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THE PRESIDENT'S COMMISSION ON HEART DISEASE, CANCER AND STROKE



REPORT TO THE PRESIDENT

A NATIONAL PROGRAM TO CONQUER HEART DISEASE, CANCER AND STROKE

Volume II

February, 1965

THE PRESIDENT'S COMMISSION ON HEART DISEASE, CANCER AND STROKE

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FOREWORD

Volume 1 of the Report of the President's Commission on Heart Disease, Cancer and Stroke contains a summary of the dimensions of the problem, the national resources and needs, and the specific recommendations for developing a national program to combat these diseases.

The contents of volume 1 were derived from the reports of the Subcommittees of the Commission and from special reports on selected subject areas. The Subcommittee reports were prepared after each Subcommittee held a series of hearings at which testimony was obtained from experts and after the members of the Subcommittee had reviewed the special reports and other material.

These Subcommittee reports and staff papers provide in greater detail the views and judgments of the Commission and some of the bases for such judgments. It was considered desirable to publish them as volume 2 of the Commission's Report, since the material has value for guiding programs and policies and for stimulating additional research. Much of the material represents fresh data, unavailable elsewhere. The special reports that were prepared for many of the Subcommittees are designated as source papers and follow the relevant Subcommittee report.

State health departments, schools of all the health professions, municipal governments, research institutions, hospitals, foundations, and voluntary organizations will find in these pages support for their earnest aims. We believe that these reports and documents will strengthen the case for their present programs and light the way to their fulfillment. We hope that the reports will stimulate health organizations to open new pathways of research and health practice. Despite the emphasis on Federal action and Federal financing, as might be expected in a report to the President, it will be obvious to the discerning reader that there are opportunities to move ahead on the recommended programs at State and community levels. Indeed, many recommendations of the Commission are based upon exemplary action which has already occurred in many communities.

In volume 1, we have already listed the many who have contributed their time and talent to the work of the Commission. There is little to add to these grateful acknowledgements except to note that the editorial services for volume 2 were performed by the Commission's Staff Director, Dr. Abraham Lilienfeld, and Marcus Rosenblum. Daniel M. Bailey reviewed the special report on libraries by the Subcommittee on Facilities. The staff of the National Library of Medicine assisted in the preparation of the bibliographies; the citations in this volume conform to the system used by the National Library of Medicine. The design of volume 2 was contributed by the capable staff of the Government Printing Office.

MICHAEL E. DEBAKEY, M.D.,
Chairman.

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REPORT OF
THE SUBCOMMITTEE ON COMMUNICATIONS

SUBCOMMITTEE ON COMMUNICATIONS

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REPORT OF THE SUBCOMMITTEE ON COMMUNICATIONS

The prevention and control of heart disease, cancer, and stroke—the saving of a human life—begins not with the doctor, the hospital, or the medical center. It begins with the individual himself.

He decides to go for a checkup—either before symptoms appear or at the earliest sign of trouble. Or he decides not to. The decision, often made casually or even subconsciously, may add or subtract a decade from his life.

Many factors influence his decision. One is his financial condition. Another is the convenience and accessibility of medical attention. The most important factor is the state of his knowledge about health matters.

Once he enters the medical orbit, his fate is again subject to many whims of chance. If he is wise enough to make his appointment soon enough, and if the physician he chooses is trained and equipped to detect an incipiently dangerous condition and make the proper referral, and if his community is blessed with the special skills and facilities his condition requires and if he is able and willing to follow through the prescribed course of treatment—in this happy conjunction of circumstances—his life will be prolonged, his function unimpaired or restored.

A Federal Mandate

The Federal Government, as described elsewhere in this report, has been given a clear mandate and substantial resources to support the generation of health knowledge through biomedical research. The results of this policy have been the great scientific advances that characterize our time.

But knowledge unused is knowledge wasted. And strangely, the Federal Government has not been given a similar mandate and similar re-

Breakage of any link in this chain can nullify the strength of the others. Nearly every link depends upon the right knowledge in the right place at the right time. Conversely, many thousands of heart disease, cancer, and stroke deaths occur because of failures in the communication of lifesaving knowledge to the potential victim or to the physician who treats him.

It is to these costly failures that the Subcommittee on Communications has directed its principal attention. We recognize the vital importance of research communication—between scientist and scientist. We wholeheartedly endorse the recommendations of other subcommittees concerning the need for strengthening the medical library system and adding to the electronic capability for handling research information. But we feel that the greatest impact on death and disability from heart disease, cancer, and stroke, now and in the years immediately ahead, can be made through intensive nationwide effort to bring to the physician and the public the information they need about these diseases. It has been said that knowledge is power. In health, it is the power of life and death.

sources to support the transmission of medical knowledge to its point of application.

One point of application is the meeting place of physician and patient. Knowledge or the lack of it on the part of the patient brings them together in time or keeps them apart too long. Knowledge or the lack of it on the part of the doctor determines the success of their encounter. Clearly, this is the ultimate target of biomedical research. These are the prime audiences.

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Equipping both patient and physician for their encounter is a communications task: A process of education and information.

There are long-standing and largely unspoken obstacles to vigorous Federal participation in this process. Federal support of education in any form has been viewed darkly because of fears of Federal control in a political sense. Strong Federal programs of public information have been treated with suspicion through fear of self-aggrandizement via press agency.

Without seeking to judge broader policy matters, we submit that in the communication of health knowledge these fears are illusory and irrelevant. They are worse: They contribute to unnecessary death and disability.

In the generation of health knowledge, the Federal Government has abundantly demonstrated its ability to stimulate and support productive effort without stifling control. It has

done so by developing a partnership of Federal and non-Federal scientific resources in a system which promotes individual freedom and initiative. Similarly in the communication of health knowledge, it can and must develop a partnership whereby scientific and communications skills and resources, both Federal and non-Federal, work together to transmit the urgent messages upon which health depends.

The Subcommittee on Communications therefore recommends, as a fundamental policy underlying its subsequent specific recommendations, that the communications functions of the Public Health Service, and especially those related to public information and the continuing education of the health professions, be recognized and supported on a scale commensurate with their importance as a major weapon in the prevention and control of disease.

Public Information

The public has an almost insatiable thirst for health information. Newspaper readership studies have shown that health articles rank high both in number of readers and in retention of information. Every major daily newspaper has at least one column devoted to health. News which suggests a scientific breakthrough is given front page prominence. The general interest magazines rarely go to press without a substantial quota of health information.

Yet the public remains remarkably uninformed, or remarkably slow to act, on many matters which are quite literally "of life and death." Part of the problem may stem from the sheer profusion of available information, sometimes contradictory and frequently half true or halfhearted.

In all three disease fields falling within our purview, we were told by medical experts that the average American family today is not aware of the simple, fundamental measures necessary to protect its members from these diseases. This is a failure of communications. The coronary-prone middle-aged male, the young mother with one of the seven danger signals of cancer, the corporation executive who is suffer-

ing from one or more precursors of stroke—why don't they act while there is still time? Because they either lack the information, or the information has been presented in such a fashion that they lack the motivation to act upon it.

We must therefore make much greater and more imaginative use of existing communications media, and we must create bold new channels of information to close the alarming gap between the acquisition of research knowledge in our medical centers and laboratories and its dissemination to the family physician and to the general public.

We have a magnificent and exciting story to tell. Every American is deeply concerned with the preservation of his own health and that of his loved ones, yet we have not capitalized upon that concern. We must take the plunge into the mainstream of modern communications. We must use the advertising and promotional techniques which have been so successful in creating a demand for consumer goods to create a similar demand for the knowledge which will save thousands of precious lives.

We therefore recommend the following steps be taken:

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STRENGTHENING PHS INFORMATION SERVICES

We believe the Public Health Service has a duty and a responsibility to use every possible resource to bring the latest health information to the American people. In a matter so urgent as the prolongation of life and the prevention of needless disability and death, we must insist upon the highest priority for these communications activities.

For this reason we recommend that the funds appropriated for the Office of Information and Publications in the Office of the Surgeon General should appear as a budgetary line item. They should be increased by \$750,000 per year to finance such additional activities as:

- a. Recruitment and inservice training of information specialists, selected from among young college graduates, to improve dissemination of health information to the public.
- b. Creation of materials for free public service announcements on health for use by radio, TV, and magazines.
- c. Development of fact books on specific health topics, summarizing present scientific knowledge for the use of reporters and community leaders.
- d. Development and production of a health yearbook, similar in scope and quality to the Agriculture Yearbook, to create a series of authoritative and understandable reference volumes in specific health topics.
- e. Assignment of writer-editors to accompany foreign PHS missions and to report promptly on the findings and experiences of such missions.
- f. Assignment of writers to produce prompt summary reports of scientific conferences in forms suitable for the health professions.

TRAINING IN HEALTH COMMUNICATIONS

Because the transmission of medical information has been given such a low priority in our total national health effort, we have given little attention to the recruitment and training of communications specialists in the health field.

There is a desperate shortage of these skilled specialists, both in the Public Health Service and in medical centers and universities throughout the country.

We therefore recommend that the Office of Information and Publications in the Office of the Surgeon General be allocated a specific annual sum of \$1 million solely for these training purposes:

- a. A grant program to educational institutions for the development of pilot training programs in the field of medical communications. Such grants should support the development of a core curriculum, the payment of faculty, and provision of stipends for trainees. A university which has both a medical center and a school of journalism would probably serve as an excellent setting for these pilot training programs in communications.
- b. Provision of fellowships for the on-the-job training of a variety of personnel in the gathering and writing of science information materials. Many of these fellows would be trained in the various agencies of the Public Health Service; many would be trained in our medical centers and large research institutions throughout the country.

In addition, we recommend that the Public Health Service conduct and support seminars and other methods designed to give professional science writers the background they need to write accurately, responsibly, and clearly on health subjects.

Science writing is a highly developed skill. The popularization of such scientific fields as nuclear physics and space has been brilliantly successful. In the medical field, both within and outside government, there has been a persistent reluctance on the part of scientists and physicians to take professional writers behind the scenes on a basis of mutual confidence and open doors to genuine understanding on matters of profound interest to the public. As a result, medical writing in the popular media—again with some outstanding exceptions has tended to be fragmentary and often misleading. The Public Health Service should take the lead in

remedying this condition, and its public information offices should be authorized and encouraged to do so.

RESEARCH CENTER ON HEALTH MOTIVATION

In mounting preventive attacks upon heart disease, cancer, and stroke, we face the difficult challenge of changing the life patterns and habits of millions of people. For example, it is fairly easy to put out a pamphlet listing the various factors which predispose an individual to a heart attack, but it is extraordinarily difficult to get that individual to reduce his calorie intake, to give up cigarette smoking, or to limit the stress factors in his daily life.

Little research has been done on the effectiveness of the various approaches which have attempted to change the ingrained habits of people. Unless this important research is conducted by behavioral scientists, sociologists, and

other specialists, we will lack a solid scientific base from which we can tailor our educational efforts toward motivating change in people.

