponsors of abstracting-indexing services are scientific societies. Organizations representing the classic, broad disciplinary groupings (e.g., chemistry, physics, and biology) are responsible for the largest U.S. abstracting services. Organizations of applied scientists (e.g., engineers and medical practitioners) also maintain major abstracting and indexing services. Commercial interests supply a number of important services that are available for public (as contrasted with intramural) use, e.g., the Agricultural Index and Current Contents of Chemical, Pharmaco-Medical and Life Sciences. Governments support some services as national resources, e.g., IM and the all-embracing services of the USSR. More recently, increasing numbers of private and governmental agencies that maintain research programs have begun to sponsor specialized abstracting-indexing services intended to further their specific missions, e.g., the American Heart Association (abstract section of Circulation), the Atomic Energy Commission (NSA), and the National Institute of Mental Health (Psychopharmacology Abstracts).

Support

In the past, U.S. abstracting services were supported by subscriptions and society membership dues. Subscription rates for some of the major services have increased progressively, but recently signs have appeared that further increases are not likely to produce additional revenue. The present trend is toward increasing Federal support, direct and indirect, of the major private, non-profit services.

Some of the largest U.S. indexing services have always been direct operations of the Federal government (e.g., IM and BAg), and many of the newer abstracting-indexing services depend on Federal support for all or most of their funds.

Approaches

Sponsoring organizations' approaches to their services may be characterized along two major axes: "orientation" and abstracting "philosophy." With regard to orientation, these services can be classified as discipline- or profession-oriented vs. mission- or problem-oriented. The broad discipline-oriented services [e.g., Chemical

Abstracts (CA) and BA] have generally tended to emphasize the long-term function of controlling the scientific record, with the attendant priorities in requirements. Mission-oriented services and many of the specialized profession-oriented services, such as the abstract sections in journals devoted to medical specialties and Psychopharmacology Abstracts, usually give priority to the short-term function of "announcement." With regard to abstracting philosophy, the contrasting approaches are the "slanted" abstract and the "balanced" abstract. Most services claim that their product is especially tailored, or slanted, for a specific population of users, i.e., the abstracts are written from a special viewpoint and in a special language, or are designed to present only certain types of information. Services advocating the balanced abstract attempt to produce an abstract useful to the broadest possible audience. The success of the major disciplinary services in achieving their avowed aim of slanting their abstracts is not notable in practice (3,4); however, certain services for applied scientists have demonstrated the feasibility of producing abstracts that are distinctly and consistently slanted, e.g., Modern Medicine.

DATA AND DISCUSSION

Number of Services

More than 1,800 abstracting-indexing services exist for science and technology (1). About 470 of these process literature that is, at least in part, "biomedical" by the traditional definition. Appendix VIII-A lists 326 services of interest to biomedicine that are published in foreign countries and gives the form and volume of their output. A considerable number of these services are in English. Table VIII-2 summarizes foreign services by country. There are 142 U.S. services of interest to biomedicine (listed in Appendix VIII-B with form and volume of annual output).

Total Output

The combined annual output of all these biomedical services is over 1,200,000 abstracts. In addition, almost 700,000 documents are processed annually by services that list the titles of documents or index them, but do not provide abstracts. Foreign services account for roughly two-thirds of the total output of abstracts and one-third of the documents processed by only title-listing or indexing. The total of almost two million documents processed is, of course, misleading as a measure of the volume of biomedical literature, in that many of the larger services process many documents that fall outside the traditional definition of "biomedical," and many documents are processed by more than one service

U.S. Services

Most of the U.S. services are relatively small and oriented toward particular diseases, problems, or professional specialties. Over half are published as sections of journals. These smaller services perform primarily "current awareness" and "ready reference" functions. U.S.

TABLE VIII-2

FOREIGN BIOMEDICAL ABSTRACTING AND INDEXING SERVICES BY COUNTRY

Country	No. Services	No. Printed as Section of Journal	Total No. Abstracts/Yr.	Total No. Documents Listed or Indexed/Yr.*
Argentina	6	4	1,210	4,000
Austria	7	6	2,850	3,000
Belgium	3	3	1,100	---
Brazil	4	3	900	1,000
Bulgaria	2	--	9,400	---
Canada	1	1	500	---
China	5	1	15,500	---
Czechoslovakia	13	6	16,140	59,000
Denmark	4	1	1,700	1,500
England	27	9	62,850	17,300
Finland	2	1	800	100
France	38	30	134,220	7,600
Germany	60	37	165,100	11,850
Hungary	3	1	1,000	16,900
India	3	3	1,400	---
Italy	42	37	14,450	62,800
Japan	15	8	38,170	18,400
Netherlands	27	3	82,400	---
Poland	10	10	4,120	---
Portugal	1	1	1,000	---
Rumania	8	3	9,340	---
Scotland	3	2	6,000	4,400
Spain	5	3	1,300	5,500
Sweden	2	2	400	2,000
Switzerland	6	4	2,300	12,000
USSR	21	5	222,120	15,000
Yugoslavia	8	6	7,070	---
Total	326	190	803,340	242,350

* Excluding those abstracted

Source: National Federation of Science Abstracting and Indexing Services. Guide to the World's Abstracting and Indexing Services in Science and Technology. Washington, D.C., NFSAIS, 1963.

Note: See "Methods" section for discussion of this source.

TABLE VIII-3

U.S. ABSTRACTING OR INDEXING SERVICES PROCESSING MORE THAN 10,000 DOCUMENTS ANNUALLY

	No. Documents Processed		
	1952	1962	% Increase
Provide Abstracts			
Chemical Abstracts	55,000	165,000	200
Biological Abstracts	37,400	100,000	170
Nuclear Science Abstracts	6,800	33,000	390
Psychological Abstracts	7,300	10,000	37
Total	106,500	308,000	190
Provide Indexes Only			
Index Medicus*	96,000	145,000	51
Bibliography of Agriculture	96,000	100,000	4
Index Chemicus**	did not exist	?	---
Chemical Titles	did not exist	75,000	---
Agricultural Index	---	40,000	---
Biochemical Title Index*	did not exist	24,000	---
Hospital Literature Index	---	17,500	---
National Library of Medicine Catalogue*†	---	15,000	---

* Only these three services limit coverage to literature falling entirely within the traditional concept of "biomedical."

**This service provides graphic "abstracts" of the synthesis of about 100,000 new chemical compounds annually and indexes these compounds. The number of documents processed is somewhat less than the number of compounds listed.

† Covers only non-serial publications.

Sources: For 1952 figures:

Chemical Abstracts: Read from graph in Crane, E.J., Chemical Abstracts, Yesterday, Today, and Tomorrow. Proceedings of the Chemical Society, December 1957, p. 335.

Biological Abstracts: Personal communication from Phyllis V. Parkinson, Staff of Biological Abstracts, October 14, 1963.

Nuclear Science Abstracts: Actual count.

Psychological Abstracts: Personal communication from Mrs. Betty Galloway, Editorial Office, American Psychological Association, October 10, 1963.

Index Medicus: Estimated from count of every tenth page of Current List of Medical Literature, the predecessor of Index Medicus.

Bibliography of Agriculture: Personal communication from Mr. L. Lulitch, Division of Indexing and Documentation, National Agricultural Library.

For 1962 figures:

National Federation of Science Abstracting and Indexing Services. Guide to the World's Abstracting and Indexing Services in Science and Technology. Washington, D.C., NFSAIS, 1963. The figures given in this source were the latest available to the compilers during the latter part of 1962.

services that process 10,000 or more documents per year and provide either abstracts or indexes are listed in Table VIII-3. The combined output of the four larger abstracting services (only 3.3 percent of the total number of U.S. abstracting services) constitutes three-quarters of all the abstracts produced. The predominance of the larger indexing services is even more marked.

The growth of some of the large services over the past 10 years (Table VIII-3) is impressive. The total output of abstracts almost tripled, and the number of documents processed by indexing services must have increased even more sharply. But, for the reasons mentioned in connection with total output, the increase in the output of any or all of these services (with the possible exception of IM) is not a reliable measure of the over-all growth of biomedical literature. (See Staff Paper No. V for estimates of the growth of U.S. biomedical literature.) The combined output of these large services alone has increased more rapidly than even the wildest estimates of the increase in the volume of scientific literature in general, or biomedical literature in particular. In addition, of the U.S. services listed in Appendix VIII-B, about 40 percent were started after 1952. Thus, there is a strong implication that U.S. services are now covering a greater proportion of the biomedical literature than they did a decade ago.

Cost

An average of $10 per document processed (abstracted or indexed) is a reasonable estimate of unit costs, at least for the major discipline-oriented services. Some of the smaller, specialized services are known to have costs as high as $50 per document. If allowance is made for the non-biomedical coverage of services such as CA and NSA,* a conservative estimate of total U.S. expenditures in 1962 for abstracting and indexing biomedical literature is $4 million.**

A recent study (5) concluded that unit costs are doubling every 12 years. If the biomedical literature grows at the same rate as it did in the past 10 years, i.e., about 30 percent (see Staff Papers Nos. I and V for growth figures using two different definitions of the literature), abstracting and indexing may be expected to cost a minimum of $9 million** in 1972, even if the performance of the present services is not improved and no new services are established.

Inclusiveness of U.S. Services

Present Assessment. Table VIII-4 shows how 13 major abstracting-indexing services covered the sample of biomedical literature selected for this study. If these data are interpreted with appreciation of their limitations (see discussion under "Methods"), they provide a useful picture of coverage by the larger U.S. services, and by Excerpta Medica (EM), the largest foreign biomedical service available in English.

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* After making this allowance, we are left with an annual output of about 200,000 abstracts and 200,000 documents processed by indexing only.

** Not included in these estimates are the costs of the extensive "intramural" services supported by pharmaceutical companies.

TABLE VIII-4

COVERAGE BY MAJOR ABSTRACTING-INDEXING SERVICES OF SAMPLE* OF OUTPUT OF U.S. BIOMEDICAL RESEARCH

Services	No. Sample Journals Processed†	% All Journals in Sample	No. Sample Papers in Processed Journals	% All Papers in Sample
Index Medicus**	598 (63)	68	12,590	88
Excerpta Medica	514 (17)	58	11,771	82
Biological Abstracts	514 (28)	58	11,622	81
Chemical Abstracts	506 (22)	58	11,611	81
Bibliography of Agriculture**	263 (13)	30	6,817	48
Psychological Abstracts	151 (10)	17	3,854	27
Nuclear Science Abstracts	67 (0)	8	4,002	28
Mathematical Reviews	37 (1)	4	1,406	10
Applied Mechanics Reviews	33 (2)	4	763	5
Review of Metal Literature	30 (2)	3	1,001	7
Engineering Index	26 (1)	3	791	5
Meteorological and Geoastrophysical Abstracts	23 (0)	3	919	6
International Aerospace Abstracts	12 (0)	1	247	2
Processed by None of Above Services	23	3	216	2

* Sample consists of 14,334 papers cited in NIH Research Grants Index, 1962. These papers were published in 882 different journals.

** These two services process all substantive articles in all the journals that they cover. The remaining services cover some or all of the sample journals selectively.

† The figures in parentheses represent the number of journals processed by only this one of the 13 services, i.e., the "unique" coverage of the sample journals by the given service.

With the exceptions of IM and the BAg, for the reasons previously given, the figures in the last two columns should not be taken as accurate measures of coverage in terms of sample articles. How closely the various services approach these theoretical upper limits of coverage varies. For EM, actual coverage may come close to the indicated upper limit. For BA and CA, the actual coverage of sample articles is probably significantly less than the figures given; and services such as NSA probably process only a fraction of the sample articles in the journals they cover.

