Mission and Discipline Orientation in Scientific Abstracting and Indexing Services

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"Science has outgrown its organization along well-delineated disciplines of the past."

Jerome Wiesner [1]

"Contemporary science with its methods and means is completely unlike the science of the last century or even of the first part of this century."

A. N. Kosygin [2]

IT IS THE ARGUMENT OF THIS PAPER that the organization of scientific abstracting services reflects the organization of sciences themselves; that scientific institutions are undergoing fundamental changes as a result of large-scale public funding; and that, as a result, new "mission-oriented" requirements are generating new services which conflict with earlier discipline-oriented ones. While no one yet (and certainly not the authors) has clearly visualized an optimum organization of scientific abstracting and indexing, the authors submit that a better understanding of the forces at work in the society, and an informed use of modern technology, may contribute to the ultimate solution of what has become a complex and frustrating problem.

Definition of Discipline and Mission. The two terms, discipline and mission, applied to the organization of scientific activity are in common usage, yet definitions appear to be loose and imprecise.

It would be well at the outset to attempt working definitions. "Discipline" has a Websterian definition of "that which is taught; a branch

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of knowledge; also, a course of study." For the purpose of this paper, a discipline will be defined as a body of knowledge empirically organized for purposes of transmission through teaching. A discipline in science is an academically transmitted corpus of knowledge, and a discipline-oriented abstract service reports on its accretions. The schema for the organization of the *International Catalogue of Scientific Literature* [3] provides an excellent conspectus of the classic scientific disciplines both as they existed at the turn of the century, and as they have been used traditionally for purposes of organizing abstracting.

"Mission" (from Latin *mittere*: to send) has as its Websterian meaning, "That with which a messenger or agent is charged; an errand, esp. a political one; a commission." Popularized by the military establishment (a review of the *U.S. Government Manual* will show the defense agencies to have "missions" while others have "purposes"), a mission at the government level is a formally stated series of purposes authorized by public law. Thus the Department of Commerce has as its purpose "to foster, promote, and develop the foreign and domestic commerce, the manufacturing and shipping industries, and the transportation facilities of the United States."

Mission statements exist at all levels of government. Among the agencies supporting research and development, a bureau (with its own mission) defines missions for the programs which it undertakes to advance its work. Programs in turn operate or support projects which relate to the accomplishment of a mission. Thus, the National Cancer Institute (NCI) has as one of its missions the functions of collecting and making available information on cancer. The National Cancer Chemotherapy Service Center, a program unit of NCI, has as one of its missions the provision of information services to advance the chemotherapy program. To this end it originated and currently supports an abstracting service, *Cancer Chemotherapy Abstracts* (1960-).

While the above suggests that mission-oriented science equates with government-supported science, or with applied science and technology, this is not entirely the case. The National Foundation for Infantile Paralysis, a voluntary health agency, supported mission-oriented scientific activities directed toward the conquest of polio, and in support of them sponsored *Poliomyelitis Current Literature*. Further, it should be noted that the government agencies engaged in mission-related science support much basic as well as applied science. Auger notes that in an age of "oriented fundamental research" classic distinctions between basic and applied science have lost their meaning.[4]

"Mission-oriented" research today can include both "basic" and "applied." Its distinguishing characteristic is its relatedness to the solution of problems encountered as science proceeds toward publicly-identified social goals.

Social Function of Science. At the root of mission-oriented science is the philosophy of Francis Bacon who viewed science as a means by which man can obtain mastery over nature.[5] In this century, the development of this philosophy through the pursuit of science to achieve social goals has been accelerated in all advanced countries through awareness of the increased economic power inherent in this doctrine. The massive increases in the employment of public funds to advance science demonstrate political recognition of this truism.

In the United States the social goals shaping public funding for science may be traced to the Constitution, and to the body of public law establishing the Federal agencies. The national defense, the health of the people, the economic growth of the nation (to name a few) are the goals of agency missions, and hence of mission-supported science in the United States. In the Soviet Union, the establishment of a State Committee for Coordination of Research [6] represents an effort to orient Soviet science and technology to the economic development and welfare of the Soviet state. With variations in approach, all developed countries today provide examples of political organization to orient national scientific programs to the social goals of the state.