We therefore recommend that the Public Health Service be provided with funds to initiate the development of a Center for Research in Health Motivation. In addition to specific behavioral studies directed at the individual decisionmaking process in changing patterns of living, the center would analyze the contents of public campaign materials with reference to their effectiveness and influence upon behavior, and it would hopefully concentrate particular attention upon hard-to-reach population groups which reject existing educational campaigns emphasizing individual initiative and changes in living patterns.

It is estimated that \$500,000 a year for 5 years would be necessary to initiate the development of such a Motivational Research Center.

Continuing Education of the Health Professions

The forward sweep of medical science has brought a kind of "instant obsolescence" in medical knowledge. Most physicians practicing today received their medical education in the 1930's and 1940's. The fact that they are practicing two or three decades later poses a critical obstacle to the delivery of up-to-date health care.

For many years, lipservice has been paid in the medical profession, as in most other professions, to the concept of continuing education. But the facts of daily life are hard to overcome.

Most doctors work a 60-hour week. Even their free time is never truly free. They are deluged with paper, ranging from professional journals to flyers advertising the latest medical gimmick. Among the papers are invitations to attend lectures, seminars, clinical conferences. But only the supermotivated or the semileisured are able to respond often enough to keep pace with their changing profession.

Thus the greatest single obstacle to a cohesive program of continuing education for the medical profession is time. The second is diversity of interests and needs. The third is the fact that continuing education, although it is recognized

as a critical problem in medicine today, is not the primary responsibility of any significant segment of our national health resource.

Medical schools, the logical locus for the major effort, are correctly preoccupied with undergraduate education first and research second. Continuing education, if it receives any attention at all, must settle for what is left of already inadequate resources. Similarly, community hospitals could contribute greatly to the continuing education of community physicians, but their first job is to care for the patients. Professional societies have many other responsibilities.

Yet continuing education is a categorical imperative of contemporary medicine. Without a large-scale, effective organized effort, the worlds of science and practice will spiral still farther apart. The gap between what is known and what is received by patients will be harder and harder to bridge.

The Public Health Service clearly has a leadership role to play in helping to forge a national continuing education effort, by assisting all the available resources in giving due attention to this problem.

STRENGTHENING CONTINUING EDUCATION PROGRAMS

The Subcommittee recommends that appropriate units of the Public Health Service be provided with funds and authority to:

- a. Stimulate and support through grants, contracts or in other appropriate ways, demonstration projects and experiments directed by medical schools, community hospitals, professional organizations or any appropriate agency, designed to make important scientific knowledge systematically and conveniently available to practicing physicians.
- b. Stimulate and support research projects designed to develop new and improved methods of conducting continuing education programs, including experimentation with various media (i.e., closed- or open-circuit television, etc.), various instruction methods (i.e., programed instruction, seminars, etc.), and various means of evaluating such programs in terms of their actual impact in upgrading medical practice;
- c. Disseminate as widely as possible the results of experiments, demonstrations and other projects in the continuing education field, whether sponsored by the Public Health Service or by others, so that all interested organizations may benefit from the experience of others.
- d. Conduct studies and demonstrations in communications technology and educational methodology.

For these purposes the Subcommittee recommends appropriations of \$2 million for the first year, \$4 million for the second, and \$6 million for the third.

A NATIONAL MEDICAL AUDIOVISUAL FACILITY

The imaginative use of new communications media offers the best hope for necessary breakthroughs in continuing education. The Subcommittee believes that in addition to its broad program of support for continuing education outlined above, the Public Health Service should also take leadership in producing, disseminating, and promoting the use of audio-

visual materials for continuing education of the health profession.

The Public Health Service Audiovisual Facility, located at the Communicable Disease Center in Atlanta, Ga., on a small scale, has already demonstrated high competence in the production of training and educational materials, and in the collection and dissemination of such materials produced elsewhere.

We therefore recommend that the Public Health Service Audiovisual Facility be enlarged in scope and strengthened so that it may become a National Medical Audiovisual Center. To this end we recommend the following specific steps:

- (a) The appropriation of \$1.5 million for necessary renovation and expansion of facilities.
- (b) Appropriation of \$1.5 million for the first year, scaled upward to \$4.0 million for the fifth year, to develop an intramural program which would include production, experimental use and evaluation of educational materials in such areas as radio, television, motion pictures, programed instruction, etc.; research and training programs in audiovisual fields; international exchange of medical motion pictures; and other purposes.
- (c) Authorization of an extramural program of grants and fellowships and appropriations to support such a program, beginning at the level of \$1.5 million per year and rising to \$8 million at the end of a 5-year period; such a program would enable the center to support selectively promising projects in audiovisual communication at medical schools, community hospitals, and other institutions and to assist, through training grants and fellowships, in the development of a national cadre of medical communications specialists.

In addition to the program outlined above, the Subcommittee feels that the National Medical Audiovisual Facility should exert immediate and strong leadership in two communications media of particularly high promise for continuing education of the health professions. These are, first, the field of closed-circuit tele-

vision which is already being used sporadically, to a limited extent, by medical schools, hospitals, and other health agencies; and, second, the use of portable projectors for cartridge-type films which are especially adaptable to private use by physicians in their own offices, at times of their own choosing.

We therefore recommend:

- (a) That an appropriation of \$2 million per year, initially, be made to the National Medical Audiovisual Center for the specific purpose of developing, disseminating, and evaluating closed-circuit television programs on subjects of vital interest to the health professions.
- (b) That an initial appropriation of \$1 million per year be made to the National Medical Audiovisual Center to produce short films for use in cartridge-type projectors, and to promote the widespread use of this promising new educational device by the medical profession.

TELEVISION

The health world has been slow to focus the awesome power of television on specific health problems requiring specific public understanding and response.

The medium is ideally suited for delivering clear visual information in dramatic and forceful terms. The art of the documentary film, true to science and at the same time challenging to the interest, is highly developed. Commercial television is capable of reaching an overwhelming majority of the American people, and educational television is growing rapidly.

Yet health documentaries have been few in number, uneven in quality, and generally drab in presentation. It has been their quality, rather than their subject matter that has relegated them to unattractive scheduling and doomed them to small audiences. Television producers are as aware as newspaper and magazine editors of the tremendous public interest in health. The products, with a few shining exceptions, have simply been inferior in the highly competitive world of commercial television.

The Subcommittee recognizes the problems faced by a Government agency like the Public

Health Service in recruiting and employing scarce topflight creative talent in motion pictures and television. It recognizes the scientific knowledge necessary to give complete accuracy and authenticity to health documentary programming and the impressive beginnings already made at the Service's Communicable Disease Center in creating a truly national medical audiovisual center.

We therefore recommend that the Public Health Service be authorized, and that funds be appropriated, to contract with professional television producers for the production of twelve 30-minute documentary films each year of the highest quality, on subjects related to heart disease, cancer, and stroke, and any other subjects as may later be deemed desirable. Each film should be budgeted at or about the level of \$150,000 to assure writing and production that will make the films competitive with the best of commercial television. This price should include a sufficient number of prints to assure widespread use on local commercial television outlets across the nation. The contract should also provide for the full participation of the producer and his organization in the marketing of the films. The Public Health Service, in conjunction with non-Federal scientists and physicians designated by the Service, should have full control of the content of each film. The films should be available for commercial sponsorship within a predetermined range of appropriate product classifications, excluding such obviously inappropriate sponsors as tobacco companies, pharmaceutical firms, and the like.

In the Subcommittee's view, the potential of television as a disseminator of health information to the public can be realized only through quality production of authoritative material, made available in such a way that it can be viewed in prime television time by the widest possible audience. The method proposed, which consists essentially of a Federal investment in communication talent, would cost about \$1.8 million per year. Alternative methods, such as the governmental purchase of prime time, would cost as much and result in the showing of inferior products, with inevitably inferior results. The impact of 12 first-class documentary films, each carrying a message of urgent importance

for the protection of American families, would be immediate and overwhelming.

The Subcommittee further recommends that the Public Health Service be authorized, and that funds be appropriated to the National Medical Audiovisual Center to support through appropriate mechanisms, such as grants or contracts, the development of effective television programming in the health field on the nation's educational television stations. The sum of \$1 million per year is recommended as a beginning figure.

ETV programs reach school audiences at all levels from primary school through college. In many communities, the ETV program is viewed widely by the adult intellectual and civic leadership as well. It represents an excellent medium for attracting young people to health careers, for establishing and maintaining desirable health habits, and for stimulating desirable community-wide health activities. In many areas, ETV facilities can also be used for continuing education of health professionals. The health potential of this growing educational force has scarcely been touched.

A CLEARINGHOUSE FOR DRUG INFORMATION

The Subcommittee recognizes the fact that improper use of drugs is today an important cause of avoidable disease. Because the gaps and wasteful duplication associated with pres-

ent independent efforts to handle drug information are responsible for much important information failing to reach those who need it most, and in view of the progressive increase in the consumption of medications and other chemical products, the Communications Subcommittee endorses current proposals for the establishment in association with the National Library of Medicine, a national drug information clearinghouse, serving and supporting governmental and nongovernmental drug information units.

We believe that the clearinghouse should be given authority and eventually additional funds for providing grants to promote compatibility and cooperation among drug information units.

The clearinghouse should include full information on the chemical structures and biological properties of all known compounds and the derivatives of such chemicals, with regard for their cellular, environmental, and social effects. It should gather information from all reliable sources, including the published literature, conference proceedings, government reports and other records. Further, that the clearinghouse should produce, both for general and specific users, annotated bibliographies, systematic files of information on drugs in forms suitable for replication, critical reviews, compilations of evaluated data, judgmental responses to individual inquiries, and other appropriate information.

The Promotion of Health

The Subcommittee on Communications is well aware of the fact that its recommendations range beyond the problems of heart disease, cancer, and stroke, if these problems are considered narrowly. We feel strongly that more effective transmission of health information to the public and the professions—whatever the specific subject may be—is essential to the saving of human lives.

We believe further that strengthening our health communications resources must inevitably advance the crusade against heart disease,

cancer, and stroke. As a member of the Commission stated early in its deliberations:

We have a majority interest in personal disaster in the United States—and conversely a majority opportunity to help improve the health and prolong the life of the U.S. population.

That is because 71 percent of all U.S. deaths are caused by heart disease, cancer or stroke.

Seventy-one percent is a majority interest in anything.

People want information about heart disease, cancer, and stroke. If reliable information is presented to them, they will act upon it. And

their action will set in motion a chain of events that will sharply reduce the toll of these diseases.

In this sense, communication is as fundamental to health as research itself. We of the Communications Subcommittee urge that the worlds of medical science and medical practice

accept this added challenge. And we strongly recommend that the Federal Government fulfill its responsibility to promote the health of the nation through strong and effective communications programs.

MR. EMERSON FOOTE,
Chairman.

Source Paper

INFORMATION HANDLING FOR THE BIOMEDICAL SCIENCES: BACKGROUND AND POSSIBILITIES

Evolution

In the history of the race, as in the history of the individual, medical communication begins at home. Transfer of knowledge by nucleic acids in the genes, imprinting of habits, and direct sensory observation, the pristine means of learning the medical arts and sciences, remain the most elementary and probably most effective methods of communication even today.