The percentages shown in the last column indicate how the services concentrate their efforts on the journals that publish relatively large numbers of articles (6) (e.g., IM covers 68 percent of the sample journals but 88 percent of the sample articles). The journals not covered by any of the services (listed in Appendix VIII-C, Part I) contained only a very small number of the sample articles.

The combined coverage of sample articles by all 13 services is somewhere between the 94 percent accounted for by the combination of IM and BAg and 98 percent. The coverage of IM is surprisingly inclusive, considering that many of the sample journals were devoted to subject matter not considered to be "biomedical" by the traditional definition (e.g., chemistry, social sciences, and mathematical sciences). Of the journals it covered, 63 were processed by none of the other services, for a higher proportion of "unique" coverage than any of the other services. Sample journals not covered by IM are listed in Appendix VIII-C, Part III.

Although the relative contributions of the listed services toward coverage is not strictly proportional to either of the percentage figures in Table VIII-4, six services stand out as major contributors. One of these, BAg, is not often considered to be a major service for biomedical research workers. The remaining seven services together added only 11 sample journals (listed in Appendix VIII-C, Part II) to the 848 covered by one or more of the six major contributors to biomedical coverage.

How these six services covered the sample is analyzed in detail in Appendix VIII-D and summarized in Table VIII-5. The 153 journals covered by only one of the six services contained only 5 percent of the papers in the sample; whereas the 31 journals covered by all six services contained 19 percent of the sample articles. Sample journals not covered by any of the six services contained fewer than 2 percent of the sample papers; but again, the actual combined coverage cannot be said with certainty to exceed 94 percent (the combined coverage of IM and BAg).

Table VIII-6 summarizes the coverage afforded by the four of these six services that provide abstracts. Although the journals not covered by any of the four abstracting services contained only about 5 percent of the sample articles (see Appendix VIII-C, Part IV for list of these journals), because of the selectivity of the abstracting services, one cannot conclude that 95 percent of all the sample papers were abstracted by at least one of the services, and no lower limit can be placed on the combined coverage by these abstracting services from the present data.

TABLE VIII-5

OVERLAPPING COVERAGE OF SAMPLE* OF OUTPUT OF U.S. BIOMEDICAL RESEARCH BY SIX MAJOR ABSTRACTING-INDEXING SERVICES**

No. Services Processing Sample Journal	No. Sample Journals So Processed	% All Sample Journals
All 6 services	31	4
Some 5 of the 6 services	101	11
Some 4 of the 6 services	197	22
Some 3 of the 6 services	182	21
Some 2 of the 6 services	184	21
Only 1 of the 6 services	153	17
None of the 6 services	34	4
Totals	882	100

TABLE VIII-6

OVERLAPPING COVERAGE OF SAMPLE* OF OUTPUT OF U.S. BIOMEDICAL RESEARCH BY FOUR MAJOR ABSTRACTING SERVICES†

No. Services Processing Sample Journal	No. Sample Journals So Processed	% All Sample Journals
All 4 services	63	7
Some 3 of the 4 services	254	29
Some 2 of the 4 services	230	26
Only 1 of the 4 services	225	26
None of the 4 services	110	12
Totals	882	100

* Sample consists of 14,334 papers cited in NIH Research Grants Index, 1962. These papers were published in 882 different journals.

** Index Medicus, Excerpta Medica, Biological Abstracts, Chemical Abstracts, Bibliography of Agriculture, and Psychological Abstracts

† Excerpta Medica, Biological Abstracts, Chemical Abstracts, and Psychological Abstracts

If the sample had included all references cited in the Grants Index rather than only those easily recognized as journal articles, the general picture would not be changed appreciably, because the references excluded from the sample were fewer than 2 percent of the total. However, if the sample had included a higher proportion of foreign articles, the coverage of this group of services would have been less comprehensive.

Comparison with Other Studies. A 1961 study (7) of the coverage of cardiovascular, endocrine, and psychopharmacological literature* found that the best coverage of the sample articles by any one abstracting service (EM) was 43 percent, and that BA, CA, EM, and Psychological Abstracts (PA) together had abstracted only about 70 percent of the sample articles that were 1 to 4 years old. The coverage of the Current List of Medical Literature (CL) (the predecessor of IM), however, was found to be almost the same (87 percent of the articles in the sample) as in our own study. The authors concluded:

> "A worker in the problem-oriented fields of medical research studied will probably find that none of the standard abstracting services adequately covers his field and, although a combination of three or four of these services will give him satisfactory coverage, it is hardly practical, lacking completely current subject indexes to these services, for a researcher to scan them all to alert him to relevant work. At present, the Index Medicus is probably one of the better tools for this purpose."

The actual coverage by abstracting services of the articles in the sample used for the present study is probably somewhere between the figures established in this earlier study and the upper limits given in Table VIII-4.

Overlapping Coverage

Present Assessment. Tables VIII-5 and VIII-6 indicate the extent of overlapping coverage of the sample journals, and Appendix VIII-D gives the frequency with which any given combination of services covered the same journal.

The journals in the sample that were covered by any of the six abstracting or indexing services included in Table VIII-5 were processed, on the average, by three different services. When only four abstracting services are considered (Table VIII-6), the corresponding figure on duplicate coverage is 2.1. From the present data no conclusions can be drawn about total duplication of processing of individual articles.

Comparison with Other Studies. The 1961 study cited above (7) found that 40 percent of all the abstracts of sample articles produced by BA, CA, EM, and PA were of articles abstracted by more than one of the four services.

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* In the study, each abstracting-indexing service was searched for every article in a relatively small sample of literature. The sample consisted of articles resulting from papers given at selected, major U.S. meetings for research workers in these fields.

The Welch Medical Library Study in the early 1950's also showed marked overlapping and concluded:

> "As has been pointed out for the five major services [BA, CA, EM, PA, and CL] there is a great amount of overlapping and duplication among them. This is even more accentuated when we take into account all the services and beyond these the great number of other journals that publish abstracts as a regular feature. A tremendous amount of time and effort is being expended on keeping up with the literature. It would seem that a great deal of it is wasteful. There is certainly a great need for more coordination of effort and publication and particularly among the major services."

A recent study (5) concludes that the world's scientific journals are being covered, on the average, nearly four times by U.S. abstracting and indexing services.

Significance of Overlapping Coverage. Coverage of a given journal or a given article by more than one service does not necessarily constitute wasteful duplication, because different services have different users and may serve different functions. However, it does represent an opportunity for saving time and effort by cooperative arrangements to minimize duplication of processing. This was the basic rationale for the formation in 1958 of the National Federation of Science Abstracting and Indexing Services (NFSAIS), a voluntary association of major, non-profit U.S. services. Recent actions indicate the beginning of progress toward the goal of close cooperation; however, much remains to be done. One of the general conclusions of a 1963 study commissioned by NFSAIS states (5): "There is much duplication of effort among many services in their production operations. An orderly plan for increasing joint action is greatly needed. There is too little cooperation at present and few plans are being made in this direction."

Currency

No attempt was made in the present study to collect original data on the interval between publication of a journal article and its appearance in the various services. Data on this interval from the previously cited 1961 study (7) are given in Table VIII-7.

These figures were based on articles published almost entirely in the U.S. journals. U.S. abstracting and indexing services are understandably somewhat slower in processing articles in foreign languages. A 1963 study of mental health literature (9), which included in its sample a proportionate share of foreign articles, found the following median figures for time-lag between journal publication and abstracting-indexing coverage: IM: 4 months, EM: 12 months, BA: 8 months, and PA: 15 months. These are quite similar to the figures for psychopharmacological papers in Table VIII-7, except for BA. The decrease in the figure for IM, as compared with CL in the earlier study, is probably also significant. Whereas, from 3 to 4 months seems to be a reasonable goal for the broad services, and one currently being approached by IM and CA, services that process relatively few articles can achieve greater currency [e.g., 8 weeks for the Hospital Literature Index (9)].

TABLE VIII-7

INTERVAL IN MONTHS BETWEEN PRIMARY AND SECONDARY PUBLICATION

SERVICE	CARDIOVASCULAR		ENDOCRINE		PSYCHOPHARMACOLOGICAL	
	Average	Range	Average	Range	Average	Range
BA	5.9	3-14	5.8	3-9	9.4	3-23
CA	3.5	2-6	4.1	2-8	5.2	2-15
EM	10.4	5-16	8.1	3-18	12.4	6-30
CL	4.0	2-16	3.8	2-7	4.9	2-28
PA	-	--	-	-	14.9	4-20

CONCLUSIONS

(1) With the help of increasing Federal support, U.S. abstracting-indexing coverage of biomedical literature has improved significantly as regards inclusiveness and currency.

(2) At present, although some gaps undoubtedly still exist, particularly in foreign coverage and in the social sciences, the combined coverage of abstracting-indexing services available in English most probably exceeds 90 percent of all documents useful to biomedical scientists. Abstracts, however, are not available for this high a percentage of the biomedical literature.

(3) A significant portion of the current effort goes to processing particular journals and articles several times. How much of this duplication is of marginal utility is unknown, but it is reasonable to conclude that there could be better sharing of work involved in some of the steps of document processing. If the coverage of document processing services is to approach completeness, and if current demands for greater currency and better indexing are to be met, effective work-sharing must take place even if the funds available for these services increase several-fold in the next few years.

(4) Progress toward work-sharing among these services has begun, but is slow. The cooperation necessary for achieving major improvements in the over-all level of biomedical abstracting-indexing must be developed at national and international levels. Many practical problems remain to be solved before large savings can be realized and the savings turned to improving services and closing gaps. Agreement is required on many basic details of document processing and on division of labor. Some standardization of form and content of output will have to be accepted under any circumstances, and if modern technology is to be fully exploited, more standardization will be required.

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APPENDIX VIII-A

FOREIGN ABSTRACTING AND INDEXING SERVICES OF INTEREST TO BIOMEDICINE

(See Explanatory Notes at End)

Title	Country	Provides Abstracts?	No. Abstracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Section of Journal?
Abstracts of Bulgarian Scientific Literature, Biology and Medicine, English ed.	Bulgaria	x	1,200	--	--	--
Acta Cardiologica	Belgium	x	200*	--	--	--
Acta Gastro-Enterologica Belgica	Belgium	x	800*	--	--	x
Acta Hepato-Splenologica	Germany	x	400*	--	--	x
Acta Medica Italica di Malattie Infettive e Parassitarie	Italy	x	1,000*	--	--	x
Acta Medica Polona	Poland	--	--	x	?	x
Acta Tropica."Bibliographie"	Switzerland	--	--	x	1,000	x
Acta Vitaminologica; Rivista Internazionale di Vitaminologia e di Enzimologia	Italy	--	--	x	1,800	x
Arztliche Sammelblatter	Germany	x	500	--	--	--
Aggiornamenti di Terapia Oftalmologica	Italy	x	400*	--	--	x
Anaesthesia	England	x	400*	--	--	--
Anales de Bromatologia	Spain	--	--	x	4,000	x
Analytical Abstracts	England	x	5,000*	--	--	--
Anesthesie, Analgesie, Reanimation	France	--	--	x	500	x
Annales d'Oculistique	France	x	700*	--	--	x
Annales de Dermatologie et de Syphiligraphie et Bulletin de la Societe Francaise de Dermatologie et de Syphiligraphie	France	x	2,000*	--	--	x
Annali della Sanita Pubblica	Italy	x	1,200*	--	--	x
Annali de Stomatologia	Italy	x	100	--	--	x
Annali Italiani di Chirurgia	Italy	x	200	--	--	x
Annals of the Rheumatic Diseases	England	x	600*	--	--	x
L'Annee Psychologique	France	x	500*	--	--	x
Annual of Czechoslovak Medical Literature	Czechoslovakia	--	--	x	7,000*	--
Antiseptic	India	x	750*	--	--	x
Archiv fur Geschwulstforschung	Germany	x	600*	--	--	x
Archiv fur Kinderheilkunde	Germany	x	700	--	--	x
Archiv fur Physikalische Therapie	Germany	x	500*	--	--	x
Archives d'Ophthalmologie et Revue Generale d'Ophthalmologie	France	x	2,000	--	--	x