Missions and Interdisciplinary Science. Since mission-oriented science is directed to the solution of complex problems in a society rather than to the advance of knowledge in an academic field, it has encouraged interdisciplinary efforts. Accomplishment of a scientific mission involves the assembly of teams of scientists from various disciplinary areas who appear to create their own synergy. Assembly of scientists from different fields speaking different private languages of science, occasions a communication problem at the heart of mission-oriented science; in a real sense, the need for new formal communication media, interdisciplinary symposia, specialized journals, and, of course, indexing and abstracting services, represents an extension of the basic needs of newly assembled groups of scientists from various fields working on a common problem to communicate better with each other.

A phenomenon of our times is the emergence of new fields, such as oceanography, to which potentially many disciplines will contribute. Being new, mission-oriented interdisciplinary fields are under rapid development; the interplay of the disciplines is dynamic. New and temporary combinations may emerge only to disappear.

Discipline-oriented science presents classic, relatively consistent and continuous forms and requirements; mission-oriented science encourages new organizational forms of unproven stability and indefinite duration. The conversion of scientific institutions from the former base to the latter is a dynamic and stressful feature of the twentieth century scientific revolution.

Postwar Growth of Mission-Oriented Science. While the concept of scientific missions antedated World War II (Rogers and Clark were mission-oriented), it was not until the Federal government mobilized science in the national defense, through the Office of Scientific Research and Development (OSRD), that mission-oriented science began to flourish. OSRD contributed two major new dynamic forces to American science: first, the accentuation of scientific missions and objectives relating to the defense and survival of the American society; and second, the cooperative interrelationships it pioneered between the academic communities and governmental sponsorship of science.[7] The effects of these forces have been far-reaching.

On the dissolution of OSRD, Dr. Vannevar Bush was invited by President Roosevelt to recommend policies relating to the role of science in American life. His report, *Science, the Endless Frontier*[8] is basic to an understanding of the scientific revolution in the United States. The single national research foundation proposed by Bush was never realized. Instead, the mission-oriented Federal agencies (the Department of Defense [DoD] agencies, Public Health Service, the Atomic Energy Commission) were successful in establishing their own grant and contract programs, and the National Science Foundation (NSF) was created to support basic research independent of the particular missions recognized by the government. This compromise became national policy through Executive Order No. 10521 of March 17, 1954, in which President Eisenhower determined that "the Foundation shall be increasingly responsible for providing support by the Federal Government for general-purpose basic research through contracts and grants. The conduct and support by other Federal agencies of basic research in areas which are closely related to their missions is recognized as important and desirable specially in response to current national needs, and shall continue."[9]

The tremendous increase in funding of science through the mission-oriented agencies has been well-documented elsewhere. In the health field alone, total Federal expenditures increased from 0.1 billion in 1935 to 5.1 billion in 1965—an increase of 5000 percent.[10] Total Federal expenditures for research and development increased from 74.1 million dollars in 1940 to 15,209.6 million dollars in 1965. Departmental breakdowns are given as follows.

	1940	*1965*
Department of Defense	$26.4 million	$7,107.1 million
Atomic Energy Commission	77.0 (1943)	1,449.3
National Aeronautics and Space Administration	2.2	4,870.6
Department of Health, Education and Welfare	2.8	810.0
Department of Agriculture	29.1	193.9
Other	13.6	668.7

One effect of funding of this magnitude for science has been to create "big science" as described by Price.[11] Price concerns himself with magnitudes, rather than with the impact of "big science" on the organizational forms of scientific institutions. Both quantitative increase and change in organizational requirements are related in the current problems of abstracting when it is viewed as a scientific institution. Recognition that "big science" has a dual impact on abstracting and indexing has been slow to come. The concurrent need to adapt to large volume and at the same time to new forms constitutes a highly complex problem for the scientific communities in the universities, industry, government, and scientific and technical societies.

"Big Science" and Volume of Scientific Publication. The latest worldwide census by Gottschalk and Desmond[12] showed that there were some 35,000 scientific and technical serials being published in 1962. While Bourne[13] seemed to agree with this estimate, a later unsubstantiated estimate by Hutton[14] indicated that there may be 60,000 to 70,000 periodicals of importance.