PARENT TO CHILD

As a child learns from its parent, the student of medicine learns from his preceptor. It is this tradition rather than sentimentality which leads physicians to regard their teachers as "parents" or the teacher to think of graying practitioners as his "children." Personal experience and personal conversations and associations continue to have a power that underlies the influence of formal systems of information exchange: textbooks, manuals, libraries, and the mass media.

Nevertheless, personal experience has its limitations. Such limitations may have motivated those who tried to encompass the living treasury of medical knowledge in the writings attributed to Imhotep, Hippocrates, and Avicenna, at different stages of human progress. Even in ancient Egypt, Greece, and Iran, the body of medical knowledge challenged the ability of the individual physician to contain in his own small head all the medical knowledge that his preceptors could bequeath.

Then, as now, the search for methods of managing medical information sought to aid both

physician and patient to cope with a dazzling and confusing array of knowledge, fact, and opinion.

And then as now, the task of putting this information into some rational order developed along with the process of recording the information on stone, metal, papyrus, clay, glass, and wood, with chisel, pen, brush, stick, paint and ink. Concepts and technics have changed, but the process of organizing and exchanging information has remained constant and continuous. These changes in concepts and technics are a product of necessity, perception, invention, and acceptance. "The genius so-called is only that one who discerns the pattern of things within the confusion of details a little sooner than the average man." (1).

INTERCHANGEABLE PARTS

It is conventional to associate a startling turn in the technology of communication with a commercial failure, a Bible assumed to have been printed by Johann Gutenberg at Mainz late in the 15th century. Gutenberg was not the first to use movable blocks of type. They had been used earlier in Korea. But Gutenberg was first to exploit the phonetic alphabet of the Occident with movable letters. That fact, and the precision of the type in the Mainz Bible, accentuate the importance of Gutenberg's adoption to printing of the principle of interchangeable standard parts, applied to the manufacture of rifles by Eli Whitney and used so successfully in the manufacture of automobiles and radios.

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The principle of employing interchangeable standard parts is critical to the construction of modern medical information systems, as suggested by efforts to establish standard nomenclature and a universal system of chemical coding (2). The fundamental relation of this principle to both the intellectual and technical elements of information management is a major theme of this account.

The technique of Gutenberg in producing standard interchangeable pieces of type did not immediately release a volume of literature. Other technical innovations were required, such as the rotary press, papermaking machinery, casting of metallic type, quick-drying inks, and especially the contributions of Faraday, Henry, and Maxwell to the electromagnetic movement of precisely machined tools.

A major retardant on the cultural side was the distrust of scientific thought, as opposed to authoritarian dogma or mystic revelations. So surreptitious were many scientific studies that their authors recorded results in cryptic forms intelligible only to themselves. (The apprehensions of that time seem to linger in the cryptography of some scientific writers today.) Under these circumstances, the writing and collection of medical literature tended to be sequestered in discrete enclaves which served as centers of medical learning, and the exchange of information among these centers was haphazard rather than free and systematic.

THE OPEN SOCIETY

America was the logical focus of a movement counter to the Old World pattern. Being dependent at first on important medical literature, American physicians could easily see the logic of an open system of medical knowledge. Such a system, with a complete central depository, was envisioned, in 1878, by John Shaw Billings, who chose to call the Library of the Surgeon General's Office (in the Department of the Army), "The National Library of Medicine." (This term first became legal in 1956.) Paradoxically, the frontier tradition of America, in disdaining precedent, also tends to disparage the scientist who examines the literature before he does his experiments. He is not felt to be working as hard as the man who plunges

right into manipulations. Such a circumstance led Calvin N. Mooers to formulate the law that "Where there is a penalty imposed upon the people who use information, the better the information system, the less it will be used."

Billings not only elected to acquire the most comprehensive collection of medical literature on earth; as his career coincided with the first flowering of periodical publications, he was quick to see the need for a monthly report on new medical titles. In 1879, he established the "Index Medicus" and the following year he produced the first volume of the first series of the "Index-Catalogue" of the Library of the Army Surgeon General's Office (3).

Since then, the history of these publications and companion works issued by the American Medical Association has been a struggle to provide an up-to-date and effective guide to the volume of literature (4, 5). When in 1955 the "Index-Catalogue" ceased publication in mid-alphabet with the 11th volume of its fourth series, the number of entries in the unpublished backlog of completed indexing exceeded the total number of entries published in four series in 78 years (6).

MEDLARS

The need to cover more literature better and quicker prompted a report to the National Library of Medicine Board of Regents, November 1957, which led to a proposal to the Council of Library Resources, April 1958, that funds be provided to investigate the feasibility of mechanizing the bibliographic process. Mechanization of the index to current medical literature ("Index Medicus"), with support of a grant to the Department of Health, Education, and Welfare from the Council of Library Resources, was a step toward an electronic system for facilitating search and retrieval of medical titles. Funds allotted by the National Heart Institute, which was interested in special bibliographies of the cardiovascular literature, enabled the library to develop the computerized Medical Literature Analysis and Retrieval System, MEDLARS. Today MEDLARS appears to have the technical potential for recording and distributing all scientific literature (7). Therefore, the present challenge to handling medical

information seems less technical than intellectual and social.

Can information scientists devise effective plans for organizing knowledge? Will society support the information system and encourage and reward its users? Such questions haunt the librarian who tries to match individual, impetuous demands for information with the disorderly contents of the scientific literature.

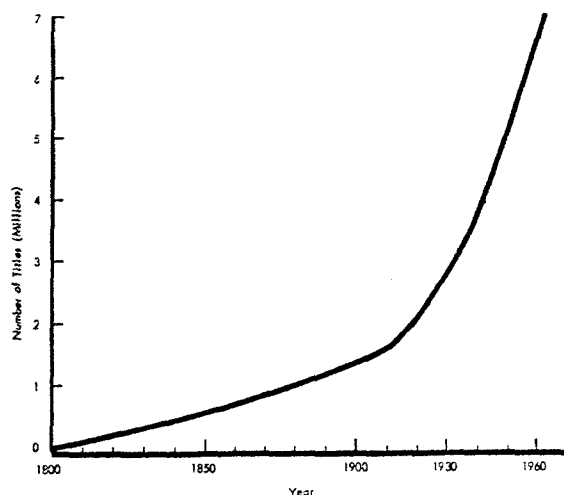
THE MATHEMATICS OF BABEL

The following data offer some concept of the volume and variety of literature which the modern information system may be expected to manage.

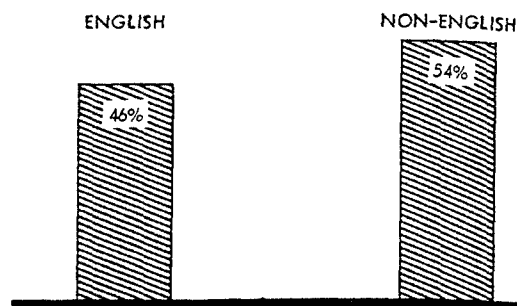
The rate of output of biomedical publications for the past 10 years has been fairly constant, at 1.4 papers per man-years employed in biomedical research and development, and 1.4 per project 1 to 2 years old (8), but the volume has grown in proportion to the expansion of research and development. In 1960, there were 5,800 biomedical serial publications. The total number of papers covered in 1 year by "Index Medicus" was 120,000 in 1960 and is expected to be 250,000 in 1970 (7). Although the chemical literature is estimated to double every 8.5 years, the National Library of Medicine calculates that the volume of biomedical literature doubles only every 25 years (9, 10).

The Library estimates that it received 4 million titles between 1933 and 1963, in contrast

TOTAL NUMBER OF TITLES RECEIVED BY THE NATIONAL LIBRARY OF MEDICINE
1800-1933 1933-1963



DISTRIBUTION OF CHEMICAL LITERATURE BY LANGUAGE OF ORIGINAL TEXT, 1963



Based on unpublished data developed by Chemical Abstracts

to 3 million received between 1800 and 1933 (9).

A productive minority among scientists writes the majority of the papers published. How small is this minority no one knows exactly, but it is probably between 10 and 20 percent of the total (8). For that matter, a small minority of journals carry the bulk of the cited literature (8, 10).

Of the serial publications founded after 1950, one-third died before 1960. The great majority of those founded in that period (80 percent) were foreign: As biomedical research increases among scientists who do not ordinarily speak English, publication of scientific reports in foreign languages will expand, unless there are special incentives for favoring English as a common scientific language. An unpublished study by "Chemical Abstracts" indicates that in the years 1961-63, there was a slight increase in the proportion of papers written originally in English, composing not quite half of the total. The proportion written originally in Russian increased substantially, while most other non-English languages declined, relatively.

Secondary Publication

The current volume of biomedical literature is not only indexed; it is also abstracted and to some degree translated. Approximately 500 such secondary publication services, a third of them American, are concerned with biomedical literature alone. The number of secondary

services for all scientific and technical literature is about four times as large (11).

The annual total of biomedical abstracts is 1,200,000. An additional 700,000 titles are listed or indexed. (Many documents are covered more than once, and some listed or abstracted are strangers in the biomedical field.) There are 31 secondary sources in the United States for drug information alone (12). (Intramural services of pharmaceutical companies are not included in these estimates.)

Of 882 journals carrying 14,334 papers cited by NIH grantees as products of their work, almost all were processed by at least 1 of 13 major secondary services, and the average processing was by more than 3 of the secondary publications. Two services, "Index Medicus" (IM) and the "Bibliography of Agriculture" (BAG), covered 94 percent of the articles (11).

A 1961 study of the coverage of cardiovascular, endocrine, and psychopharmacological literature found that the combined efforts of "Excerpta Medica" (EM), "Psychological Abstracts" (PA), "Chemical Abstracts" (CA), and "Biological Abstracts" (BA) covered 70 percent of the articles, all 1 to 14 years old. "Excerpta Medica" alone covered 42 percent, the best of the four (13).

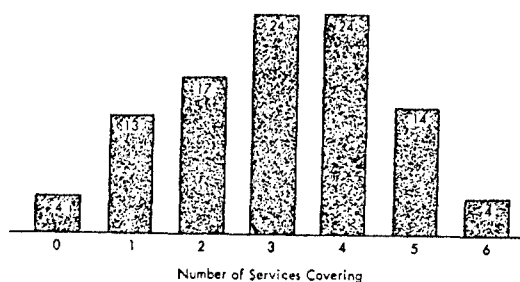
Forty percent of all the sample articles were covered by more than one of the four services cited.

A study of coverage by six services (EM, BAG, CA, BA, PA, and IM) found a symmetrical distribution. None covered 4 percent and all six covered another 4 percent. About 13 percent of the sample journals were covered by no more than one service; 14 percent were covered by five and 17 percent were covered by two; 24 percent were covered by three and 24 percent by four. (11).

On the average, the world's scientific journals are being covered four times over by U.S. abstracting-indexing services, but not always for the same content.