Title	Country	Provides Abstracts?	No. Abstracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Section of Journal ?
Archives des Maladies de l'Appareil Digestif et des Maladies de la Nutrition	France	x	300*	x	--	x
Archives des Maladies du Coeur et des Vaisseaux	France	x	2,000*	--	--	x
Archives des Maladies Professionnelles de Medecine dur Travail et de Securite Sociale	France	x	500	--	--	x
Archivio di Tisiologia e delle Malattie dell'Apparato Respiratorio	Italy	x	--	x	600	x
Archivio "Putti" di Chirurgia degli Organi di Movimento	Italy	x	900*	--	--	x
Archivio Veterinario Italiano	Italy	x	300	--	--	x
Archivos Argentinos de Enfermedades del Aparato Digestivo	Argentina	x	100*	--	--	x
Arhiv za Higijenu Rada i Toksikologiju	Yugoslavia	x	120	--	--	x
Arkhiv Patalogii	USSR	x	400	--	--	x
Arquivos Brasieilros de Nutricao	Brazil	--	--	x	1,000	x
Arquivos de Neuro-Psiquiatria	Brazil	x	150*	--	--	x
Arzneimittel Standardisierung	Germany	x	100	--	--	x
Berichte uber die Allgemeine und Spezielle Pathologie	Germany	x	3,000*	--	--	--
Berichte uber die Gesamte Biologie Abteilung A: Berichte uber die Wissenschaftliche Biologie	Germany	x	500*	--	--	--
Berichte uber die Gesamte Biologie Abteilung B: Berichte uber die Gesamte Physiologie und Experimentalle Pharmakologie	Germany	x	500*	--	--	--
Berichte uber die Gesamte Gynakologie und Geburtshilfe sowie deren Grenzgebiete	Germany	x	3,000*	--	--	--
Bibliograffa Medica Internacional	Spain	x	1,000*	--	--	--
Bibliografia Scientifica Medicina e Chirurgia	Italy	x	?	--	--	--
Bibliographia Medica Cechoslovaca	Czechoslovakia	--	--	x	8,000*	--
Bibliographia Medica Helvetica	Switzerland	--	--	x	10,000*	--
Bibliography of Systematic Mycology	England	--	--	x	900	--
Bilten Naucne Dokumentacije za Farmaciju	Yugoslavia	x	2,500	--	--	--
Bilten Naucne Dokumentacije za Medicinu i Veterinu	Yugoslavia	x	1,200	--	--	--
Biologisches Zentralblatt	Germany	x	200	--	--	x
Bitamin. Vitamins	Japan	x	300	--	--	x

Title	Country	Provides Abstracts?	No. Abstracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Section of Journal?
Blood Group News	Denmark	--	--	x	300	--
Bollettino d'Oculistica	Italy	--	--	x	1,500	x
Bollettino Schermografia	Italy	--	--	x	150	x
British Journal of Dermatology	England	x	500*	--	--	x
British Journal of Medical Psychology	England	x	150	--	--	x
British Journal of Physiological Optics	England	x	150	--	--	x
British Journal of Plastic Surgery	Scotland	--	--	x	150*	x
British Journal of Urology	Scotland	--	--	x	4,250*	x
British Journal of Venereal Diseases	England	x	200*	--	--	x
British Medical Abstracts	England	x	1,000	--	--	--
Bulgarska Akademiya na Naukite. Komitet po Teknicheskiya Progres. Informatsionen Byuletin: Selsko Stopanstvo Veterinarna Meditsina	Bulgaria	x	8,200	--	--	--
Bulletin de l'Institut Pasteur	France	x	12,000*	--	--	--
Bulletin de la Societe Scientifique d'Hygiene Alimentaire; l'Alimentation et la Vie	France	x	120*	--	--	x
Bulletin de Microscopie Appliquee	France	--	--	x	2,400*	x
Bulletin of Hygiene	England	x	4,000*	--	--	--
Bulletin of Narcotics	Switzerland	--	--	x	1,000*	x
Bulletin Signaletique. Section 12: Biophysique. Biochimie, Chimie analytique biologique	France	x	12,000*	--	--	--
Bulletin Signaletique. Section 13: Sciences Pharmacologiques. Toxicologie	France	x	10,000	--	--	--
Bulletin Signaletique. Section 14: Microbiologie. Virus. Bacteriophages. Immunologie. Genetique	France	x	12,000*	--	--	--
Bulletin Signaletique. Section 15: Pathologie Generale et Experimentale	France	x	15,000*	--	--	--
Bulletin Signaletique. Section 16: Biologie et Physiologie Animales	France	x	36,000*	--	--	--
Calcutta Medical Journal	India	x	400	--	--	x
Canadian Medical Association Journal. Le Journal de l'Association Medicale Canadienne	Canada	x	500	--	--	x
Cardiologia nel Mondo	Italy	x	2,800*	--	--	--

Title	Country	Provides Abstracts?	No. Abstracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Section of Journal?
Ceskoslovenska Farmacie	Czechoslovakia	x	400	--	--	x
Ceskoslovenska Fysiologie	Czechoslovakia	x	120	--	--	x
Ceskoslovenska Pediatrie	Czechoslovakia	x	120	--	--	x
Chemisches Zentralblatt	Germany	x	90,000*	--	--	--
Chest Disease Index and Abstracts	England	x	3,000	--	--	--
Chimie Analytique	France	x	1,500*	--	--	x
Chinese Medical Journal	China	x	1,000	--	--	x
Der Chirurg	Germany	x	300*	--	100*	x
Chirurgia Narzadow Ruchu i Ortopedia Polska	Poland	x	100	--	--	x
Courrier	France	x	5,000*	--	--	x
Cuore e Circolazione	Italy	x	100	--	--	--
Current Work in the History of Medicine	England	--	--	x	4,000	--
Czasopismo Stomatologiczne	Poland	x	100	--	--	x
Dairy Science Abstracts	England	x	3,600*	--	--	--
Danish Medical Bulletin	Denmark	x	1,500*	--	--	--
Dermatologische Wochenschrift	Germany	x	500*	--	--	x
Das Deutsche Gesundheitswesen	Germany	--	--	x	2,000	x
Deutsche Zahn-, Mund- and Kieferheilkunde mit Zentralblatt fur die Gesamte Zahn-, Mund- und Kieferheilkunde	Germany	--	--	x	3,000*	x
Deutsche Zeitschrift fur die Gesamte Gerichtliche Medizin	Germany	x	3,000*	--	--	x
Duodecim	Finland	--	--	x	100	x
Encyclopedie Veterinaire Periodique	France	x	1,200*	--	--	x
Endokrinologie	Germany	x	1,500	--	--	x
Excerpta Criminologica	Netherlands	x	1,500*	--	--	--
Excerpta Medica. Section I: Anatomy, Anthropology, Embryology, Histology	Netherlands	x	4,000*	--	--	--
Excerpta Medica. Section II: Physiology, Biochemistry and Pharmacology	Netherlands	x	6,000*	--	--	--
Excerpta Medica. Section III: Endocrinology	Netherlands	x	2,500*	--	--	--
Excerpta Medica. Section IV: Medical Microbiology, Immunology and Serology	Netherlands	x	4,000*	--	--	--
Excerpta Medica. Section V: General Pathology and Pathological Anatomy	Netherlands	x	3,850*	--	--	--
Excerpta Medica. Section VI: Internal Medicine	Netherlands	x	7,500*	--	--	--
Excerpta Medica. Section VII: Pediatrics	Netherlands	x	3,350*	--	--	--

Title	Country	Provides Abstracts?	No. Abstracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Section of Journal?
Excerpta Medica. Section VIII: Neurology and Psychiatry	Netherlands	x	6,300*	--	--	--
Excerpta Medica. Section IX: Surgery	Netherlands	x	7,200*	--	--	--
Excerpta Medica. Section X: Obstetrics and Gynaecology	Netherlands	x	2,200*	--	--	--
Excerpta Medica. Section XI: Oto-, Rhino-, Laryngology	Netherlands	x	2,200*	--	--	--
Excerpta Medica. Section XII: Ophthalmology	Netherlands	x	1,900*	--	--	--
Excerpta Medica. Section XIII: Dermatology and Venereology	Netherlands	x	3,300*	--	--	--
Excerpta Medica. Section XIV: Radiology	Netherlands	x	2,400*	--	--	--
Excerpta Medica. Section XV: Chest Diseases	Netherlands	x	2,900*	--	--	--
Excerpta Medica. Section XVI: Cancer	Netherlands	x	5,200*	--	--	--
Excerpta Medica. Section XVII: Public Health, Social Medicine & Hygiene	Netherlands	x	3,900*	--	--	--
Excerpta Medica. Section XVIII: Cardiovascular Diseases	Netherlands	x	3,500*	--	--	--
Excerpta Medica. Section XIX: Rehabilitation	Netherlands	x	3,000*	--	--	--
Excerpta Medica. Section XX: Gerontology and Geriatrics	Netherlands	x	2,000*	--	--	--
Farmaceuticky Obzor	Czechoslovakia	--	--	x	?	--
Farmaceutski Glasnik	Yugoslavia	x	600	--	--	x
Fiches Documentaires. Radiobiology (Issued as cards)	Switzerland	x	1,000	--	--	--
Fortegnelse Over Medicinsk Litteratur i Arhus	Denmark	--	--	x	1,200	--
Fortschritte auf dem Gebiete der Rontgenstrahlen und der Nuklear Medizin Diagnostik, Physik, Biologie, Therapie	Germany	x	?†	x	?†	x
Fortschritte der Medizin	Germany	x	300*	--	--	x
Fresenius' Zeitschrift fur Analytische Chemie	Germany	x	350*	--	--	x
Ftiziologia	Rumania	x	100	--	--	x
Gaceta Medica Espanola	Spain	x	200	--	--	x
Galenica Acta	Spain	x	100*	--	--	x
Ganka Rinsho Iho (Journal of Clinical Ophthalmology)	Japan	x	500	--	--	x
Gesundheits-Ingenieur	Germany	x	150*	--	--	x
Giornale di Batteriologia e Immunologia	Italy	--	--	x	1,500	x
Gruzlica. Tuberculosis	Poland	x	250	--	--	x

Title	Country	Provides Ab-stracts?	No. Ab-stracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Sec-tion of Journal?
Gynecologie et Obstetrique	France	--	--	x	200	x
Haematologica; Archivio	Italy	--	--	x	150	x
Die Heilkunst; Zeitschrift fur Praktische Medizin	Germany	x	250	--	--	x
Helminthological Abstracts	England	x	2,500*	--	--	--
Hospital Abstracts	England	x	1,800*	--	--	--
Igaku Chuo Zasshi. Japana Centra Revuo Medicina	Japan	x	20,000	--	--	--
Igiene Moderna	Italy	x	500	--	--	x
Imprensa Medica	Brazil	x	600	--	--	x
Index Analyticus Cancerologiae	France	x	2,000*	--	--	--
Index of Fungi	England	--	--	x	2,400*	--
Index Veterianarius	England	--	--	x	10,000	--
Indian Journal of Pediatrics	India	x	250	--	--	x
Indice Bibliografico Italiano di Ortopedia e Traumatologica "Carlo Pais"	Italy	--	--	x	2,500*	x
Indice de la Literatura Dental Periodica en Castellano y Portugues	Argentina	--	--	x	4,000	--
Informatsionnyi Byulleten' Novykh Inostrannykh Knig Postupivshikh v Biblioteku Dmeni V. I. Lenina. Seriya II: Biologicheskie, Meditsinskie, Sel'skokhozyaistvennye Nauki	USSR	--	--	x	13,000	--
International Abstracts of Biological Sciences	England	x	26,000*	--	--	--
Jahrbuch der Gesamten Therapie	Germany	x	2,000*	--	--	--
Japan Science Review; Biological Sciences	Japan	x	2,500	--	--	--
Japan Science Review; Medical Sciences	Japan	x	4,000†	x	12,000	--
Jibiinkoka. Otolaryngology.........	Japan	--	--	x	400	--
Journal de Chirurgie	France	x	1,200*	--	--	x
Journal de Radiologie, d'Electrologie et de Medecine Nucleaire ..	France	x	1,400*	--	--	x
Journal of Antibiotics. Series B ..	Japan	--	--	x	3,100	x
Journal of Obstetrics and Gynaecology of the British Empire	England	x	300*	--	--	x
Klinische Monatsblatter fur Augenheilkunde und fur Augenarztliche Fortbildung	Germany	x	300*	--	--	x
Kongresszentralblatt dur die Gesamte Innere Medizin und Ihre Grenzgebiete	Germany	x	9,000*	--	--	--
L und E: Osterreichisches Zentralorgan fur Lebensmittel und Ernahrung	Austria	--	--	x	3,000	--