Most estimates agree, in principle, that the overall increase in published scientific papers is above 5 to 6 percent, compounded annually. Price points out that these rates indicate a doubling of volume, on an accumulative basis, every fifteen years. NSF estimated the annual number of scientific and technical articles to be 1,700,000 in 1964. Other estimates range from one to two million articles per year[14,15] while a Russian estimate suggested that there may be 4.5 million articles per year. A later study by the System Development Corporation (SDC)[16] estimated conservatively that 2,573,000 individual items were abstracted or cited by 220 abstracting and indexing publications in 1966.

Indexes and Abstracts. Organization of the literature in such a way that all worthwhile documents will be available and retrievable has long been an objective of secondary information services. According to the recent SDC report,[16] 56 percent of the total literature covered by abstracting and indexing services (an estimated 1,440,000 papers in 1966) is covered by abstracts, and the remainder by citations (1,-133,000). This report showed that for 1962 scientific societies in the U.S. produced 58 percent of the abstracts, 21 percent were produced by agencies of the Federal government, 8.5 percent by commercial information firms, 8 percent by industry, and 4.6 percent by other institutions. Relative production volumes of index items in 1962 were: 37.9 percent societal, 32.3 percent Federal, 20.3 percent commercial, 5.4 percent industrial, and 4.1 percent institutional.[17] Thus, those services which tend to preserve discipline orientation (societies and other institutions) produce both abstracts and indexes, while mission-oriented services (Federal and commercial), which tend to be devoted largely to technology, also tend to produce more indexes than abstracts.

Discipline-oriented services make information available on no fixed time scale; they are prompt, but also archival. The emphasis in this decade has been on timeliness in reporting the literature. The studies by the International Council of Scientific Unions (ICSU) for 1963 and for 1965 show that the major international discipline abstracting services have a lag period of from three to eight months, with a median of about five months, between date of publication of the original paper and the appearance of the abstract. This is not so slow as many believe but also not so prompt as the services would wish to be. Accordingly, in recent years discipline-oriented services have developed many variations of rapid alerting services both in discipline and mission fields (e.g., *B.A.S.I.C.* and *Chemical Titles*) to speed up delivery to the user of abstract-index reference tools. These special services have usually utilized computers, thus lending support to the belief that computer technology holds the real solution to the discipline-mission problem.

Changing Science and Technology. While the prompt reporting through secondary publications on the increasing volume of scientific publication constitutes an economic problem of considerable magnitude, the organization or packaging of services to meet the requirements of evolving science and technology constitutes an intellectual and logistic problem of great complexity. This latter problem is complicated by the rapidity of development of the newer fields of science, by their instability, and their interdisciplinary character.

Chemistry, as a well-documented example of a traditional discipline, stands midway between physics and the biological sciences, and shares the conceptual framework and practical applications of both. As a basic science, chemistry is a dynamic discipline, changing and evolving with any natural phenomenon it may be called upon to interpret. It grows in terms of how much is known; it changes in terms of its own definition and scope. Knowledge begets knowledge, and compounded with all that man has learned since he first became intrigued by the nature of matter and the transformations of which it is capable, this basic science has become a cornerstone of technological advance. As research both broadens into other fields and deepens into the fundamentals of chemistry itself, the frontiers change daily.

One can point to "the various sciences of biochemistry, geochemistry, chemical physics, atmospheric chemistry, molecular biology, and astrochemistry [which] attest to the importance of chemistry to the community of scientists."[18] Chemistry, at the same time, is basic to the complexes of scientific activity organized to achieve social goals—the national defense, the nation's health, nuclear energy. To achieve prompt reporting on the literature related to specific objectives, multiple specialized abstracting services have been created in such fields as air pollution, prevention of deterioration of materials, and pharmaceutical chemistry.

There are a limited number of disciplines, but an unlimited number of missions. But it is important to remember that the information utilized by missions is contained within disciplines. Computer technology, design and use, for example, is a mission drawing primarily from information generated in the fields of mathematics and electrical engineering. Solving mission information problems with information derived from its discipline bases is both a logistic and an intellectual problem.