IM indexes 145,000 documents a year (1963), the same number abstracted by the U.S.S.R. "Referativnyi Zhurnal: Biologiya." The various sections of "Excerpta Medica" total about 90,000 abstracts a year. CA produces 165,000 abstracts a year, in contrast to 30,000 for "Re-

PERCENTAGE OF 14,275 U.S. BIOMEDICAL DOCUMENTS IN 891 JOURNALS ABSTRACTED OR INDEXED BY SEVERAL SERVICES



COVERAGE BY INDEX MEDICUS OF 14,275 DOCUMENTS



ferativnyi Zhurnal: Biologicheskaya Khimiva" (14). BA produces 100,000 abstracts a year. Its French counterpart, "Bulletin Signaletique," claims to annotate 200,000 titles. Most services in specialized categories produce fewer than 10,000 or even fewer than 1,000 abstracts a year.

Technical Reports

In addition to items in books and serial publications, the biomedical literature in recent years has been peopled with a new breed called the "technical report." Some such reports are deemed ineligible for formal publication because of "length, degree of detail, specialized language, or restricted interest," according to criteria used by the Division of Biological Standards of the Public Health Service. Another factor is that the criteria for review before printing of technical reports differ sometimes from those for journal publication. Some are presented in preliminary form at scientific conferences before a refined version is offered for formal publication. Some consist of author abstracts, submitted for distribution at meetings, for publication with the proceedings, and these are regarded as seriously as a formal publication. In 1962, 1,615 biomedical technical reports were identified, half from the Department of Defense. The indexing services cover such reports only on a selective basis. A clearinghouse in the Department of Commerce has been designated to announce and distribute all nonclassi-

fied technical reports issued under Federal auspices.

Sources of announcements of technical publications include, "Technical Abstract Bulletin" (TAB), issued by the Defense Documentation Center (DDC); "Nuclear Science Abstracts" (NSA) of Atomic Energy Commission (AEC); "Technical Publications Announcements" (TPA) of National Aeronautics and Space Administration; and "Government Research Reports" (GRR), Office of Technical Services (OTS) of the Department of Commerce. Each lists a separate category of documents for the biomedical sciences.

Technical reports usually are published within a month, in contrast to journal articles, which usually take 6 to 8 months. In TAB, the lag from publication to announcement is 6 months.

The American Documentation Institute, Library of Congress, provides a depository for papers, or portions thereof, which are denied formal publication because of length or degree of detail, provided they are recommended by the editor of a scientific journal and announced in the journal.

LIBRARY SERVICE

Few medical libraries today are much better off than the scientists in managing the volume of information available. The librarian is expected to stock or procure all documents requested, to prepare announcements and bibliographies, and to keep all this information in neat order. As if this were not enough of a burden, librarians have been attacked for not providing answers instead of documents and for failing to alert scientists and practitioners to new information. Far from being able to provide the research services in which they are trained, most librarians are compelled to give most of their time to housekeeping and administrative duties.

In 1962, only two of every five hospitals with fewer than 99 beds reported having a professional library, and these had an average collection of only 158 books. Of the total of 5,444 short-term non-Federal general hospitals registered with the American Hospital Association, only 3 out of 5 had professional libraries (15).

The average collection in professional li-

braries in hospitals with more than 400 beds was 2,657 books, in contrast to one recommendation for more than 6,000 books and more than 126 journals for the larger hospitals (16). For hospitals with more than 100 beds, one professional body recommends at least 1,000 books published within the past 10 years (17).

The 3,192 hospitals with professional libraries employed only 863 full-time personnel and barely 3,000 part-time personnel (15). Despite this shortage of trained personnel, only 294 have attended the four institutes on hospital librarianship held since 1959 by the American Hospital Association.

A particular difficulty in this setting is the hospital's tendency to confuse the separate callings of the medical librarian, the medical records librarian, and the librarian who serves the patients (18).

Doing their utmost with limited resources, small libraries lean heavily on the resources of the National Library of Medicine and other major depositories. They have participated in an interlibrary loan system to exchange relatively rare documents, but the demands upon this system, too, are on the verge of a breakdown.

Interlibrary loans by the National Library of Medicine, which stocks 1 million volumes, increased 82 percent from 1958 to 1961. The demand for such loans is expected to accelerate as MEDLARS expands its coverage from 2,200 journals to 3,500 journals plus 5,000 books annually. There is some expectation that MEDLARS, instead of supplying bibliographies, whether recurrent or on demand, will simply supply tapes to regional centers which will conduct the searches and provide the bibliographies to answer the prospective volume of requests.

The value of such bibliographies is suggested by a test run of a prototype prepared for cardiovascular studies. Investigators in this field, who are well read even by the standards of the profession, found that 85 percent of the references pertinent to their work in the MEDLARS prototype bibliography were new to them although the average age of the titles listed was more than 6 months, according to an unpublished study by Herner and the Institute for Advancement of Medical Communications.

INTERDISCIPLINARY AND INTERNATIONAL COMMUNICATION

The above figures are a rough indication of the dimensions of biomedical literature. To add all scientific and technical literature to biomedical writings would multiply the number and variety of publications by a factor on the order of 10, and the complexity of the information pattern by a factor of 100 or more. Improvements in the arts of medicine nevertheless depend more and more on the sciences of chemistry, physics, engineering, and mathematics: Most medical missions today are interdisciplinary.

One result of the interdisciplinary mission has been a realization that communications in any one subject are limited by the quality of scientific communications in general. This conclusion was voiced by the President's Commission on Mental Retardation which observed,

It is * * * essential to support the foundations of scientific research in all fields, and to stimulate the communication of both needs and solutions among investigators and clinicians working at every level * * * (19).

Requirements of improved and accelerated communications across the boundaries not only of disciplinary lines but of Nations can be met in part by vigorous exploitation of conventional methods as well as new methods * * * prompt exchange of unpublished scientific data and development of efficient, systematic retrieval of results of research is urgently needed * * * increased support for research in communication theory and technology must be provided if we are to make effective use of our scientific potential and translate new scientific knowledge into practice (19).

On a limited scale, the foregoing data offer a fair view of the pattern and volume of biomedical information. But the dynamics of communications are not as easily described as the dimensions. There is some evidence that the exponential growth of scientific literature will level out (8, 20). There is also considerable opinion that the formal literature may be a relatively minor force in biomedical communications, outpaced by the grapevine, the invisible colleges, conferences, and specialized information centers. The influence of cybernetics, employing computers, TV, microforms, photocopiers, magnetic tapes, and long-line circuits,

may strengthen methods of handling medical information in years to come, but Mooer's law, cited above, will also operate.

INVISIBLE COLLEGES AND INFORMATION CENTERS

Two typical and somewhat contradictory responses are heard from most scientists or practitioners when they are asked how they obtain scientific information. (A) Smug: "I have no trouble. When I wish to know something, I know where to look or whom to call." (B) Desperate: "How can I cope with the quantity of information published?"

It may be argued that neither is sophisticated. But both indicate a disposition to turn to personal acquaintances for information rather than to the bewildering jungle of the formal literature. Neither is much help to the middleman whose job is to help all users get the medical information they need.

In the exchange of scientific and technical information, available data indicate that scientists spend several times as many hours at meetings or on the telephone as they spend reading the literature. Even though delays or frustrations in efforts to use the literature may be responsible for this relative dependence on conversation, such conferences are not in themselves necessarily an economical method of exchanging knowledge. The number of meetings alone seems extravagantly high. The biomedical meetings in the United States and Canada listed by calendars published by the American Medical Association and others total more than 1,500 a year, and these are said to be only a fourth of the number actually held. (21).

At the cutting edge of science, among families of specialists, such as those concentrating on viral etiology of cancer, resort to personal conversations, telephone calls, and occasional visits or conferences is understandable and justifiable. Such scientists need not and should not wait for publication of final results by their colleagues. It is a tribute to the camaraderie of science that they form and maintain associations for free exchange of information. At the same time, such sources of specialized information grad-

ually expand to include others outside the intimate circle.

Once a body of special information is solidly established and of wide enough concern, it is common for the not-so-invisible college to set up a specialized information center, a focus for the storage of specialized knowledge to answer or anticipate germane inquiries.

The National Referral Center for Science and Technology, Library of Congress, has produced its first directory to shed further light on the number and distribution of such specialized information centers. An early study of information centers (22) necessarily dodges the duty of idealizing their function (23). But it seems widely agreed that such centers are a logical device for matching specialized questions to the quantities of data in specialized fields.

This all too hasty summation of the evolutionary changes in the technology of medical information transfer—from preceptor to manual, journal, library, and information center—has given sparse attention to the concepts of medical knowledge. The concept of medical communication has shifted from a private conversation among a hierarchy of physicians to an international, permanent, floating caucus of scientists, practitioners, and laymen. The pathways of information have opened up. Straight lines, from preceptor to apprentice,

have been supplemented by a network that radiates and ricochets in all directions (24). But little has been said here of the shift of medical emphasis from treatment to cure or, still better, to prevention; from specific single predisposing, provocative, precipitating, and perpetuating events to multifactorial processes; from discrete, isolated specialists to a multidisciplinary team; from sporadic clinical observations to systematic genetic, clinical, epidemiologic, and laboratory studies of individuals and of large populations. And yet these conceptual changes radically revise the “pattern of things within the confusion of details” (1) as envisaged in the past.

Equally significant to the process of information transfer has been the increasing ability to identify specific pathogenic agents and conditions with names which are almost universally understood and accepted, whether parasites, chemicals, or forces of temperature, velocity, mass, or electromagnetism. The terminology of anatomy also is well established. Even the language of biochemistry and virology has become less occult among the specialists. Definition and precision of concepts are the intellectual counterpart of the system of standard interchangeable parts used in the technology of information handling.

Definitions and Assumptions

It is widely assumed that interchangeable standard terms, meaning the same in all languages and disciplines, will facilitate the flow of information, even though achievement of a standard language is slow and difficult.

It may be assumed also that a technology which links all the cities of the world with instant information will accentuate the use of standard terms.

Although undisciplined natural language will undoubtedly continue to prevail in common discourse and in much professional writing, its automatic translation into standard disciplined forms will be necessary if a network of scientific information is to operate satisfactorily.

Perhaps the most egregious assumption is that it is possible to frame and employ such a disciplined language, but that is the faith of many “information scientists,” a category which in this context includes documentalists, librarians, indexers, bibliographers, writers, and editors.

“Information” itself is defined, succinctly, as “meaning assigned to data” (25). The implication of this definition is to exclude transmission of random signals: Casual conversations, unsystematic records, and accidental collections or accumulations, not to mention noise and dysplastic art.

“Communication” may be conceived as a step

beyond information: It implies perception of the meaning on the part of both sender and receiver and exchange of information, but it does not necessarily imply active response. In other words, the function of the information scientist is to facilitate delivery of the message and to be sure that it is understood.

Feedback ordinarily tells how the user interprets a message. But it ought not be the duty of the information scientist to assure that the user acts upon the information given. The behavior of the user is something to be determined by his individual judgment in the context of public affairs: e.g., it is the information scientist who informs the practitioner of the character of a vaccination; administration of the vaccination may depend on the judgment of the physician, the decision of the patient, or the requirements of law. This distinction may serve to disabuse information scientists of apprehensions of messianic responsibility and to anticipate extraordinary expectations on the part of administrators.

Such a concept of communication also answers the natural question: Why bother with fresh messages for people who do not apply what they already know? The task of motivating people to act is a responsibility for the community at large. Motives for action involve common goals and aspirations. The basis for feeding information is the assumption that people may act more suitably with the right in-

formation than with wrong information or with no relevant information at all.