Title	Country	Provides Abstracts?	No. Abstracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Section of Journal?
Landwirtschaftliches Zentralblatt. Abt. IV: Veterinarmedizin	Germany	x	8,300*	--	--	x
Lijecnicki Vjesnik	Yugoslavia	x	300	--	--	x
Magyar Orvosi Bibliografia (Hungarian Medical Bibliography)	Hungary	--	--	x	6,900*	--
Magyar Orvosi Bibliografia; Bibliographia Medica Hungarica	Hungary	--	--	x	10,000	--
Medicina del Lavoro	Italy	x	400*	--	--	x
Medicina Fennica; Bibliography of Finnish Medicine	Finland	x	800*	--	--	--
Medicina Sportiva: Studi di Medicina e Chirurgia dello Sport	Italy	x	100*	--	--	x
Meditsinskii Referativnyi Zhurnal. Razdel I: Vnutrennie Bolezni; Endokrinologiya; Kurortologia, Fizioterapiya i Lechebnaya Fizkul'tura; Kozhnye i Venericheskie Bolezni	USSR	x	7,800*	--	--	--
Meditsinskii Referativnyi Zhurnal. Razdel II: Tuberkulez	USSR	x	2,000*	--	--	--
Meditsinskii Referativnyi Zhurnal. Razdel III: Infektsionnye Bolezni; Meditsinskaya Mikrobiologiya; Virusologiya; Meditsinskaya Parazitologiya; Epidemiologiya; Antibiotiki	USSR	x	4,000*	--	--	--
Meditsinskii Referativnyi Zhurnal. Razdel IV: Khirurgiya; Travmatologiya i Ortopediya; Neirokhirurgiya; Urologiya	USSR	x	6,000*	--	--	--
Meditsinskii Referativnyi Zhurnal. Razdel V: Detskie Bolezni	USSR	x	4,000*	--	--	--
Meditsinskii Referativnyi Zhurnal. Razdel VI: Onkologiya; Meditsinskaya Radiologiya; Rentgenologiya	USSR	x	4,000*	--	--	--
Meditsinskii Referativnyi Zhurnal. Razdel VII: Organizatsiya Zdravookhraneniya; Gigiena i Sanitariya; Istoriya Meditsiny; Sudebnaya Meditsina; Meditsinskaya Tekhnika	USSR	x	5,000*	--	--	--
Meditsinskii Referativnyi Zhurnal. Razdel VIII: Otorinolaringologiya; Stomatologiya; Oftal'mologiya	USSR	x	3,600*	--	--	--
Meditsinskii Referativnyi Zhurnal. Razdel IX: Nevropatologiya i Psikhiatriya	USSR	x	2,400*	--	--	--
Meditsinskii Referativnyi Zhurnal. Razdel X: Akusherstvo i Ginekologiya	USSR	x	2,400*	--	--	--

Title	Country	Provides Abstracts?	No. Abstracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Section of Journal?
Die Medizin der Sowjetunion und der Volksdemokratien im Referat	Germany	x	6,700*	--	--	--
Methods of Information in Medicine. Methoden der Information in der Medizin	Germany	--	--	x	250	x
Mikroskopie; Zentralblatt fur Mikroskopische Forschung und Methodik	Austria	x	300*	--	--	x
Militaire Geneeskunde, Literatuuroverzicht	Netherlands	x	250	--	--	x
Minerva Ginecologica	Italy	--	--	x	2,500	x
Minerva Medica	Italy	--	--	x	7,500	x
Minerva Medicobibliografica; Indici trimestrali della Letteratura medica chirurgica e specialistica Mondiale	Italy	--	--	x	40,000	--
Minerva Ortopedica	Italy	x	250*	--	--	x
Minerva Pediatrica	Italy	x	800*	--	--	x
Minerva Stomatologica	Italy	x	200*	--	--	x
Mitteilungen der Virusdokumentationsstele Veroffentlicht im Rahmen der Osterreichischen Gesellschaft fur Mikrobiologie und Hygiene	Austria	x	200	--	--	x
Monatshefte fur Veterinar Medizin	Germany	x	700	--	--	x
Monitore Ostetrico-Ginecologico di Endocrinologia e dell Metabolismo	Italy	--	--	x	900*	x
Munchener Medizinische Wochenschrift	Germany	--	--	x	500	x
Der Nervenarzt	Germany	x	200*	--	--	x
Neurologia, Neurochirurgia i Psychiatria Polska	Poland	x	250	--	--	x
Nichidai Igaku Zasshi. Nihon University Medical Journal	Japan	x	120	--	--	x
Nihon Naibunpi Gakkai Zasshi. Folia Endocrinologica Japonica	Japan	x	500	--	--	x
Nihon Naika Shonika Chuo Zasshi. Abstracts of Internal Medicine and Pediatrics from Japanese Journals	Japan	x	10,000*	--	--	--
Nordisk Medicin	Sweden	--	--	x	2,000	x
Nordisk Veterinaermedicin	Denmark	x	200*	--	--	x
Novinky Svetove Lekarske Literatury ve Statnich Vedeckych Knihovnach	Czechoslovakia	--	--	x	4,000*	--
Novinky Zahranicni Literatury. Zdravotnictvi	Czechoslovakia	x	3,000	--	--	--
Novye Knigi za Rubezhom. Seriya C: Biologiya, Meditsina, Sel'skoe Khozyaistvo	USSR	x	500	x	2,000	--

Title	Country	Provides Abstracts?	No Abstracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Section of Journal?
Nuclear-Medizin. Nuclear Medicine. Medecine Nucleaire	Germany	x	100*	--	--	x
Nuntius Radiologicus	Italy	x	350	x	1,000	x
Nutrition Abstracts and Reviews	Scotland	x	6,000*	--	--	--
Nutrition Information Abstracts	England	x	250*	--	--	--
Obstetricia y Ginecologia Latinoamericanas	Argentina	x	100*	--	--	x
Occupational Hygiene Abstracts (formerly Bulletin of Hygiene Reprints)	England	x	750*	--	--	--
Odontologisk Revy	Sweden	x	400	--	--	x
Osterreichische Apothekerzeitung	Austria	x	250*	--	--	x
Omnia Therapeutica	Italy	x	150*	--	--	x
Ophthalmic Literature	England	x	5,000*	--	--	--
Orthopaedics and Traumatology (Excerpta Medica. Section IXB)	Netherlands	x	1,700*	--	--	--
Orvosi Hetilap: Orvos-Egeszsegugyi Szakszervezet Lapja (Medical Weekly: Journal of the Doctors' and Health Workers' Trade Organization)	Hungary	x	1,000*	--	--	x
Panminerva Medica	Italy	x	250*	--	--	x
Paracelsus; Archiv der Praktischen Medizin	Austria	x	500*	--	--	x
Pediatria Polska	Poland	x	300	--	--	x
Pharmaceutisch Weekblad	Netherlands	x	150*	--	--	x
Pharmazeutische Zeitung	Germany	x	150	x	4,500	x
Pharmazeutische Zentralhalle fur Deutschland	Germany	x	1,200*	--	--	--
Pharmazeutisches Jahrbuch; Referatesammlung der Internationalen Pharmazeutisches Schrifttums im Jahre	Germany	x	3,000	--	--	--
Physiotherapy	England	x	150*	--	--	x
Poliomyelitis Abstracts	Netherlands	x	800	--	--	--
Polski Przeglad Chirurgiczny	Poland	x	400	--	--	x
Polski Tygodnick Lekarski	Poland	x	2,000	--	--	x
Polskie Archivum Medycyng Wewnetrznej	Poland	x	420	--	--	x
Pracovni Lekarstvi	Czechoslovakia	x	250	--	--	x
Prakticke Zubni Lekarstvi	Czechoslovakia	x	100*	--	--	x
Prehled Svetove Zdravotnicke Literatury	Czechoslovakia	--	--	x	40,000	--
Prehled Zemedelski Literatury (Zahranicni i Domaci)	Czechoslovakia	x	12,000	--	--	--
La Prensa Medica Argentina	Argentina	x	700	--	--	x
La Presse Medicale	France	x	2,200*	--	--	x
Produits Pharmaceutiques	France	x	?††	x	?††	x

Title	Country	Provides Abstracts?	No. Abstracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Section of Journal?
Quarterly Review of Scientific Publications. Series B: Biological Sciences	Poland	x	300*	--	--	x
Quintessenz der Zahnarztlichen Literatur	Germany	x	200*	--	--	--
Radiologia Medica	Italy	x	1,200*	--	--	x
Rassegna Bibliografica della Stampa Ostetrico-Ginecologica	Italy	x	1,500*	--	--	--
Rassegna di Dermatologia e Sifilografia	Italy	x	100*	--	--	x
Rassegna Trimestrale di Odontoiatria	Italy	x	100	--	--	x
Recueil de Medecine Veterinaire	France	x	300*	--	--	x
Referativno-Bibliograficheskii Spravochnik po Veterinarii	USSR	x	2,000	--	--	--
Referativnyi Zhurnal: Biologicheskaya Khimiya	USSR	x	30,000*	--	--	--
Referativnyi Zhurnal: Biologiya	USSR	x	145,000*	--	--	--
Referativnyi Zhurnal: Meditsinskaya Geografiya	USSR	x	2,100	--	--	--
Resumos Bibliograficos	Brazil	x	150	--	--	--
Review of Medical and Veterinary Mycology	England	x	700*	--	--	--
Revista de Ciencias Veterinarias	Portugal	x	1,000	--	--	x
Revista de la Asociacion Odontologica Argentina	Argentina	x	150	x	--	--
Revista de Psicoanalisis	Argentina	x	160	--	--	x
Revista de Referate din Literatura Sovietica de Specialitate: Biologie	Rumania	x	2,000*	--	--	--
Revista de Referate din Literatura Sovietica de Specialitate: Chirurgie	Rumania	x	500	--	--	--
Revista de Referate din Literatura Sovietica de Specialitate: Medicina Generala	Rumania	x	1,000	--	--	--
Revista de Referate din Literatura Sovietica de Specialitate: Stiinte Medico-Biologice	Rumania	x	2,500	--	--	--
Revista de Referate din Literatura Sovietica de Specialitate: Zootehnie-Medicina Veterinara	Rumania	x	2,800	--	--	--
Revista Espanola de Obstetricia y Ginecologia	Spain	--	--	x	1,500*	--
Revista Medico-Chirurgicala	Rumania	x	140	--	--	x
Revue Belge de Medecine Dentair (continuing the Revue Belge de Science Dentaire and Le Journal Dentair Belge)	Belgium	x	100	--	--	x