Recognition of the Challenge. The Royal Society's Scientific Information Conference of 1948 provided scant recognition of the new mission-oriented requirements for indexing and abstracting. The conferees, rather, were largely concerned with technical questions, although they revived once more the ideals of international cooperation on which the *International Catalogue* was founded. UNESCO sponsored a conference in October, 1947, on abstracting and indexing in the medical and biological sciences and a further conference on science abstracting in 1949. Both of these conferences were more concerned with technical questions of formatting of abstracts, standards, and with potential international cooperation than they were with the restructuring of abstract services for developing interdisciplinary fields.

Growing from the UNESCO Conference, the International Council of Scientific Unions (ICSU) Abstracting Board (ICSU-AB) was created to provide surveillance for scientific abstracting in fourteen fields represented by ICSU. In 1952 the ICSU-AB devoted its attention to abstracting in physics; in 1956 to chemistry; in 1962 to biology; and in 1965 to astronomy.[19] The ICSU approach, deriving from the classic interests of its constituent international scientific societies, has been consistently academically and discipline-oriented. Its objective is "through international cooperation, to improve the quality of scientific information and the acceleration of its distribution among scientists."[20]

In general, efforts at the international level during the 1940's and 1950's reflected the concern of existing services to effect economies through cooperation and standardization, which might lead to the improvements of classic forms of abstracting services.

Over the past ten years, however, there has been increasing concern in U.S. government circles with questions relating to the organization and support of abstracting services, as well as with the classic concerns with format standardization and mechanisms for voluntary cooperation. This concern stems from the following considerations:

(1) that the growth rates of the literature to be covered by the services threaten to outstrip the private resources available; (2) that Federal funding for mission-oriented services, to fill new needs which the government has brought about, may be creating imbalances and unnecessary duplication of effort; (3) that a rapidly developing machine technology can contribute to solutions; and (4) that comprehensive, economically healthy, integrated abstracting and indexing are essential to the science information needs of the communities of scientists who comprise the national science effort.

Successive hearings before committees of the Congress, as well as consideration by subcommittees of the President's Science Advisory

Committee, testify to the continuing Federal concern with this problem. Doubtless this interest was heightened by reports descriptive of the solutions the All-Union Institute of Scientific and Technical Information (VINITI) was attempting to find through the creation in 1953 of the comprehensive, centrally managed abstracting system, the *Referativnyie Zhurnaly*.[21]

In the United States the NSF which, as we have seen, has a basic concern with balancing support for discipline-oriented research with that of the mission-oriented agencies, took the initiative in identifying problems relating to the coexistence of abstracting services supporting the disciplines and missions. In 1957, it aided in the establishment of the National Federation of Science Abstracting and Indexing Services and in 1961-62 supported this organization in the conduct of a study by Robert Heller Associates Inc.[22] The Heller Plan called attention to the relationships which might be created between the large discipline-oriented abstracting and indexing services and the smaller mission-oriented services funded or sponsored by government agencies. The status report on scientific and technical information of the Committee on Scientific Information [23] (the predecessor of COSATI) again focused attention on the need to improve the coordination of Federal programs for support of specific abstracting and indexing services.

The latest comprehensive study of scientific and technical abstracting and indexing is the System Development Corporation's report previously cited.[16] Under contract from the National Science Foundation, and working closely with the COSATI Task Group on National Systems for Scientific and Technical Information, the SDC study addressed itself to the following issues:

(1) the role of abstracting and indexing services in the national system of scientific and technical communication; (2) the current status and problems of the services; and (3) actions which should be initiated by the Federal government to help bring about desired improvements.

The resulting report provides a valuable analysis of the status and sponsorship of abstracting and indexing, poses for the first time in a systematic way questions which must be answered to reach solutions, and explores a series of mechanisms ranging from *laissez faire* to a Federally operated Capping Agency by means of which abstracting and indexing services might be developed as a sub-system of a national scientific and technical information system. Recognizing the complexity of governmental and private interests involved, the SDC recommendations call for further studies and discussions.

Solutions at the Molecular Level. The abstracting service for each major discipline and mission has evolved its own definition of the field or scope of coverage. On three occasions in the history of ICSU-AB, attempts have been made to coordinate the subject arrangements and indexing of the abstracting journals in the field of physics along the lines of UDC. Uniformity of field definition among the British, French, German, and Russian services was never reached. The Russians and French used a much broader definition of physics than the Germans, British and Americans, so that today the *Referativnyi Zhurnal* and *Bulletin Signalétique* abstracting services cover as many as three times more papers in their services than the *Physikalische Berichte* and *Physics Abstracts*. Through the years, virtually all of the major abstracting services have grown with careful culture and nurture, but their growth has been completely autonomous and with little coordination of subject content on a national or international basis.