A further assumption is that the flow of information is screened and regulated at key points. These include the scientific colloquies, the medical societies, the medical schools, the professional journals, science writers, librarians and other science information specialists, and the directors of various mass media.

Publishers and TV producers in particular are assumed to have a responsibility, as well as a rare opportunity, to satisfy the manifest interest of their clientele in health information (26). While it is incumbent upon professional journals and libraries to speed exchange of information among scientists, and while it is the presumptive duty of medical schools, medical societies, and hospitals, in cooperation with various voluntary and official health agencies, to maintain and improve the competence of the health practitioner, such enterprises require public sympathy and support. It is assumed that the health sciences are best fostered in a society where knowledge is widely diffused. The mass media, including the carriers of advertising, are among the most potent forces for conveying information or misinformation, as the case may be, for the improvement or impairment of the species.

The success or failures of such efforts are influenced materially by forces described in the following paragraphs.

Impediments of Message Transmission

The impedance factors in message transmission usually cited are: A weak or confused signal; circuits insufficient to carry or distribute the load; receptors of insufficient sensitivity; or the absence of a feedback to regulate the nature or flow of the signal.

A signal may be confused by competition with other louder or contradictory signals, or by the presence of a mere multitude of signals. The circuits may suffer from a shortage of filtering or switching mechanisms. Human as well as physical failings may impede reception and feedback.

This model does not serve our present purpose, however, except for its bearing on the volume of information as it affects the entire circuit. Other factors discussed below are obsolescence, which concerns the speed and timing of transmission; accuracy and evaluation, which are judgmental rather than physical factors in communications; language, related not only to the nature of the signal but to the nature of the mind; and a radical revision of "the pattern of things within the confusion," affecting the design of the information system.

FLOOD OR SCATTERED SHOWERS

Most of the studies of biomedical information promptly conclude that the mere volume of literature in itself is a major impeding factor. To quote but one such study,

*Science and technology can flourish only if each scientist interacts with his colleagues and his predecessors, and only if every branch of science interacts with other branches of science; in this sense science must remain unified if it is to remain effective * * *. Yet, because of the tremendous growth of the literature, there is danger of science fragmenting into a mass of repetitious findings, or worse, into conflicting specialties that are not recognized as being mutually inconsistent. This is the essence of the "crisis in scientific and technical information." (27).*

Faced with an overload of information, the receiver resorts to one or more of the following actions. He may skip, ignore his mistakes, let a backlog build up, select only important items, abbreviate the response, call for help, handle messages wholesale, or quit. These actions are also known as omission, error, queuing, filtering, approximation, multiple channels, chunking, and escape (28).

Filtering or selection is an elementary action on the part of all receivers. As Freud has pointed out, the art of forgetting is more important than remembering: Otherwise the mind would be completely cluttered. The development of specialties in science is a filtering process, an effort to select only items of information that are pertinent to a given discipline or mission.

In most discrete specialties, there does not appear to be an overload of information, despite the experience noted above with the bibliography of cardiovascular literature. Within a narrow specialty, the available work of the leading contributors is quickly located and studied, and if an unknown comes up with a significant report, the grapevine soon has the word, often before formal publication.

Nevertheless, the task of dealing with the current volume of medical literature remains critical for producers and users of information and above all for the middleman, the information scientist. The user who ranges over the great mass of literature sees only a limited, biased sample, even though such stimulating browsing may be the road to serendipity. For

systematic interaction among specialties, various forms of linkage and switching of information sources need to be developed (27). The task of the information scientist may be one of building irrigation ditches to handle the runoff from scattered showers, rather than one of damming or channeling a flood (21).

OBSOLESCENCE BY THE HOUR

The rapid obsolescence of medical information is suggested by survey data as well as by reports of medical research. A study of inter-library loans by the National Library of Medicine found that 59.6 percent of the serial publications requested were less than 10 years old, 78.3 percent were less than 20 years old, and only 5.6 percent were more than 40 years old (29). Without implying that the more recent information is necessarily new, the figures indicate that the reference works in the physician's bookcase may not tell him all he needs to know.

A more dramatic figure, widely cited, is that 90 percent of the pharmaceuticals on the market today were unknown 20 years ago. Again, it is not implied that the 90 percent are necessarily better than the durable 10 percent. Nevertheless, rapid and notable changes in the practice of medicine such as prophylaxis of rheumatic heart disease, exercise of stroke victims, and cytological diagnosis of cervical cancer have tended to replace older methods. These changes in clinical practice sound a clear challenge to practitioners to keep up with the times, in part by consulting current literature.

The rise in U.S. funding of biomedical research and development, an increase from \$148 million in 1950 to \$890 million in 1961, has unquestionably multiplied such changes in clinical practice. And realization of these medical advances has been disturbing to many practitioners and some of their patients. While ordinarily they recognize it is wise to eschew novelty, to stay with tried and tested procedures, they cannot help but be tempted by the fact that many medical novelties of the past 20 years, such as valvular surgery, antibiotics, and steroids, have become established and respected. Between caution and hope, they are as badly torn as Hamlet. And nothing can re-

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lieve them so much as scientific information which will distinguish between genuine discoveries and mere changes of fashion.

The hazard they fear is that they may be victims of fashion. Medical fashions in diagnosis have prompted the flippant comment that we sometimes have epidemics of statistics rather than epidemics of disease. Treatment also may be a fashion as much as diagnosis, even to the extent of surgery. The assertion that 75 percent of the cancer victims might have their lives "saved," meaning "prolonged," by early diagnosis and preventive surgery, for example, has been shaken by data offered with respect to mammary sites (30).

Information is available to support the claim in behalf of surgery, but the question is, is the claim truly scientific? In such a situation the conscientious physician needs evaluative information rather than mere documents.

The uncertain scientific basis for other forms of medical practice is reflected in serious literature on acupuncture, the Chinese technique of treating ailments by putting needles in the joints, and moxibustion, known in the West as cupping, a technique of drawing blood to the skin with a vacuum. The persistence of these practices in the Orient may encourage curiosity as to their value, but a conclusive scientific experiment has not validated these technics.

Arguments over dietary factors or the use of anticoagulants in heart disease offer another example of the need for scientific evaluation of transient reports. Such arguments also illustrate the volatility of scientific theories and the tendency for fashion and discovery to be confused with one another.

While such disputes are best settled by experiment and careful accumulation of evidence, a desperate patient is seldom willing to wait for the final verdict. Having seen first hand the ubiquitous achievements of modern science and technology, he insists that something new be tried, especially when established methods are slow and unsatisfying. Moreover, the possibility that something new may actually be useful is one that no practitioner cares to discount today.

But the physician will be handicapped in applying new methods unless information methods

become capable of supplying fresh information promptly, in perspective, and well evaluated. The present rate of research and development is so far ahead of the reporting and evaluation that much scientific information is out-of-date before it is in print.

The time lag between the delivery of a report and its publication ranges from a few months even to a few years. Secondary publication invariably takes a few months more. But the delay between the completion of the report and delivery of an acceptable report usually is even longer than the delay in publication. In the process of announcing new information, therefore, both the writing and publication phases are too slow for the modern pace of obsolescence or for the scientific appraisal of the newest information.

FREE MARKET vs CARTEL: THE PROCESS OF EVALUATION

It is considered by many that a critical step in managing scientific information is to weed out false, frivolous, or foolish contributions, or conversely to select for publication only the significant and the sound. In other words, evaluation and screening are trumpeted as critical to information handling (12), except among those who feel frustrated by obdurate critics and editors (31).

The evaluation system is both formal and informal. Evaluation begins in the author's struggle to select precise words, proceeds with comments by his preceptors and reviewers, and concludes in the response of readers to his work, if not in this generation then in a later one. The theme of critics of this process is that evaluation needs to be refined, to be more self-conscious and critical, and to exert more influence.

At the same time it appears that, despite all hurdles and hazards presented by editors and referees, the author who really tries can succeed in having almost anything published and distributed. By this means the free market in scientific information tests a scientific work by the ancient rules of supply and demand. If the open market is indifferent, few copies will be read; if readers are respectful, the paper will be reproduced and broadcast. Apologists for this

procedure assert that such freedom is necessary to escape from hardening of the hierarchies.

Experience with an epidemiological study of encephalitis (32) serves both as a warning against restricting publication and as evidence of the futility of such restriction. L. L. Lumsden was alone among 100 eminent colleagues in ascribing a St. Louis epidemic of encephalitis to a mosquito vector. Although his paper was not published formally for 25 years, the rejected text was mimeographed and circulated among a select scientific underground until the frayed copy was recognized for the classic analysis that it proved to be.

A similar history attended a theoretical and creative study which was rejected by 32 journals before one bold editor gave it space. The author predicted, on the basis of his theories, that biologists would find a free-living treponeme and a simian reservoir of malaria. These predictions were vindicated within a year (33).

Such incidents also indicate some hazards in evaluating factors of impedance or intensification of biomedical communications.

Dr. Richard Orr, director of the Institute for the Advancement of Medical Communications, has asserted that many prized assumptions about the process of information transfer do not stand up under the test of experience. His advice is well warranted. Studies undertaken to assess such assumptions are pathetically few.

Meanwhile, demands for a free flow of information cannot be stilled by a plea for additional evaluative studies. Decisions to improve scientific communications must be taken on the basis of temporary assumptions, however uncertain they may be. In this sense, each communications program is an experiment, and the quality of its assumptions is to be judged less by the superficial success of the communications program than by the discernible relation between those assumptions and the results. A free market for science information should be the logical response to the uncertainty of our assumptions as well as an expression of confidence in the experimental method.

Nevertheless, free circulation of important information is restricted by considerations of national security; by zealous protection of proprietary interests; by rivalry in the contest for

professional eminence; by reluctance to report negative results, so called; and by simple indifference to publication. Under these circumstances, the common market for science information suffers from a variety of political and psychological trade barriers.

THE PATHOLOGY OF LANGUAGE

Although it is a truism that verbal skills are fundamental to the communications process, current awareness of the health and pathology of language is largely pragmatic or intuitive. Achievement of verbal skills is an art rather than a science. Knowledge of the source of verbal skills or their real nature is on the level of medical knowledge of malaria or typhoid fever 200 years ago: The symptoms are obvious, but the agents and the biological process are mysterious.

It is possible that psychological factors, such as fear, exhibitionism, greed, brutality, slovenliness, egotism, or libido may handicap communications more than ignorance of the rules of grammar or vocabulary. Otherwise, stylebooks, dictionaries, and teachers presumably would have far wider effects than we see. There are reasons to believe that many good writers apparently learn their craft unconsciously by echoing the style of books they read (34). But most authors who contribute to the scientific and technical literature seem untouched by any literary aids.

The question, "Can we teach scientists to write well?" is answered by the question, "Do we teach scientists to write well?" Despite the fact that English occupies a disproportionate amount of time in classrooms, much scientific prose consistently fails to achieve lucidity or accuracy, not to mention elegance. High schools, colleges, and publishing companies apparently are social forces which either have failed to cope with resistant psychological forces or have been undermined by more powerful social forces, such as the lame verbal habits of peer groups or the pressure to publish in haste and repent at leisure in the competitive struggle for recognition.