Title	Country	Provides Ab- stracts?	No. Ab- stracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Sec- tion of Journal?
Revue d'Elevage et de Medecine Veterinaire des Pays Tropicaux	France	x	200*	--	--	x
Revue de Chirurgie Orthopedique et Reparatrice de l'Appareil Moteur	France	x	150	--	--	x
Revue de Laryngologie, Otologie, Rhinologie	France	x	800*	x	1,500	x
Revue de Stomatologie	France	x	600*	--	--	x
Revue de Tuberculose et de Pneumologie	France	x	500*	--	--	x
Revue des Corps de Sante des Armees-Terre, Mer, Air	France	x	350	--	--	x
Revue du Rhumatisme et des Maladies Osteo-Articulaires	France	x	300*	x	2,000*	x
Revue Francaise d'Odonto-Stomatologie	France	x	150	x	1,000	x
Revue Internationale des Services de Sante des Armees de Terre, de Mer et de l'Air. International Review of the Army, Navy and Air Force Medical Services. Organ of the International Office of Military Medicine Documentation	France	x	1,000	--	--	x
Revue Neurologique	France	x	250*	--	--	x
Rinsho Hifu Hinyokika. Dermatologica et Urologica	Japan	--	--	x	1,000	--
Rinsho Ketsueki, Japanese Journal of Clinical Hematology	Japan	--	--	x	1,500	--
Rivista di Clinica Pediatrica	Italy	--	--	x	1,200	x
Rivista di Gerontologia e Geriatria	Italy	x	200*	--	--	x
Rivista di Malariologia	Italy	x	400*	--	--	x
Rivista di Medicina Aeronautica e Spaziale	Italy	x	100*	--	--	x
Rivista di Ostetricia e Ginecologia	Italy	x	150*	--	--	x
Rivista Italiana di Stomatologia	Italy	--	--	x	1,500	x
Rozhledy v Tuberkulose a v Nemocech Plicnich	Czechoslovakia	x	150*	--	--	x
Schweizerische Medizinische Wochenschrift. Journal Suisse de Medecine	Switzerland	x	900*	--	--	x
Schweizerische Monatsschrift fur Zahnheikunde	Switzerland	x	400-500	--	--	x
Science Abstracts of China: Biological Sciences	China	x	1,000	--	--	--
La Semaine des Hopitaux	France	x	10,000*	--	--	x
Sheng Wu Hsueh Wen Chai--Chih Wu Hsueh Pu Fen (Biological Abstracts--Botany Section)	China	x	5,000	--	--	--
Sheng Wu Hsueh Wen Chai--Tung Wu Hsueh Pu Fen (Biological Abstracts-Zoology Section)	China	x	6,000	--	--	--

Title	Country	Provides Ab- stracts?	No. Ab- stracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Sec- tion of Journal?
Sheng Wu Hua Hsueh Wen Chai--K'ang Sheng Su Teng Pu Fen. (Biochemical Abstracts--Antibiotics Section)	China	x	2,500	--	--	--
Shonika Rinsho. Japanese Journal of Pediatrics	Japan	--	--	x	400	x
Smokeless Air	England	x	100	--	--	x
Staub	Germany	x	300-500*	x	1,500-2,000*	--
Studii si Cercetair de Biochimie	Rumania	x	300	--	--	x
Takeda Kenkyujo Nempo. Annual Reports of the Takeda Research Laboratory	Japan	x	100	--	--	x
Tampakushitsu, Kakusan, Koso. Protein Nucleic Acid Enzyme	Japan	x	150	--	--	x
Technique Pharmaceutique	France	--	--	x	?	--
Tijdschrift voor Tandheelkunde	Netherlands	x	300*	--	--	x
Tropical Diseases Bulletin	England	x	2,500*	--	--	x
Der Tuberkulosearzt	Germany	x	700*	--	--	x
Tuberkuloza	Yugoslavia	x	150	--	--	x
Urologia	Italy	x	200	--	--	x
Vestnik Dermatologii i Venerologii	USSR	x	300	--	--	x
Veterinariya	USSR	x	120	--	--	x
Veterinarstvo	Yugoslavia	x	1,600	--	--	x
Veterinary Bulletin	England	x	4,200*	--	--	--
Voenno-Meditsinskii Zhurnal	USSR	x	300	--	--	x
Vojnosanitetski Pregled	Yugoslavia	x	600	--	--	x
Was Gibt es Neues in der Medizin?	Germany	x	100	--	--	x
Wiener Medizinische Wochenschrift	Austria	x	1,100*	--	--	x
Wiener Tierarztliche Monatsschrift	Austria	x	500	--	--	x
World-Wide Abstracts of General Medicine	Netherlands	x	500*	--	--	--
Zeitschrift fur Artzliche Fortbildung	Germany	x	150	--	--	x
Zeitschrift fur Alternsforschung	Germany	x	300	--	--	x
Zeitschrift fur Kreislaufforschung	Germany	x	250*	--	--	x
Zeitschrift fur Orthopadie und Ihre Grenzgebiete	Germany	x	400	--	--	x
Zeitschrift fur Rheumaforschung	Germany	x	400*	--	--	x
Zeitschrift fur Tuberkulose und Erkrankungen der Thoraxorgane	Germany	x	500*	--	--	x
Zeitschrift fur Urologie	Germany	x	250*	--	--	x
Zeitschrift fur Wissenschaftliche Mikroskopie und fur Mikroskopische Technik	Germany	x	100*	--	--	x
Zentralblatt fur Allgemeine Pathologie und Pathologische Anatomie	Germany	x	200*	--	--	x
Zentralblatt fur Arbeitsmedizin und Arbeitsschutz	Germany	x	500*	--	--	x
Zentralblatt fur Bakteriologie, Parasitenkunde, Infectionskrankheiten und Hygiene. Abt.1. Medizinisch-Hygienische Bakteriologie, Virusforschung und Parisitologie. Referate	Germany	x	10,000*	--	--	--

Title	Country	Provides Abstracts?	No. Abstracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Section of Journal?
Zentralblatt fur Bakteriologie, Parasitenkunde, Infektionskrankheiten und Hygiene. Abt.2. Allgemeine Landwirtschaftliche, Technische, Nahrungsmittel-Bakteriologie und Mykologie, Protozoologie Section: Referate	Germany	x	750*	--	--	--
Zentralblatt fur die Gesamte Kinderheilkunde	Germany	x	1,500*	--	--	--
Zentralblatt fur die Gesamte Neurologie und Psychiatrie	Germany	x	1,500*	--	--	--
Zentralblatt fur die Gesamte Ophthalmologie und Ihre Grenzgebiete	Germany	x	1,500*	--	--	--
Zentralblatt fur die Gesamte Radiologie	Germany	x	1,500*	--	--	--
Zentralblatt fur die Gesamte Tuberkuloseforschung	Germany	x	1,500*	--	--	--
Zentralblatt fur Hals-, Nasen- und Ohrenheilkunde Sowie Deren Grenzgebiete	Germany	x	1,500*	--	--	--
Zentralblatt fur Haut- und Geschlechtskrankheiten Sowie Deren Grenzgebiete	Germany	x	1,500*	--	--	--
Zentralorgan fur die Gesamte Chirurgie und Ihre Grenzgebiete	Germany	x	1,500*	--	--	--
Zhurnal Mikrobiologii, Epidemiologii i Immunobiologii	USSR	x	200	--	--	x
Zootecnica e Veterinaria	Italy	x	500	--	--	x
Totals (one service issued as cards)	(No. of Services) 326	274	803,340	63	242,350	190

Source: National Federation of Science Abstracting and Indexing Services. Guide to the World's Abstracting and Indexing Services in Science and Technology. Washington, D.C., NFSAIS, 1963.

Explanatory Notes: Column 1-- country of publication; Column 2-- X indicates that the given service publishes abstracts; Column 4--X indicates that the given service lists document titles or indexes documents that it does not abstract; Column 5--figures indicate number of documents processed by title listing or indexing but not abstracted; Column 6--X signifies that the service appears as a section in a journal devoted primarily to other types of material (original articles, reviews, etc.).

* The source description of the service specifically mentions that subject indexes to these documents are provided.

† Provides "600 abstracts and references," i.e., of the total of 600 documents processed, the service abstracts some and lists the titles of the remainder.

†† Provides "500 abstracts and references" a year.

APPENDIX VIII-B

UNITED STATES ABSTRACTING AND INDEXING SERVICES OF INTEREST TO BIOMEDICINE

(See Explanatory Notes at End)

Title	Provides Abstracts?	No. Abstracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Section of Journal?	Issued as Cards?
Abstracts from World Medical Literature**	x	240	--	--	--	--
Abstracts of Bioanalytic Technology**	x	200	--	--	--	--
Abstracts of Human Developmental Biology**	x	2,000*	--	--	--	--
Abstracts of Japanese Medicine**	x	6,000*	--	--	--	--
Abstracts of Selected Articles from Soviet Bloc and Mainland China Technical Journals. Series VI: General Science and Miscellaneous, including Meteorology, Oceanography, Biology, Astrobiology, Botany, Zoology, Medical Science, Aeromedicine, Education, Fuels, Fuel Products, and Power, etc.**	x	2,600	--	--	--	--
Abstracts of World Medicine	x	3,000*	--	--	--	--
Aerospace Medicine**	x	1,000*	--	--	x	--
Aerospace Medicine and Biology: an Annotated Bibliography**	x	3,000*	--	--	--	--
Agricultural Index	--	--	x	40,000	--	--
Air Pollution Bibliography**	x	800*	--	--	--	--
America Clinica	x	300*	--	--	--	--
American Annals of the Deaf	--	--	x	125*	x	--
American Journal of Clinical Nutrition**	x	500*	--	--	x	--
American Journal of Gastroenterology	x	400	--	--	x	--
American Journal of Obstetrics & Gynecology	x	150*	--	--	x	--
American Journal of Ophthalmology	x	450*	--	--	x	--
American Journal of Psychotherapy	x	120	--	--	x	--
American Journal of Public Health and the Nation's Health	x	400	--	--	x	--
American Journal of Roentgenology, Radium Therapy and Nuclear Medicine	x	300	--	--	x	--
American Review of Respiratory Diseases	x	1,250*	--	--	x	--
Anesthesia Abstracts	x	500*	--	--	--	--
Anesthesiology	x	450	--	--	x	--
Annals of Allergy	x	150	--	--	x	--
An Annotated Bibliography of Influenza**	x	600*	--	--	--	--

Title	Provides Ab-stracts?	No. Ab-stracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Sec-tion of Journal?	Issued as Cards?
Archives of Dermatology	x	280*	--	--	x	--
Archives of Environmental Health	x	400*	--	--	x	--
Archives of Neurology	x	200*	--	--	x	--
Archives of Oral Biology**	--	--	x	1,200	x	--
Archives of Physical Medicine and Rehabilitation	x	300*	--	--	x	--
The Auburn Veterinarian	x	100*	--	--	x	--
Bibliography of Agriculture	--	--	x	100,000*	--	--
Bibliography of Medical Reviews**	--	--	x	2,300*	--	--
Bibliography on Medical Electronics**	--	--	x	2,000*	--	--
Biochemical Title Index**	--	--	x	24,000*	--	--
Biological Abstracts	x	100,000*	--	--	--	--
Blood, The Journal of Hematology	x	700*	--	--	x	--
Boletin de la Oficina Sanitaria Panamericana	x	400*	--	--	x	--
Bulletin of the Medical Library Association**	x	?†	x	?†	x	--
COPNIP List**	--	--	x	300*	--	--
Cancer Chemotherapy Abstracts**	x	5,000*	--	--	--	--
Cancer Immunology Abstracts**	x	600	--	--	--	--
Chemical Abstracts	x	165,000*	--	--	--	--
Chemical Titles**	--	--	x	75,000*	--	--
Child Development Abstracts & Bibliography	x	850*	--	--	--	--
Circulation	x	1,000*	--	--	x	--
Classified Abstract Archive of the Alcohol Literature**	x	450	--	--	--	x
Clinical Chemistry**	x	200	--	--	x	--
Clinical Medicine**	x	100	--	--	x	--
Current Contents of Chemical, Pharmaco-Medical and Life Sciences**	--	--	x	?	--	--
Current Literature--Arthritis and Related Diseases**	x	1,000*	--	--	--	--
Current Literature--Congenital Anomalies**	x	1,500*	--	--	--	--
Current Literature--Poliomyelitis and Related Diseases	x	1,500*	--	--	--	--
Current Literature on Venereal Disease**	x	500*	--	--	--	--
Current Scientific Literature Review; Gastro-Intestinal Abstracts**	x	1,000	--	--	--	--
DSH Abstracts**	x	1,600*	--	--	--	--
Dental Abstracts	x	1,000*	--	--	--	--
Dental Digest	x	100*	--	--	x	--
Dental World	x	160	--	--	x	--
Diabetes	x	300*	--	--	x	--
Digest of Neurology and Psychiatry	x	450*	--	--	x	--
Diseases of the Colon and Rectum**	x	600	--	--	x	--
Drug and Cosmetic Industry	x	200*	--	--	x	--
E.E.N.T. Digest	x	500	--	--	--	--