Working parties on scientific documentation at a UNESCO [24] meeting in Moscow, November, 1963, considered it urgent that harmonization of glossaries, keyword lists, descriptor lists, and thesauri should be attempted for science and technology. Regional bodies were visualized for North America, Latin America, Western Europe, USSR and Eastern Europe, and the Afro-Asian countries. To date, this UNESCO effort has not come to fruition. Definition of the subjects and standardization of the material to be covered in the various mission and discipline-oriented services are both necessary and important to achieve compatible, coordinated information services on a world-wide basis.

Evolving from DoD-wide technical thesaurus in the early 1960's were two important activities. First, COSATI in 1964 issued a list of subject fields to be the official government-wide technical vocabulary for document announcement, handling, and retrieval. The twenty-two subject areas of the lists include the names of the most of the traditional disciplines of science and engineering. The list also includes mission-oriented subject areas such as atmospheric sciences, energy conversion, materials, methods and equipment, military sciences, missile technology, ordinance, and space technology, thus strongly implying a dichotomy between the disciplines and the missions. This COSATI list has a very limited definition of chemistry, for example, so that one must look for fundamental studies on combustion under propulsion, for isotopes under nuclear science, for solvents under materials. Categorization in the medical sciences is similarly underdeveloped.

Impact of Modern Methods of Handling Information. The power and flexibility of the new information storage, retrieval, and dissemination techniques that have been developed, or are being developed, are having a tremendous effect on abstracting and indexing methodology, both in the missions and in the disciplines.

Major discipline and mission abstracting and indexing services are in the process of acquiring dynamic and flexible information-processing and disseminating capabilities. The use of the computer and graphic devices to repackage information may well be the most important development of the decade that will affect the capability of the abstracting and indexing services to meet user requirements. Further, the new information technology may be the basis on which more effective and efficient coordination among missions and disciplines can be achieved.[25]

One of the early efforts toward mechanization of abstracting and indexing was started by the American Chemical Society (ACS) in 1946 through the activities of its ACS Committee on Punched Cards. In 1955, the Chemical Abstracts Service (CAS) started its own research and development program to attempt to use machines in the handling of abstracts and indexes. In 1957, the American Society of Metals undertook with Western Reserve University to establish a group to abstract and index material for publication and to encode it for mechanized retrieval. The first computer-produced index publication, *Chemical Titles*, appeared in 1961 after several years of research and development. The National Library of Medicine (NLM) supported studies relating to indexing mechanization as early as 1948, while its operational system, MEDLARS, started in 1964 after more than three years in development.[26] MEDLARS, which produces *Index Medicus* as well as 100,000 pages a year of specialized bibliographies, also makes 4,000 demand searches a year through its system.

Likewise, *Biological Abstracts* has undergone great changes in recent years, in a program which has become known as the BioSciences Information Service of *Biological Abstracts* (BIOSIS).[27] A new index, the *BioSystematic Index*, was achieved through its computer program. BIOSIS has over 500,000 titles, references, and index entries in machine form.

Consideration of a modernized physics information system, including abstracts and indexes, was defined in 1966 by Van Zandt Williams, Hutchisson, and Wolfe.[28] The American Institute of Physics established a program of author-produced abstracts and indexes and worked with the British *Physics Abstracts* to produce a machine-based weekly publication of titles in the field of physics.

By 1964, research at CAS had yielded some powerful new techniques so that a five-year program was initiated, designed to implement fully a computer-based system by 1969. By 1965, a sophisticated, computer-produced information service, *Chemical-Biological Activities (CBAC)* was launched in its biweekly publication form.[29] Starting with the first of 1966, *CBAC* became available also in magnetic tape form and as a search service to be conducted on CAS computers. Based on two years of experience with *CBAC*, a new service, Polymer Science & Technology (*POST-J* and *POST-P*) was launched in 1967.

CBAC and *POST* and MEDLARS all illustrate how new computer-based techniques make possible breaking through the interfaces between discipline- and mission-oriented services with no loss of speed or effectiveness.