The increase of research and development in countries which do not favor English, as noted earlier, is claiming an increasing portion of the

body of scientific literature. Consequently, those who read only English may expect to be restricted to a progressively smaller share of the literature.

The principle of interchangeable standard parts implies a single language, preferably English, which is still dominant in biomedical literature; precise, consistent terminology; and orderly arrangements of words. How this principle is to be applied will depend on the ability to design successful studies of the process of mastering verbal skills and on such administrative measures as may convert most of the scientific world to the use of a standard vocabulary, neatly organized. It remains to be seen what may be the effect of contracts with foreign journals to publish English text or of worldwide use of MEDLARS tapes.

One disadvantage of the variety of languages is the need to translate a single document into four or more other important languages. While there may be some justification for such duplication, there is far less excuse for creating several English translations of one document. Under aegis of the Organization for Economic Cooperation and Development, a European Translations Center has been established to give western Nations knowledge of eastern European research and to make available translations not otherwise obtainable. Various national agencies cooperate in this activity.

MULTIDISCIPLINARY MISSIONS

Perhaps the most important storm center in the informal biomedical communications system

today is none of the physical, institutional, or psychological forces cited above, but a historical process. Scott Adams, Deputy Director of the National Library of Medicine, recently stated in an address to the American Library Association (July 1964) that much of the unrest expressed about information among scientists results from the fact that their traditional tight, tidy disciplines are moving into missions which draw upon a wide variety of scientific resources. This process was accelerated by the Manhattan District project and others with military associations, but it now extends also, if less desperately, to a wide variety of public health missions.

To illustrate, a scientist trained to recognize physical characteristics of cardiac tissues may have a cozy grasp of his subject. But if he enlists in a mission to study dietary, biomedical, and viral factors as well as social, environmental, and genetic influences on cardiac tissues, he is subject to new demands. If different effects are associated with different viruses or environments, he aims to learn to distinguish all such differences. In correlating various factors as he analyzes the tissues, he tries to acquire new knowledge in a host of unfamiliar subjects. Similarly the traditional hierarchies of subject matter of each conventional discipline tend to be fattened by word lists with a new range of association.

Mission and experiments designed to deal with this ferment of biomedical information are discussed in the following section.

Experiments and Missions

As Dr. James Miller observed (28), there are only a limited number of things to be done with an overload of information, but within the processes he described, there are many refinements. For example, in the processes of queuing and filtering, or in storage and selection, there are many techniques of organizing or indexing (35) the information so as to simplify the process of finding it (search and retrieval) (36).

INDEXING POLICY

In the small card file on the desk of a scientist and in catalogs, bibliographies, and directories in the National Library of Medicine, there is a common need to conceive of a pattern or system of organization and to arrange the information accordingly. Even when information is piled up in the order of arrival, some scheme is used to find a specific item. In a small collec-

tion, the search may be based upon free association, such as a "small book with a green cover that came in about 2 weeks ago," or "the letter James asked about." In a larger collection, the search will be related to dates, names, serial numbers, sizes, forms, sources, titles, or topics, separately or collectively.

Numbers, dates, and alphabetical lists of authors are among the most familiar bases for organizing information, but not always the easiest for the prospective user with only one subject on his mind. Few ask a librarian for "Number 59-60045 in the Library of Congress catalog." Although there is a strong interest among scientists in all publications of certain authors, their searches usually concentrate on specific topics, such as thermal therapy.

Because of the prime need to organize topical information in accessible patterns, the tactical management of information, whether stored on cards, tapes, microfiche, or notes scribbled on the back of an envelope, is less crucial in the biomedical field than the strategy. (It is unlikely, however, that a single strategic topical pattern will rule the biomedical sciences completely. The current multiple sympathetic if not precisely compatible schemes of biomedical knowledge have demonstrated persistent survival values.)

PLATO VERSUS TOPSY

A fundamental difference of policy in the strategy of planning an indexing system is what might be called the deductive versus the inductive method. The first seeks to assign topics to a prearranged set of categories; the other derives categories from the topics encountered. One is the hierarchic system contrasted with the so-called UNITERM system. In practice, such systems tend to approach one another.

Herner has said that "the phenomenon that best characterizes modern documentation is the recurring denunciation and discovery of the need for context and resolution in index entries" (36). On one hand, discrete terms inevitably form clusters. Simultaneously, those who embark on a program of rigid categorization are certain to encounter items that let the category out of the bag.

A general theory as a logical framework of events has been a driving force and a powerful instrument in the physical sciences, exemplified in the works of Gibbs, Newton, Einstein, and Bohr, as James Conant has demonstrated in his essays collated under the title, "On Understanding Science." General theories in medicine, the pythogenic theory, the germ theory, and most recently the stress theory, have been productive also, if not always valid. The hope of constructing a general theory of behavior, based on the information concept, animates the studies of Miller and associates (37). In one sense, all reasoning is deductive insofar as generalizations are based on incomplete data (38).

On the other hand, the pragmatic approach, or the inductive method, is relatively open, more inclined to allow events to define concepts, patterns, or structures.

Such a contrast in strategy is exemplified in two publications issued by the Public Health Service to facilitate the search for scientific information.

One, "Medical Subject Headings," called MeSH, frequently is assumed to be typical of the hierarchical structure of information (39), although it is actually based on the literature rather than on classical concepts. Under 13 main headings, such as anatomical terms, organisms, humanities, or communication, MeSH arranges various subcategories and terms or descriptors, which in turn contain cross-references. To illustrate, under anatomical terms (A), nose appears under three categories; parts of the body (A1), musculoskeletal system (A2), and respiratory system (A4). Nose is also indexed under face (A1); and, in the other categories (A2), (A4), it is subdivided into nasal septum, turbinates, nasal mucosa, and nasopharynx. These classifications provide a road map for storing and recovering information about the nose. MeSH is used primarily as a skeleton for "Index Medicus."

In the introduction to MeSH, Winifred Sewell, subject heading specialist, states, "Our basic principles of assigning subject headings in medicine have not changed from those set forth in the * * * first edition. We are convinced of the value of using an identical authority list for the indexing of periodicals and the

cataloging of books. Experience has led us to make some changes in specific practices and a major change in discontinuation of the use of topical subheadings * * * But we continue to regard subject headings * * * as directional signals or vectors which * * * serve to locate the essence of a particular paper * * * (39).

In contrast, the Division of Research Grants devised an index with 6,700 main headings in alphabetical order, based upon the terms used by investigators in describing their work (40). The system of deriving index terms from titles or text is known also as permutation or keyword indexing. When these terms are grouped with others, by links, roles, or codes, the system is called coordinated (36). But like the editors of MeSH, the editors of the "Grants Index" find a need for categorical treatment.

With the 1963 edition, the staff of the Division of Research Grants concluded that their system had proved "too rigid and cumbersome" and they therefore introduced modifications. The more significant changes were to group related items "as convenient categories * * * rather than as hierarchical classifications." The editors aim at compatibility with MeSH but have formed no hierarchical system to cover the many descriptors which are needed to identify the work of grantees.

In such a wordlist, cross-references in themselves tend to form categorical groupings: for example, under "heavy metals," there is a complete list of the heavy metals preceded by "see also."

Use of the keyword system has been encouraged by two developments. One is the shift, noted above, from disciplines into missions, a shift which creates new categories of association. The other is electronic machinery which makes it possible to set up an index automatically, the so-called permuted index. For example, given certain instructions and a title, such as "Sensory mechanisms, the reduction of redundancy and intelligence," a machine may list the terms alphabetically as follows:

intelligence/sensory mechanisms, the reduction of redundancy and
sensory mechanisms, the reduction of redundancy and
intelligence/sensory

reduction of redundancy and intelligence/sensory mechanisms,
redundancy and intelligence/sensory mechanisms, the reduction of
sensory mechanisms, the reduction of redundancy and intelligence

Such a procedure, however, puts a premium on the ability of authors to select informative titles and pertinent keywords.

RETRIEVAL VERSUS RELEVANCE

Although it is clear that the art of indexing is the key to organizing and finding scientific information, indexing is also a human and intellectual process. It can be facilitated but never wholly replaced by machinery. The techniques of indexing have subtle implications which summon the skills of higher mathematics and semantics (41).

In one study comparing the success of a mechanized system with a human system based on 3 x 5 cards, the advantage of the human system was thought to lie with the superior quality of the indexing.

An incidental finding of this study, conducted by Cyril W. Cleverdon, College of Aeronautics, Cranford, Cletchley, Bucks, England, was that there is an inverse relationship between relevance and retrieval in a complex information system. That is to say, the more narrowly the searcher defines the information sought, in the interest of relevance, the fewer items will turn up, and the more likely he will miss something. Conversely, if the information is defined broadly, the search will turn up a great many documents which have no relevance to the inquiry. For example, an inquiry about the families of heart patients will turn up far more literature than one which asks for reports on brothers and sisters of victims of coronary occlusion born in Kansas. In this dilemma, uncertain whether to sacrifice relevance to retrieval or vice versa, the investigator finds that the construction of the index and its subclassifications, to provide the so-called depth of indexing, is as critical as the framing of the terms of search.

The state of indexing in general is indicated by the fact that the donors of the Wheatley Medal for Excellence in Indexing had to wait several years until they found a new book deserving of the prize, late in 1964.

BIBLIOGRAPHIES

Exploitation of an index for purposes of identifying sources of information about a given subject has been facilitated by the automation of the "Index Medicus" at the National Library of Medicine. MEDLARS, mentioned above, is capable of printing out 50 recurring bibliographies at a rate of 3 or 4 issues a day, with a periodicity ranging from 1 week to 6 months. It can also print out an addition 22,500 special bibliographies on demand each year. With MEDLARS tapes, any regional information center may produce as many more bibliographies (7).

MEDLARS bibliographies will not be annotated, although it is technically possible for a computer to produce annotated bibliographies, at some additional cost, once the annotations are composed by a human brain. In the judgment of many librarians, annotations add considerably to a bibliography. To a degree, they serve as a superficial review of the literature and spare some readers the necessity of examining each document. On the other hand, more specifically informative titles could reduce the need for annotations.

Meanwhile, the capacity of MEDLARS to produce bibliographies has been limited by the number of trained personnel. One informal test has indicated that MEDLARS in an hour will turn up twice as many citations as a team of librarians working for 3 weeks. The possibility of training librarians to utilize MEDLARS in their searches offers an opportunity for substantial economies in information handling.

Still another source of bibliographical information is the citation index, which lists authors alphabetically in association with the papers which have cited them (42, 43). J. W. Tukey, in the "Journal of Chemical Documentation," January 1962, describes a citation index system which would facilitate exploration of all literature pertinent to a specified topic, by repeatedly winnowing the citations, eliminating those papers which are not of direct concern to the topic specified.

For purposes of browsing and alerting authors to new titles, the tables of contents of

many biomedical journals are published periodically in a serial publication called "Current Contents."