Title	Provides Abstracts?	No. Abstracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Section of Journal?	Issued as Cards?
Encyclopedia of Contact Lens Practice**	x	120	--	--	x	--
GP	x	250*	--	--	x	--
Gastroenterology	x	1,000*	--	--	x	--
Geriatrics	x	280	--	--	x	--
Headache**	x	70*	--	--	x	--
Hospital Abstract Service**	x	100-150	--	--	--	x
Hospital Literature Index	--	--	x	17,500*	--	--
Hospital Planning Abstract Service**	x	150	--	--	--	x
Human Engineering Bibliography**	x	1,500	--	--	--	--
I.C.R.S. Medical Reports**	--	--	x	1,500*	--	--
Index-Catalogue of Medical and Veterinary Zoology. Supplement. Authors**	--	--	x	12,000	--	--
Index Chemicus**	x	?††	--	--	--	--
Index Medicus	--	--	x	145,000*	--	--
Index Medicus Homoeopathicus Cumulativus**	--	--	x	450	--	--
Index to Dental Literature	--	--	x	7,000*	--	--
International Journal of Fertility**	x	500	--	--	x	--
International Journal of Leprosy	x	250*	--	--	x	--
International Medical Digest	x	600*	--	--	--	--
International Surgical Digest	x	500*	--	--	--	--
Journal of Allergy	x	200*	--	--	x	--
The Journal of Applied Nutrition	x	120	--	--	x	--
Journal of Clinical and Experimental Psychopathology and Quarterly Review of Psychiatry and Neurology	x	200*	--	--	x	--
Journal of Gerontology	--	--	x	4,200	x	--
Journal of Histochemistry and Cytochemistry**	--	--	x	600	x	--
Journal of Medical Laboratory Technology	x	400	--	--	x	--
Journal of Occupational Medicine**	x	500*	--	--	x	--
Journal of Osteopathy**	x	125	--	--	x	--
Journal of Speech and Hearing Disorders	x	350	--	--	x	--
Journal of the Air Pollution Control Assoc.	x	750*	--	--	x	--
Journal of the American Dental Assoc.	x	200*	--	--	x	--
Journal of the American Dental Society of Anesthesiology, Inc. **	x	100*	--	--	x	--
Journal of the American Dietetic Assoc.	x	600*	--	--	x	--
Journal of the American Geriatrics Society**	x	300	--	--	x	--
Journal of the American Medical Assoc.	x	2,600*	--	--	x	--
Journal of the American Optometric Assoc.**	x	100	--	--	x	--
Journal of the American Osteopathic Assoc.	x	120*	--	--	x	--

Title	Provides Abstracts?	No. Abstracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Section of Journal?	Issued as Cards?
Journal of the American Physical Therapy Assoc. **	x	160	--	--	x	--
Journal of the American Podiatry Assoc. **	x	200*	--	--	x	--
Journal of the American Veterinary Medical Assoc.	x	350*	--	--	x	--
Lab World	x	2,000*	--	--	x	--
Leukemia Abstracts**	x	1,200*	--	--	--	--
Medical Abstract Service	x	100-150	--	--	--	x
Medical Abstracts from Current Medical Literature, Annotated Bibliographies, Abstracts (on reproducible cards), References (IBM cards)	x	4,000-5,000	x	4,000-5,000	--	x
Medical and Biological Illustration	x	4,000*	--	--	x	--
Medical Digest**	x	1,000	--	--	--	--
Medical Times	x	100	--	--	x	--
Metabolism: Clinical and Experimental**	x	200*	--	--	x	--
Microchemical Journal**	x	1,000	--	--	x	--
Modern Veterinary Practice Reference & Data Library**	x	2,400*	--	--	--	x
Monthly Accession List**	x	700	--	--	--	--
Multiple Sclerosis Abstracts**	x	1,700*	--	--	--	--
Muscular Dystrophy Abstracts**	x	1,200*	--	--	--	--
National Library of Medicine Catalog	--	--	x	15,000*	--	--
Nuclear Science Abstracts	x	33,000*	--	--	--	--
Obstetrical and Gynecological Survey	x	350*	--	--	--	--
Polish Medical Science and History Bulletin**	x	1,200*	--	--	x	--
The Psychoanalytic Quarterly	x	150*	--	--	x	--
Psychological Abstracts	x	10,000*	--	--	--	--
Psychopharmacology Abstracts	x	3,000	--	--	--	--
Psychosomatic Medicine	x	140	--	--	x	--
Public Health Economics	x	400*	--	--	x	--
Public Health Engineering Abstracts	x	2,200*	--	--	--	--
Quarterly Journal of Studies on Alcohol	x	400	--	--	x	--
Quarterly Review of Biology	x	?*##	x	?*##	x	--
Radiology	x	1,350*	--	--	x	--
Rehabilitation Literature	x	1,960	--	--	x	--
Review of Allergy and Applied Immunology	x	600*	--	--	x	--
Review of Modern Medicine (formerly Modern Medicine. Abstracts also appear in Modern Medicine)	x	1,100*	--	--	--	--

Title	Provides Abstracts?	No. Abstracts /yr.	Lists or Indexes only?	No. Documents Listed or Indexed/yr.	Printed as Section of Journal?	Issued as Cards?
The Sight-Saving Review	x	120*	--	--	x	--
Stain Technology	x	100*	--	--	x	--
Surgery, Gynecology and Obstetrics	x	2,300*	--	--	x	--
Survey of Anesthesiology**	x	300-400*	--	--	--	--
Tissue Culture Bibliography**	--	--	x	1,200*	--	--
Ulcerative Colitis Abstracts**	x	500	--	--	--	--
Unlisted Drugs (loose leaf)	x	?#	--	--	--	--
Upper Respiratory Infections	x	275	--	--	--	--
Urological Survey	x	500*	--	--	--	--
Vitamin Abstracts	x	430	--	--	--	--
What's New	x	100-150	--	--	x	--
Totals (No. of Services) 142	122	403,170	23	453,375	75	7

Source: National Federation of Science Abstracting and Indexing Services. Guide to the World's Abstracting and Indexing Services in Science and Technology. Washington, D.C., NFSAIS, 1963.

Explanatory Notes

* The source description of the service specifically mentions that subject indexes to these documents are provided.

** These services have existed only since 1952.

† Provides "135 abstracts and references" a year, i.e., either an abstract or the title of documents.

†† Provides "graphic" abstracts of the synthesis of about 100,000 new chemical compounds annually and indexes these compounds. More than one abstract is produced for documents describing the synthesis of more than one chemical compound.

\# Provides about 2,000 "abstracts" (annotated references) yearly relating to drug names that have not previously appeared in standard compilations.

\## Provides "400 references and abstracts" per year.

APPENDIX VIII-C

SAMPLE JOURNALS NOT COVERED BY SERVICES

Using the tabulations of the coverage of "sample journals" by the 13 abstracting-indexing services reported in Table VIII-4 and Appendix D, four groups of "sample journals" were singled out for special attention: (1) those not covered by any of the 13 services listed in Table VIII-4; (2) those not covered by any of the 6 biomedical abstracting-indexing services listed in Table VIII-5; (3) those not covered by any of the four abstracting services listed in Table VIII-6; and (4) those not covered by IM. Publications falling into these groups were rechecked in an effort to ensure that their titles were complete and correct and that they qualified as "journals" by our definition (issued more often than annually). In the course of this rechecking*, we found additional data on periodicity that definitely excluded several publications from further consideration as journals. Publications listed as "irregular" were accepted as journals, as were those for which no explicit statement of periodicity could be found but for which the acceptance seemed reasonable.

Each journal title was then checked with the latest available lists of journals covered by IM, CA, BA, EM, and PA.** Because a number of the journals that fell into one or more of the groups pertained to dentistry, these were also checked against a list of journals covered by the Index to Dental Literature (supplied by Dr. Donald Washburn, Director, Bureau of Library and Indexing Service, American Dental Association). These more current lists indicated coverage of numerous sample journals not shown in "Lists of Science Serials Covered by Members of NFSAIS"(2), the basic reference used for the original tabulations. This appendix summarizes the new information developed by this analysis.

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* National Library of Medicine. List of Journals Indexed in Index Medicus. Index Medicus, Vol. 4, No. 1, January 1963, pp. LJI-39-73. Ayer, N.W. and Sons Directory of Newspapers and Periodicals. Philadelphia, N.W. Ayer and Sons, 1963. New Serial Titles; a Union List of Serials Commencing Publication after December 31, 1949. (Joint Committee on the Union List of Serials.) Washington, D.C., Card Division, Library of Congress. 1950--. Union List of Serials in Libraries of the United States and Canada. 2nd ed. Supplements, 1941-1943, 1944-1949. New York, H.W. Wilson Company, 1943, 1945, 1953. 3 vols. Ulrich's Periodicals Directory. 10th ed. New York, R.R. Bowker Company, 1963 Chemical Abstracts Service. Chemical Abstracts List of Periodicals, 1961. Washington, D.C., American Chemical Society, 1961. National Library of Medicine. Biomedical Serials, 1950-1960. Public Health Service Publication No. 910. Washington, D.C. U.S. Government Printing Office, 1962. World Medical Periodicals. New York, World Medical Association, 1961.

** IM list dated January 1963; CA, 1961 list and 1962 supplement; BA, July 1963; PA, 1962; and undated list supplied by Peter Warren of the Excerpta Medica Foundation, who stated that recent additions to the coverage of EM (particularly Japanese journals) were not included.

Non-coverage of a certain number of the sample journals by a given service or combination of services should not be construed as evidence of poor performance of any service without studying the character of the journals involved. An examination of these journals discloses (1) that most carried relatively few of the sample papers; (2) that some of the journals containing considerable numbers of sample papers publish abstracts of oral reports, which most abstracting-indexing services do not process on the assumption that the work will be published in full later; (3) that several are periodicals devoted primarily to abstracts of journal literature but carrying a few original articles of a review nature; and (4) that a few are journals started only within the last few years.

In the tabulations that follow, an asterisk after the title indicates that the publication's periodicity has not been definitely established, a dagger (†) designates journals known to publish considerable numbers of abstracts of oral reports, and "DI" designates journals covered by the Index to Dental Literature.

Part I. Sample journals not covered by any of the 13 abstracting-indexing services in Table VIII-4.