In a computer-based system, information selected in a single intellectual analysis of the source documents, and analysis combining both abstracting and indexing, is put into a unified machine-manipulative store through a single keyboarding. Then from the unified bank of information, material appropriate for special-subject alerting and retrieval publication can be drawn, largely by computer programs.[30]

The principal reasons behind the shift to computer-based abstracting and indexing services which apply across the board in science and technology are:

(1) the growth of the literature, increasing at an exponential rate for over twenty years, requires the most modern equipment and technology to cope with the flood, now and in the future; (2) traditional methods of abstract and index processing require too much scarce and expensive manpower devoted to redoing accomplished work; (3) the patterns of information use by scientists and engineers have been changing toward more selective requirements; (4) users need more timely and responsive information services; and (5) packaging in conventional forms and repackaging for multiple mission-oriented products is economically feasible. This flexibility for meeting both present and future requirements provides the potential for solving the discipline-mission problem.

Relationships to Other Developments. Basic to the achievements of the goals of abstracting and indexing services is definition of the interfaces between disciplines and missions and construction of the bridges necessary for efficient and effective transfer of information among the services. Mission-oriented services tend to decrease information flow across mission borderlines because of their specialized nature. On the other hand, because information of consequence to missions is included within the scientific disciplines, and because of new systems capabilities, information flow from disciplines to missions is enhanced.

An example of interdisciplinary programs to increase information flow across subject borders is the current collaborative effort between the NLM and CAS in the handling of chemical compounds. Chemical data processed for the Drug Literature Program of the MEDLARS system is directly compatible with the techniques used to build the store of compounds in the Chemical Compound Registry System at CAS. Other CAS programs are active with the American Institute of Physics and the American Institute of Chemical Engineers to build additional bridges to help solve the interdisciplinary coverage problem.

The studies and programs by national groups are expected to help point the way to improved cooperation necessary to achieve the interlinking of the developing abstracting and indexing services. Interlinkage of information systems must take into account several facts: (a) large and small systems are often not interchangeable, (b) interlinkage must be created beween large and small systems to assure effective interaction, and (c) information is usually delivered to the user through local, often small, information-handling systems. The smaller, localized information systems tend to be mission-oriented in view of the specialized interests of a local community of users. Existing information resources, as subsystems of a comprehensive network of limited but larger systems which are primarily discipline based, can slowly but surely be tied together in logical patterns to satisfy our future needs for information.

The Heller plan proposed a single clearing house,[31] Organization X, through which abstracts prepared by discipline-oriented services might be repackaged and marketed to mission-oriented services. The SDC report[32] suggests that some variation of the Heller proposal which might provide for joint Federal-private participation might be a feasible compromise. What is in fact in process of evolution is not a single Organization X, but a series of lower-case organization x's, each of which, as a service responsible for macro-disciplinary areas, is attempting to develop mission-oriented services, through the computerized repackaging of its products.

Summary of Trends

1. The revolution in science, primarily caused by increased public interest and public funding, is having major effects on scientific institutions which are being converted from traditional discipline to mission orientation. Abstracting and indexing, viewed as a scientific institution, have been affected by this revolution.
2. Increased basic concern with the problems of coexistence of abstracting services in support of the disciplines and in support of missions has led to comprehensive studies which recommend a network of the various abstracting and indexing services.
3. The number of abstracting and indexing services (about 1,850 in 1963) is growing with the increased growth of the literature. While few new, large, discipline-oriented abstracting services appear to be developing, more mission-oriented services are starting each year than are being terminated.
4. There is an increasing emphasis on defining and standardizing coverage of abstracting services, both mission- and discipline-oriented, for the purpose of achieving understanding, compatibility, and coordination of the abstracting efforts.
5. Major discipline- and mission-oriented abstracting services are systematically transforming from traditional formats to more flexible information-processing and disseminating programs.
6. New computer-based techniques of abstracting and indexing make possible multiple, interlinked processing of information across discipline borderlines with no loss of speed or effectiveness.
7. By recognizing that the scientific and technical abstracting and indexing problem is in reality a multitude of different, interacting problems to which there is no single, all-purpose answer, we have begun to construct a powerful framework to satisfy our future needs for information.

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