UNIVERSAL SYSTEMS

Eugene Garfield, publisher of "Current Contents" and of a mechanized citation index (in contrast to the selective citation index proposed by Tukey), is also a proponent of a Unified Index to Science, originally proposed by Neurath (44, 45), as a means of organizing scientific information in the era of the "Biophysicist, psychochemist, the human engineer, the instrumentation scientist, and the cosmobiologist."

A comparable proposal for a comprehensive science information service has been advanced by Dr. Stafford Warren, Special Assistant to the President for Mental Retardation. In common with other proposals for handling science information, the Warren plan offers the concept of a single system of all science information, with a central storehouse of abstracts and citations on tape, extensive use of microforms for storage and duplication, and distribution of duplicate tapes and microforms to regional libraries and to specialized information centers for direct service to users. Like the National Library of Medicine, Warren's proposed National Science Library would provide extremely limited service directly to individual scientists.

Both the Garfield and the Warren presentations emphasize the need to develop standard nomenclature and the importance of a comprehensive science index to meet interdisciplinary needs. Garfield has also advocated governmental standards of literature searching, for compliance with Food and Drug Administration regulations, as an essential preliminary to acceptance of a national drug information service.

ABSTRACTING

The volume and variety of abstracting services has been described earlier. Such services were conceived originally as a method of reducing and corralling the herd of scientific literature. Today they are widely considered to have reached a stage where steps must be taken to avoid chaos (41). In the field of chemistry and physics, the Abstracting Board of the Interna-

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tional Council of Scientific Unions (ICSU) has undertaken to encourage abstracting services to adopt uniform or consistent systems of indexing, abbreviation, classification, and translation, but no such formal steps have been taken by others. Herner has undertaken to design modular forms of informative, descriptive, and critical abstracting, to permit one set of abstracts to be used by many different services—for a wide variety of purposes, and to subdue the need to write a variety of abstracts of the same document.

The consensus of most editors is that authors are perfectly capable of writing their own abstracts, given a set of ground rules and an intelligent editor to discourage verbosity. It is recommended by various bodies, including the UNESCO Working Party on Scientific Publications, that journals publish authors' abstracts with the full paper, but not many have heeded this advice (46). This procedure could materially reduce current payments for composing abstracts.

Ironically enough, with all the effort invested in abstracting services, it appears that research scientists depend far less on these sources than on the journal papers and their citations (41). Engineers, on the other hand, appear to favor abstracts. The variety of texts, user needs, and applications, however, discourages generalizations on the future of abstract publications.

TRANSLATIONS

The management of abstracts has much in common with the management of translations. In both situations, assuming the author knows a second language, it is preferable to receive the text from the author rather than from a second party. In both, there is excessive duplication, with the same document being abstracted or translated by different services (11). In both, there is a need for agreement on standard usage. Especially is this need evident in transliteration. For example, should it be Khrushchev, Hrooscheff, Kroosheff, or any of a dozen other variants.

Furthermore, little is known about the needs for biomedical translations. Since the ICSU translation program began, there has been a decided increase in the citations of foreign lit-

erature by American and British physicists and chemists. But such an interest is not evident in the biomedical papers. A service to alert users to the availability of specialized translated information might be a consequence of the Warren proposals, working through affiliated information centers.

Coordination of scientific translation projects on Government contract is a function of the National Science Foundation to the extent that counterpart funds are used according to the terms of Public Law 480. The Foundation also supports announcements by the Office of Technical Services of available translations, classified by subject, and announcement of translations by private enterprise, issued by the Special Libraries Association at the John Crerar Library in Chicago. But there is no legal mechanism for coordinating translation services, public or private, beyond instruction to the National Science Foundation to exert leadership. Under these circumstances, persuasion and cooperation determine how far such coordination can go.

READING AND WRITING

Considering the importance of verbal skills in communication, the effort given to improve this phase of communications in any field of science is modest relative to expenditures on improvement of other processes, such as indexing or translation. Projects undertaken so far, however, include many that are promising and noteworthy. For example, the National Heart Institute has issued a glossary to assist medical writers in using simple, lucid language (47). The Public Health Service has employed professional science writers exclusively for the purpose of preparing reviews, such as one on the association of diet with atherosclerosis. It also conducts or supports seminars which offer science writers an opportunity to draw freely upon the information and advice of specialists in developing background information on new developments in science.

The National Tuberculosis Association has financed a science writer to work in a laboratory with a scientist, a project originated by the Council for the Advancement of Science Writing (48). The council also promotes seminars

for science writers, on-the-job training programs, and an annual briefing on new horizons in science. Minor projects of the council include a registry of science writers, a library, and a bibliography.

The council was created by the National Association of Science Writers, which was organized to promote the quality of science reporting by popular mass media. The science writers have done much to improve relations between scientists and mass media reporters and have advised scientists and physicians on effective use of mass media, notably in the management of a press room for scientific meetings (49).

Other societies concerned with improvement of biomedical writing include the Conference of Biological Editors, whose stylebook (50) has been widely accepted by professional journals, and the American Medical Writers Association, which numbers among its members many physicians devoted to writing and editing.

The Public Health Service has granted funds for a course to assist editors of dental journals and to support a course in writing for medical students. It conducts a monthly seminar for writers and editors in its employ. And on rare occasions a division or program invites a noted editor to speak to a group of its employees.

For the most part, however, training in writing and editing is on-the-job rather than inservice. Opportunities for special training in an academic setting are relatively few. No legislation specifically provides for support of applications for career fellowships or training grants for scientific writing and editing.

MICROFORMS AND BITS

Although it is generally agreed that human and social factors continue to be more critical to medical communications than the technology, the dazzling and tantalizing potentials of the technology can not be ignored. For example, to economize on the space occupied by much literature, it is possible to print 50 pages or more on one small card and yet enlarge the type to a readable size without loss of definition. Such a reduction in the size of a document or a less dramatic one (most Government agencies have agreed (51) upon a standard reduction of 18:1

for technical documents) makes it possible to store documents on cards or chips or transparencies (microfiche) which in turn can be stored, retrieved, and reproduced by electromechanical techniques (52), barring copyright restrictions which could hamstring automation of scientific communications. Such machines may be classed as speculative, experimental, or commercially available, as Morton Taube has suggested.

Experimental machinery can read a document, record the document in an electromagnetic file, recall the document on request, and print it out again at a rate of 900 lines a minute. In the speculative class is a machine that will listen to a question, ask the speaker to refine it, and deliver the answer both orally and in print.

At Massachusetts General Hospital, with Public Health Service aid, nurses and doctors are operating an experimental system which permits a computer to exchange typewriter messages with 320 separate stations simultaneously; to receive, record, and report information; to request clarification of instructions; to detect errors by the sender and demand verification; and to issue reminders, cautions, or warnings. When medication is prescribed, it can instantly tell the doctor what it costs.

With such technical competence, demonstrated by the automation of the files of the Social Security Administration, it is conceivable that, with the National Library of Medicine as a basis, the Government could maintain a depository of all scientific literature (in microform or on tape), index that literature, print out recurrent bibliographies of special interest to certain users, and deliver duplicate microfilms or tapes to special information centers.

The full resources of this depository might be duplicated in a number of regional centers, in keeping with the principle of centralizing bibliographic duties and decentralizing bibliothecal functions (53). And the distribution of documents could be facilitated: Any item in the store could automatically identify a series of adverse reactions associated with specific chemicals and print out a list of the reports giving the information.

To illustrate the versatility of the machine on a more conservative basis, MEDLARS is capable, with a little reprogramming, of publish-

ing a truncated "I generally available" for use by hospital libraries (53).

A critical element distribute microfilm including core libraries relatively inexpensive for enlarging and printing demand.

Experimental devices, clear image at high that would be attached laboratories, is part the Public Health one of these machines copies will answer question: Immediate awareness works.

Only experience line between wild moments in information world which exchange the seas by way of information science

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ing a truncated "Index Medicus," based on 150 generally available English-language publications, for use by general practitioners in hospital libraries (53).

A critical element in a system which would distribute microform copies of documents, including core libraries for remote outposts, is a relatively inexpensive and satisfactory instrument for enlarging microform copies for reading and printing the text or any part of it on demand.

Experimental development of several reading-printing devices, capable of producing a sharp clear image at high magnification, at a price that would be attractive to most libraries and laboratories, is proceeding under contract with the Public Health Service. A combination of one of these machines and a handful of microcopies will answer a major need in communication: Immediate and easy access to essential reference works.

Only experience and economics can draw the line between wild fantasy and practical achievements in information handling today. In a world which exchanges words and views across the seas by way of a satellite, the speculations of information scientists are relatively modest.

USER SERVICES

Once information is collected and organized there remains the task of delivering it selectively to users. Their requirements and the uses of the information ought to determine the design of an information system and services (41). User needs include: Awareness, through announcements or other publicity; training, in the use of information facilities as well as in the sciences; access, not only to information in their own field but in others, including browsing opportunities; assistance in search, including directories, reviews, manuals, compendia, translations, wordlists, guides, standard tables; and consultation, especially in the domain of practice, to provide prompt direct answers to specific urgent questions.

Awareness

A spontaneous response to the need for an awareness service is exemplified by the Virology Alert originated early in 1964 in the National

Cancer Institute, Public Health Service. Virologists in various institutions accepted assignments to inspect allotted journals for articles on virology, which they agree to review. Their reviews are collected, reproduced, and distributed to all participants, originally 120 in number.

For the awareness of health professions in general, large plans are in view. The Public Health Service Surgeon General has said:

For most communities, the hospital should be the pivotal agency for health communications.

Two major premises are agreed upon by many who are working in this area:

1. The community hospital will continue to take a larger and larger central role in medical care programs, for good professional and economic reasons.
2. The community hospital will become increasingly important in health education for all types of health practitioners and the general public (54).

Practitioners themselves receive an arsenal of free phonograph records, tapes, TV programs, radio broadcasts, and seminars, as well as literature, loaded with miscellaneous medical information.

The "Journal of the American Medical Association" catalogs no less than 1,430 seminars for the Nation's 150,000 physicians. The American Medical Association proposes to accredit institutions which offer approved programs for postgraduate training. To retain standing in the American Academy of General Practice, a physician must complete 150 hours of approved postgraduate study every 3 years, and similar standards are posed by various medical specialties, societies, and hospitals.

But as yet no system has been devised which provides the tired, overburdened practitioners with the information they need to apply to a specific patient at a given time, or which even makes it possible for them to obtain and absorb the new information that is most important to their regular practice. Some hopes are held out for a desk-size film viewer described below.

Training

Unfortunately for medical education, most training films for practitioners are out of date, and resources for producing new ones are scant. There is no comprehensive program in any institution for the review and selection of training

films for medical practitioners, although the Public Health Service Audiovisual Facility performs its task of stocking, repairing, maintaining, and distributing medical films in an exemplary manner. Resources for distributing and showing training films are far better organized than the production, assembly, and evaluation of these valuable informational aids (55). There is no formal biomedical program for training users or information scientists in information handling.

Concern for practitioners as well as for scientists is expressed in a PHS contract with Long Island University to prepare a manual for nurses on the care of chronically ill patients. A PHS grant to Harvard to prepare an index to the medicinal uses of plants of Southeast Asia and a grant to Utah State University to produce a volume on the composition and nutritive value of 5,300 forms of food are indicative of informational resources under development to assist medical studies and practice.