Journal Title	No. Sample Articles in Journal
American Dental Hygienists' Association Journal (DI)	1
Journal of Dental Education (DI)	1
Journal of the District of Columbia Dental Society (DI)	4
Journal of Periodontology (DI)	9
Nursing Forum	4
Pharmacologist†	41
Quarterly of the National Dental Association (DI)	2
Revista Brasileira de Odontologia	1
Revista de la Sociedad Chilena de Urologea*	5

No. of sample journals = 9

No. of sample articles = 68

Part II. Sample journals not covered by any of the 6 abstracting-indexing services in Table VIII-5 (in addition to those listed in Part I).

Journal Title	No. Sample Articles in Journal
Association for Computing Machinery. Journal	1
Communication and Electronics	1
Control Engineering	1
Electrical Engineering	1
Revista de la Universidad Industrial de Santander*	3

No. of sample journals = 5 + 9 (from Part I) = 14

No. of sample articles = 7 + 68 (from Part I) = 75

Part III. Sample Journals not covered by any of the four abstracting services in Table VIII-6 (in addition to those listed in Parts I and II).

Journal Title	No. Sample Articles in Journal
Alabama Dental Review (DI)	2
Annales de Chirurgie Thoracique et Cardio-Vasculaire*	4
Arizona Medicine	1
Bibliotheca Anatomica	1
Bulletin of Akron City Hospital	1
Bulletin of Gastrointestinal Endoscopy*	2
Bulletin of the Sloane Hospital for Women	2
Bulletin of the University of Miami School of Medicine and Jackson Memorial Hospital	1
Cancer Bulletin, Texas Edition	1
Chicago Medicine	2
Connecticut Medicine	6
Current Psychiatric Therapies*	2
Current Therapeutic Research, Clinical and Experimental	3
Dental Progress (DI)	11
Ergebnisse der Allgemeinen Pathologie und Pathologischen Anatomie	2
Ganno Rinsho (Japanese Journal of Cancer Clinics)	2
Illinois Research	1
International Abstracts of Surgery	1
International Ophthalmology Clinics	1
Investigative Ophthalmology	35
Japanese Journal of Human Genetics	5
Journal of the American Physical Therapy Association	1
Journal of the Mississippi State Medical Association	1
Journal of Sport Medicine and Physical Fitness	2
London Clinic Medical Journal	1
Medical Record and Annals	1
Middle East Medical Journal*	1
Modern Hospital	2
National Fur News	1
Physical Therapy Review	1
Physiologist†	94
Presbyterian-St. Luke's Hospital Medical Bulletin*	1
Rein et Foie; Maladies de la Nutrition*	1
Revista Argentina de Circugia	1
Spastics Quarterly	1
Survey of Ophthalmology	3
Traffic Safety	1
Vie Medicale	1
Western Veterinarian*	1

No. of sample journals = 39 + 14 (from Parts I and II) = 53

No. of sample articles = 201 + 75 (from Parts I and II) = 276

Part IV. Sample journals not covered by Index Medicus (in addition to those listed in Parts I and II).

Journal Title	No. Sample Articles in Journal
Acarologia*	3
Acta Chemica Scandinavia	11
Acta Crystallographica	25
Acta Physica Austriaca	2
Acta Zoologica Mexicana	1
AIBS Bulletin	2
A.I.Ch.E. Journal	3
American Annals of the Deaf	1
American Anthropologist	1
American Biology Teacher	1
American Documentation	1
American Journal of Botany	1
American Journal of Orthodontics	13
American Midland Naturalist	12
American Milk Review and Milk Plant Monthly	4
American Naturalist	1
American Potato Journal	4
American Psychologist†	1
American Sociological Review	8
American Zoologist†	3
Analytica Chimica Acta	92
Analytical Chemistry	1
Angewandta Chemie	36
Angle Orthodontist	4
Animal Behavior	7
Annals of the Entomological Society of America	1
Anzeiger fuer Schadlingskunde vereinigt mit Schadlingsbekampf	4
Applied Spectroscopy	1
Archiv fuer Experimentelle Veterinarmedizin	1
Archiv fuer Protistenkunde	1
Archivio Zoologico Italiano*	2
Arkiv fuer Kemi	1
ASB Bulletin*	4
ASHRAE Journal	5
Australian Journal of Science	1
Australian Journal of Zoology	3
Avian Diseases	1
Behaviour	5
Biological Bulletin	2
Bolletino di Zoologia Agraria e Bachicoltura, Universita degli Study di Milano	46
Botanical Gazette	2
Bulletin of the Brooklyn Entomological Society	1
Bulletin of the Chemical Society of Japan	3
Bulletin of the Ecological Society of America	2
Bulletin of Marine Science of the Gulf and Caribbean	1
Bulletin of the Museum of Comparative Zoology	1
Bulletin on Narcotics	2
	1

Part IV. (continued)

Journal Title	No. Sample Articles in Journal
Canadian Journal of Botany	2
Canadian Journal of Chemistry	8
Canadian Journal of Zoology	7
Canadian Veterinary Journal	1
Carnegie Institution of Washington Publication	1
Casopis Ceckoslovenska Spolecnosti	1
Cereal Science Today	1
Chemical Engineering	1
Chemistry and Industry	22
Chemisch Weekblad	1
Child Welfare	1
Ciencia e Cultura	3
Clinical Research†	187
Contributions from Boyce Thompson Institute	2
Copeia	3
Cornell Plantations	3
Crop Science	2
Dental Digest (DI)	1
Deutsch Botanishe Gessellschaft Berichte	1
Dissertation Abstracts	2
Ecology	2
Educational and Psychological Measurement	6
Electrochimica Acta	2
Embryologia	1
Ergonomics	2
Evolution	2
Exceptional Children	1
Finska Kemistsamfundets Meddelanden	1
Florida Entomologist	1
Food Technology	7
Fruchtsaft Industrie	1
Genetical Research	1
Health Education Journal and Health Information Digest	3
Highlights of Agricultural Research	1
Hilgardia	2
Human Relations	1
Illinois Research	1
International Bulletin of Bacteriological Nomenclature and Taxonomy	2
International Dental Journal (DI)	1
International Social Science Journal	1
Japanese Journal of Genetics	2
Journal of the Acoustical Society of America	27
Journal of Agricultural and Food Chemistry	1
Journal of the American Association of Nurse Anesthetists	1
Journal of American Chemical Society	213
Journal of American College of Dentists (DI)	1
Journal of the American Oil Chemists Society	20

Part IV. (continued)

Journal Title	No. Sample Articles in Journal
Journal of the American Statistical Association	1
Journal of the American Waterworks Association	8
Journal of Animal Science	8
Journal of Applied Psychology	3
Journal of Biochemical and Microbiological Technology and Engineering	1
Journal of Chemical and Engineering Data	2
Journal of Chemical Education	1
Journal of Chemical Physics	22
Journal of the Chemical Society	14
Journal de Chimie Physique et de Physicochimie Biologique	11
Journal of the Chinese Chemical Society (Taiwan)	1
Journal of Colloid Science	2
Journal of Counseling Psychology	1
Journal of Dairy Science	29
Journal of Dental Medicine (DI)	2
Journal of Economic Entomology	26
Journal of the Elisha Mitchell Scientific Society	2
Journal of Existential Psychiatry	1
Journal of Experimental Botany	1
Journal of Fluid Mechanics	1
Journal of Food Science	8
Journal of Genetics	1
Journal of Home Economics	1
Journal of Industrial Engineering	1
Journal of Inorganic and Nuclear Chemistry	5
Journal of Insect Pathology	2
Journal of Insect Physiology	8
Journal of Kansas Entomological Society	2
Journal of Mammalogy	5
Journal of Milk and Food Technology	2
Journal of Molecular Spectroscopy	1
Journal of Obstetrics and Gynaecology of India	1
Journal of Organic Chemistry	167
Journal of Paleontology	2
Journal of Physical Chemistry	25
Journal of Polymer Science	12
Journal of Prosthetic Dentistry (DI)	11
Journal of Psychology	7
Journal of the Research Institute for Catalysis, Hokkaido University	1
Journal of the Science of Food and Agriculture	1
Journal of Social Issues	3
Journal of the Society of Cosmetic Chemists	2
Journal of the Society of Leather Trades' Chemists	1
Journal of Social Psychology	2
Journal of the Society of Motion Picture and Television Engineers	1
Journal of the Tennessee Academy of Science	1
Journal of Water Pollution Control Federation	1

Part IV. (continued)

Journal Title	No. Sample Articles in Journal
Journal of Wildlife Management	1
Laboratory Practice	1
Lavori Dell' Instituto di Anatomia e Istolgia Patologica della Universita degli Studi di Perugia	9
Limnology and Oceanography	6
Lloydia	4
Makromolekulare Chemie	3
Medicine et Hygiene	3
Microchemical Journal	3
Mikrochimica Acta	2
Modern Medicine	4
Mosquito News	7
Mycologia	4
National Fur News	1
Naval Research Reviews	1
New York Journal of Dentistry (DI)	2
New Zealand Dental Journal (DI)	2
Northwest Science	1
Odontologiska Foreningens Tidskrift (DI)	1
Pacific Insects*	2
Pacific Science	2
Parodontology (DI)	3
Personnel Psychology	1
Philippine Journal of Science	1
Physiologia Plantarum	4
Physiological Zoology	3
Phytochemistry	1
Phyton (Buenos Aires)	1
Phytopathology	21
Plant and Soil	1
Plant Disease Reporter	2
Plant Physiology	24
Planta Medica	2
Poultry Science	8
Praxis: Schwizer Rundschau fuer Medizin	1
Proceedings of the American Philosophical Society	1
Proceedings of the American Society for Horticultural Science	1
Proceedings of the Entomological Society of Washington	3
Proceedings of the Helminthological Society of Washington, D.C.	3
Proceedings of the Indiana Academy of Science	1
Proceedings of the Institute of Radio Engineers*	2
Proceedings of the Japan Academy	8
Proceedings of the Marketing Section of the Association of Southern Agricultural Workers*	2
Proceedings of the South Dakota Academy of Science	1
Proceedings of the Zoological Society of London	1
Psychological Monographs	4
Psychological Record	6
Psychological Reports	37
Psychologische Beitraege	1

Part IV. (continued)

Journal Title	No. Sample Articles in Journal
Psychometrika	2
Public Opinion Quarterly	1
Pure and Applied Chemistry	4
Quaderni di Criminologia Clinica	1
Reading Teacher	1
Recueil des Travaux Chimiques des Pays-Bas	2
Review of Scientific Instruments	7
Revista de Biologia Tropical	1
Revue de Psychologie Appliquee	2
Rheology Bulletin	2
Rhodora	1
Schweizer Archiv fuer Tierheilkunde	2
Sight-Saving Review	1
Social Casework	1
Social Forces	2
Social Problems	1
Societa Peloritana di Scienze Fisiche Matematiche e Naturali. Atti.	1
Sociometry	1
Soil Science	2
Southern California Academy of Sciences Bulletin	2
Spectrochimica Acta	2
Svensk Tandlakare-Tidscrift (DI)	1
Teachers College Record	1
Tetrahedron	19
Tetrahedron Letters	8
Texas Journal of Science	1
Traffic Safety	1
Transactions of the American Microscopical Society	10
Transactions of the Society of Rheology	1
Tulane Studies in Zoology*	5
Turtox News	3
University of Texas Publication	14
Utah Farm and Home Science*	1
Veterinary Medicine	2
Veterinary Record	1
Virginia Journal of Science	4
Vision Research	3
Volta Review	1
Wasmann Journal of Biology	1
Water and Sewage Works	2
Weeds	2
Western Veterinarian	1
Wildlife Disease	1
Zeitschrift fuer Morphologie und Antropologie	1
Zeitschrift fuer Physiologische Chemie	3
Zeitschrift fuer Tierpsychologie*	1

No. of sample journals = 235 + 14 (from Parts I and II) = 249

No. of sample articles = 1,623 + 75 (from Parts I and II) = 1,698

APPENDIX VIII-D

MULTIPLE PROCESSING OF SAMPLE* OF OUTPUT OF U.S. BIOMEDICAL RESEARCH BY SIX MAJOR ABSTRACTING-INDEXING SERVICES

Explanatory Note: IM = Index Medicus, BA = Biological Abstracts,
BAg = Bibliography of Agriculture,
CA = Chemical Abstracts, EM = Excerpta Medica,
PA = Psychological Abstracts

Part I. Journals

	IM	BA	BAg	CA	EM	PA
Alone	63	28	13	22	17	10
IM	--	5	3	26	90	4
BA	5	--	11	12	4	4
BAg	3	11	--	13	0	2
CA	26	12	13	--	3	0
EM	90	4	0	3	--	7
PA	4	4	2	0	7	--
IM BA	--	--	0	19	26	6
IM BAg	--	0	--	3	1	1
IM CA	--	19	3	--	35	0
IM EM	--	26	1	35	--	4
IM PA	--	6	1	0	4	--
BA BAg	0	--	--	66	2	4
BA CA	19	--	66	--	3	2
BA EM	26	--	2	3	--	4
BA PA	6	--	4	2	4	--
BAg CA	3	66	--	--	1	3
BAg EM	1	2	--	1	--	2
BAg PA	1	4	--	3	2	--
CA EM	35	3	1	--	--	0
CA PA	0	2	3	--	0	--
EM PA	4	4	2	0	--	--
IM BA BAg	--	--	--	8	9	1
IM BA CA	--	--	8	--	134	1
IM BA EM	--	--	9	134	--	17
IM BA PA	--	--	1	1	17	--
IM BAg CA	--	8	--	--	3	0
IM BAg EM	--	9	--	3	--	0
IM BAg PA	--	1	--	0	0	--
IM CA EM	--	134	3	--	--	8
IM CA PA	--	1	0	--	8	--
IM EM PA	--	17	0	8	--	--
BA BAg CA	8	--	--	--	10	2

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* The sample consisted of 14,334 journal articles by NIH grantees cited in NIH Research Grants Index, 1962. These articles appeared in 882 different journals.

Part I. Journals (continued)

	IM	BA	BAg	CA	EM	PA
BA BAg EM	9	--	--	10	--	2
BA BAg PA	1	--	--	2	2	--
BA CA EM	134	--	10	--	--	2
BA CA PA	1	--	2	--	2	--
BA EM PA	17	--	2	2	--	--
BAg CA EM	3	10	--	--	--	0
BAg CA PA	0	2	--	--	0	--
BAg EM PA	0	2	--	0	--	--
CA EM PA	8	2	0	--	--	--
IM BA BAg CA	--	--	--	--	67	2
IM BA BAg EM	--	--	--	67	--	2
IM BA BAg PA	--	--	--	2	2	--
IM BA CA EM	--	--	67	--	--	29
IM BA CA PA	--	--	2	--	29	--
IM BA EM PA	--	--	2	29	--	--
IM BAg CA EM	--	67	--	--	--	0
IM BAg CA PA	--	2	--	--	0	--
IM BAg EM PA	--	2	--	0	--	--
IM CA EM PA	--	29	0	--	--	--
BA BAg CA EM	67	--	--	--	--	1
BA BAg CA PA	2	--	--	--	1	--
BA BAg EM PA	2	--	--	1	--	--
BA CA EM PA	29	--	1	--	--	--
BAg CA EM PA	0	1	--	--	--	--
IM BA BAg CA EM	--	--	--	--	--	31
IM BA BAg CA PA	--	--	--	--	31	--
IM BA BAg EM PA	--	--	--	31	--	--
IM BA CA EM PA	--	--	31	--	--	--
IM BAg CA EM PA	--	31	--	--	--	--
BA BAg CA EM PA	31	--	--	--	--	--
Totals	598	514	263	506	514	151

No. of journals in sample covered by at least one of the six services = 848

No. of journals in sample not covered by any of the six services = 34

Part II. Journal Articles*

	IM	BA	BAg	CA	EM	PA
Alone	527	59	19	67	63	15
IM	--	27	7	165	797	10
BA	27	--	32	49	8	14
BAg	7	32	--	94	0	2

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* This tabulation gives the number of journal articles in the sample that would have been processed by the given combination of services if the services processed all the articles in the journals they covered.

Part II. Journal Articles (continued)

	IM	BA	BAg	CA	EM	PA
CA	165	49	94	--	190	0
EM	797	8	0	190	--	10
PA	10	14	2	0	10	--
IM BA	--	--	0	234	363	65
IM BAg	--	0	--	25	3	2
IM CA	--	234	25	--	253	0
IM EM	--	363	3	253	--	8
IM PA	--	65	2	0	8	--
BA BAg	0	--	--	714	5	5
BA CA	234	--	714	--	10	14
BA EM	363	--	5	10	--	46
BA PA	65	--	5	14	46	--
BAg CA	25	714	--	--	1	3
BAg EM	3	5	--	1	--	5
BAg PA	2	5	--	3	5	--
CA EM	253	10	1	--	--	0
CA PA	0	14	3	--	0	--
EM PA	8	46	5	0	--	--
IM BA BAg	--	--	--	143	157	2
IM BA CA	--	--	143	--	3403	13
IM BA EM	--	--	157	3403	--	164
IM BA PA	--	--	2	13	164	--
IM BAg CA	--	143	--	--	13	0
IM BAg EM	--	157	--	13	--	0
IM BAg PA	--	2	--	0	0	--
IM CA EM	--	3403	13	--	--	191
IM CA PA	--	13	0	--	191	--
IM EM PA	--	164	0	191	--	--
BA BAg CA	143	--	--	--	31	6
BA BAg EM	157	--	--	31	--	8
BA BAg PA	2	--	--	6	8	--
BA CA EM	3403	--	31	--	--	29
BA CA PA	13	--	6	--	29	--
BA EM PA	164	--	8	29	--	--
BAg CA EM	13	31	--	--	--	0
BAg CA PA	0	6	--	--	0	--
BAg EM PA	0	8	--	0	--	--
CA EM PA	191	29	0	--	--	--
IM BA BAg CA	--	--	--	--	2779	8
IM BA BAg EM	--	--	--	2779	--	58
IM BA BAg PA	--	--	--	8	58	--
IM BA CA EM	--	--	2779	--	--	481
IM BA CA PA	--	--	8	--	481	--
IM BA EM PA	--	--	58	481	--	--
IM BAg CA EM	--	2779	--	--	--	0
IM BAg CA PA	--	8	--	--	0	--
IM BAg EM PA	--	58	--	0	--	--
IM CA EM PA	--	481	0	--	--	--
BA BAg CA EM	2779	--	--	--	--	3

Part II. Journal Articles (continued)

	IM	BA	BAg	CA	EM	PA
BA BAg CA PA	8	--	--	--	3	--
BA BAg EM PA	58	--	--	3	--	--
BA CA EM PA	481	--	3	--	--	--
BAg CA EM PA	0	3	--	--	--	--
IM BA BAg CA EM	--	--	--	--	--	2692
IM BA BAg CA PA	--	--	--	--	2692	--
IM BA BAg EM PA	--	--	--	2692	--	--
IM BA CA EM PA	--	--	2692	--	--	--
IM BAg CA EM PA	--	2692	--	--	--	--
BA BAg CA EM PA	2692	--	--	--	--	--
Totals	12,590	11,622	6,817	11,611	11,771	3,854

<u>No. of journal articles in sample covered by at least one of the six services</u> = 14,092

<u>No. of journal articles in sample not covered by any of the six services</u> = 242

<u>Sources</u>: 1. For services other than EM--National Federation of Science Abstracting and Indexing Services. <u>List of Science Serials Covered by Members of NFSAIS, Volumes 1 and 2</u>. Washington, D.C., NSFAIS, January 1962.

2. For EM--List of journal coverage provided by <u>Excerpta Medica</u>.

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APRIL 29, 1964

MEMO TO THE EX-STAFF OF THE NAS STUDY

AT LONG LAST, THE STAFF PAPERS HAVE BEEN REFEREED AND THE ADVISORY BOARD OF FASEB HAS MET AND GIVEN DR. LEE FORMAL APPROVAL FOR THEIR PUBLICATION IN FEDERATION PROCEEDINGS. UNTIL WE HAD THIS APPROVAL, I COULD DO LITTLE ABOUT REVISING THEM FOR JOURNAL PUBLICATION SINCE THERE WAS ALWAYS THE POSSIBILITY THAT EXTENSIVE REVISIONS WOULD BE SUGGESTED. AFTER THIS DELAY, OUR ORIGINAL HOPES TO PUBLISH THE PAPERS IN THE JULY-AUGUST ISSUE ARE DOOMED, SINCE MUCH WORK REMAINS BEFORE THE PAPERS ARE READY FOR JOURNAL PUBLICATION. HOWEVER, I WILL WORK AS FAST AS I CAN, AND IF ALL GOES WELL, WE WILL SEE THEM IN THE SEPTEMBER-OCTOBER ISSUE.

I HAVE BEEN ABLE TO DISCUSS THE QUESTION OF AUTHORSHIP WITH EVERYONE EXCEPT BOURNE, AND THE FOLLOWING LINE-UP SEEMS GENERALLY AGREEABLE:

PAPER #1 -- NOT TO BE PUBLISHED AS JOURNAL ARTICLE
PAPER #2 -- ABDIAN, BOURNE, COYL, LEEDS, PINGS, AND ORR
PAPER #3 -- ABDIAN, LEEDS, AND ORR
PAPER #4 -- COYL, LEEDS, AND ORR
PAPER #5 COMBINED WITH PAPER #7 -- LEEDS AND ORR
PAPER #6 -- PINGS AND ORR
PAPER #8 -- PINGS, LEEDS, AND ORR

PLEASE CONTACT ME SOON IF YOU FEEL THAT THIS SCHEME FOR ATTRIBUTING AUTHORSHIP IS UNFAIR TO ANYONE.

THE MAIN CHANGES IN CONVERTING THE PAPERS FOR JOURNAL PUBLICATION WILL BE CORRECTION OF ERRORS, SUBSTITUTION OF BETTER DATA WHERE AVAILABLE, ADDING NEW REFERENCES, PREPARATION OF BETTER ILLUSTRATIONS, AND SUBORDINATION OF DETAIL (ARRANGEMENTS WILL BE MADE THAT RAW DATA AND DETAILED METHODOLOGY ARE AVAILABLE ON DEMAND). WHEN THE "NEXT-TO-FINAL" DRAFT OF EACH ARTICLE IS READY, I WILL SEND A COPY TO ALL INDIVIDUALS WHO WILL BE LISTED AS AUTHORS FOR THAT ARTICLE. AT THAT STAGE I HOPE EACH AUTHOR WILL GO OVER THE COPY VERY CAREFULLY BUT RAPIDLY, SO THAT THE KIND OF MINOR ERRORS THAT MARRED THE SUPPLEMENT CAN BE CAUGHT AND SO THAT EVERYONE IS SATISFIED THAT THE DATA ARE ACCURATELY PRESENTED AND THE CONCLUSIONS ARE ADEQUATELY SUPPORTED.

R.H.O.

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January 4, 1965

Mr. Charles P. Bourne
Research Engineer
Stanford Research Institute
Menlo Park, California

Dear Charlie:

The reprints of the individual papers in the September-October issue of FP finally came! I am enclosing five copies of each on which your name appeared. I would be more generous, but I had to limit my order to 100 copies each since the total cost ran into several hundreds of dollars.

The Federation plans to have some special booklets made up containing the report proper and all 6 papers. When these arrive, I will ask them if they will send 10 copies to each member of the task force.

Best wishes for the New Year,

Sincerely,

Dick

Richard H. Orr, M.D.
Director

RHO:gs
Enclosures