Search Assistance

Informational assistance is so abundant that it is argued that the system would be working well if it only were used. A typical service for abstracting specialized heart information, for example, may draw upon the contents of 4,500 different journals.

The need for reviews of literature in specialized fields is met with such monographs as those on diet and atherosclerosis, smoking and heart disease, and the hydrodynamics of pulsatile flow. In recognition of the importance of scientific conferences, government and professional societies support a constant round of meetings. Publication of proceedings covers such topics as evolution of the atherosclerotic plaque, thrombosis, and embolism. A bibliography of medical translations, supported by a grant from the National Library of Medicine, is a step toward increasing awareness as well as an aid in searching.

Consultation

Not the least of the forms of assistance is consultation in person or by telephone with scholars. Physicians at the M.D. Anderson

Hospital in Houston, for example, respond several times a day to urgent requests by practicing physicians, and they will arrange for additional telephone lines to be plugged in, if necessary, to provide for a conference with other specialists.

The foregoing examples are a bare sampling of the total science information projects supported by health agencies, institutions, societies, and businesses. The expenditures for such services, by the Department of Health, Education, and Welfare alone, including payments for page costs of scientific papers contributed to professional journals by Public Health Service employees and grantees, direct grants and contracts, and intramural activity, reach an annual total in excess of \$28 million, possibly as much as \$84 million, under a broad definition (56).

Priorities

The influence of such an expenditure, out of a total budget of more than a billion for scientific knowledge and medical practice, will be colored by the way it is directed toward servicing specific user needs having a high priority. Though present science information activities may be praiseworthy, the process by which they are organized is diffused among a variety of relatively esoteric interests.

Such diffusion is to be expected in a procedure which emphasizes the support according to the objectives of individual institutions or personalities rather than according to common needs and goals. Even if the keepers of the funds are aware of priorities in health needs, they cannot readily distribute funds according to such priorities unless the demand for such uses is widely recognized (57).

At the same time, the medical community cannot escape responsibility for the fact that certain users of biomedical information, primarily practitioners, are neglected by present methods of information management. Although the original objective of one private nonprofit enterprise, The Institute for the Advancement of Medical Communication, was to provide medical information to practitioners, its director, Dr. Richard Orr, said he could obtain little support for this purpose.

The Public Health Service budget determine priorities for programs.

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The Public Health Service, with its substantial budget for grants, has a special need to determine priorities for users of biomedical information and to direct attention to these priorities with contracts and intramural programs.

GRANTS AND CONTRACTS

The authority of the Public Health Service to employ grants in support of communication of biomedical information was clarified by a decision of the Comptroller General, March 4, 1964. Even prior to that decision, grants had been used in a variety of experiments and missions dealing in science information. Major grants went to support abstracting services of "Excerpta Medica" and "Biological Abstracts," conferences, symposia, primary publications, a handbook which indexes effects of chemical compounds on the cardiovascular system, and trial issues of a cardiovascular bibliography. The National Heart Institute granted \$50,478 to the Institute for the Advancement of Medical Communication for training in the art of communications, and in 1963 it granted \$54,280 to improve the teaching and practice of preventive medicine (58).

Ingenious and relatively inexpensive applications of modern technology supported by such grants include magnetic tapes, which reproduce the sounds of the heart for the study of congenital and acquired heart disease, and video tapes, which permit repeated viewing of fluoroscopic images of heart and lungs in motion without further exposure or presence of the patient, for use in diagnosis, research, and training. One interdisciplinary study, supported by a grant, reviews exchanges between engineers and biologists on the hydrodynamics of circulation of the blood.

In years to come, it is assumed that the flexibility of the grants mechanism may be employed extensively to support biomedical communications and continuing education for scientists and practitioners. But, as noted above, the grants mechanism by its nature is less likely to serve indicated needs of a Federal information system than are contracts and budgeted programs. For example, contracts were issued for development of MEDLARS, for developing

biological activity cards based on literature of cancer chemotherapy, for preparing cancer chemotherapy abstracts, and for the secondary heart literature described above. These few contracts alone exceeded an outlay of \$3 million in 1 year.

INTRAMURAL PROGRAMS

A superficial study of the science information programs conducted internally by various health agencies and organizations finds a variety of commendable, discrete enterprises in a relatively loose relationship to one another. Such relations as are found tend to be informal, spontaneous, and voluntary, as befits a freely functioning institution.

The price of such freedom, unfortunately, is the sacrifice of much economy of money and effort, submersion of primary needs and objectives, and limp exploitation of the technical potentialities of a well-organized information system. To illustrate, the preparation of authority lists or word lists for use in various indexing schemes frequently proceeds without interchange among the various programs, grantees, or contractors, although their judgments will determine the compatibility of their systems. Sporadic contracts for translations and abstracts incur needless duplication and expense. Support of publications proceeds on an *ad hoc* basis with little regard to the design of a total information system. Little heed is given to the fact that progressive automation of library services requires editorial cooperation in the form of titles, abstracts, and key words. There is little insistence that evaluative procedures be built into information experiments and even less regard for the contribution of these experiments to continuing education of the practitioners and to public enlightenment and encouragement.

It is far easier to criticize this condition than to correct it. The administrative, legal, and psychological barriers to coordinating information activities even in a totalitarian state are formidable (59): How much more difficult is the task in an institution which stakes its scientific life upon freedom to experiment, which depends wholly on cooperation and persuasion to obtain acceptance of authoritative channels and

procedures in the interest of economy, priorities, and effective exchange of information? No individual reproof is warranted for the flaws in the biomedical information programs of the Nation. As Dean Rusk said of the Bay of Pigs fiasco, "There is something in it for everyone." For those burdened with this difficult task of coordinating information, there should be less criticism and more sympathy, cooperation, and support.

As a move in this direction, the Public Health Service has established a focal point of responsibility in the office of the Special Assistant to the Surgeon General for Science Information. Many PHS divisions also have appointed science information officers. Several of the recommendations of the Surgeon General's Conference on Health Communications (60) have met with a conscientious response. New functions have been defined, new programs have been developed in communications, and ambitious plans for the future have been drawn. Similar steps by the American Medical Association have been noted above. Nevertheless, the Nation is only on the threshold of an expanded program of health communications and continuing education.

It is to be expected, moreover, that these steps will go in the direction of national and worldwide developments.

(An exceptionally cogent review of the information facilities available to pharmaceutical firms has been prepared by Mr. S. T. Zelter for the Organization for Economic Cooperation and Development, Paris, October 23, 1964.)

FEDERAL PLANS

Conception of a Federal information system had its origin in Thomas Jefferson's vision of a university and in the Constitutional authority of Congress to fix standards of weights and measures. For the most part, the system has developed informally; much of it is regulated officially by the Government Printing Office and the Joint Committee on Printing but otherwise it is disciplined on a voluntary and cooperative basis.

The need to improve interchange of scientific information intensified 25 years ago. Scientific and technical development of nuclear weapons,

for example, demanded information in the fields of physics, chemistry, and engineering at a speed and on a scale without limit. This demand for information continued, under postwar conditions, in development of unconventional weapons, nuclear energy, space vehicles, and medical techniques.

In 1950, the National Science Foundation was established. Among other duties, it was asked to "bring about the effective coordination of the various scientific information activities within the Federal Government, develop new or improved methods for making scientific information available, foster the interchange of scientific information among scientists in the United States and foreign countries, and provide financial support for translation of foreign science," as well as to "maintain a register of scientific and technical personnel in the United States" (61).

Early efforts at coordination by the Office of Science Information Services (OSIS) of the National Science Foundation, including formation of a Federal Advisory Council on Scientific Information, were strengthened by establishment in 1959 of the Federal Council for Science and Technology, composed of officers of policy rank from the major Government agencies. A Presidential task force, headed by James H. Crawford, Jr., in a report to Jerome Wiesner, chairman of the Council, stated that:

As one of the many agencies supporting R & D (research and development) the Foundation cannot reasonably be expected to exercise any forceful direction of other agency STINFO (scientific and technical information) policies and practices" (62).

The Crawford recommendations included creation of Governmentwide clearinghouses to deal with reports on current research, research results, specialized information centers, and scientific meetings. The report also proposed a referral center to provide "coordinated access" to specialized information centers and services.

Issuance of this report had been preceded by a series of hearings conducted by congressional committees, notably the Senate Committee on Government Operations, and by a great deal of scholarly activity, much of it supported by the National Science Foundation. (A bibliography on handling scientific information (63) in the

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years 1957-61 listed 1,121 items without including reference to commercial applications, linguistics, medical records, or technical writing.)

Upon reviewing the Crawford report, the Council proposed that the Office of Science and Technology, serving as Secretariat for the Council and for the President's Advisory Committee on Science and Technology, provide "general policy guidance but not control or direction" for the Federal information system (64).

Also, in June, the Council established a Committee on Scientific and Technical Information, composed of science information specialists in the Federal agencies, to carry forward the task of voluntary coordination of effective and compatible information systems.

The components of this system include collections of documents, facilities for analyzing and searching the collections or recalling documents, and facilities for organizing and distributing the information contained in the documents in response to user needs.

Major Federal collections of scientific documents are in the Library of Congress (LC), the National Agricultural Library (NAL), the National Library of Medicine (NLM), the Science Information Exchange (SEI), and the Clearinghouse for Federal Scientific and Technical Information.

The first three collections are composed mainly of reports of research results and associated information. The National Library of Medicine is the most comprehensive single collection of formal biomedical literature anywhere. The SIE collection consists wholly of reports of research in progress: Its main task is to enable administrators to review the allocation of research funds and activities, but it is useful also in some situations for advising scientists what others are undertaking in a given field. The Clearinghouse deals entirely in unclassified technical reports issued by Government agencies: It announces them, distributes notices to specialized users according to their interests, and provides copies on request.

The Federal system has no facility with responsibility for collecting and organizing biomedical information which does not appear in the formal literature. This neglected category

of "unpublished" literature includes information presented more or less informally at meetings, reports to Government agencies such as the Food and Drug Administration, medical or clinical records, letters, advertisements, films, and unpublished reports of research which include much valuable information about so-called negative results. Lack of such a facility tends to delay the prompt application of research findings. For example, the fatal effect of diethylene glycol to the kidneys was known to an industrial laboratory which did not bother to publish its findings because it had no intention of offering the chemical for human consumption. In ignorance of this finding, a pharmaceutical company used the chemical as a solvent for sulfanilamide, causing 100 deaths before the drug was withdrawn. This proprietary information was not intentionally concealed: There was simply no established channel for circulating this information.

A clearinghouse function, to evaluate, package, and distribute biomedical information widely but selectively, is an essential component of an effective biomedical information system. The National Referral Center for Science and Technology, established recently in the Library of Congress, promises to be useful in facilitating access to present sources of information. But referrals in response to inquiries do not serve the purpose of announcements, explanations, warnings, cautions, alerts, alarms, and glad tidings.

To a considerable extent, the mass media have served to distribute biomedical information in popular forms, with varying degrees of accuracy. Their participation, along with the Advertising Council, has been creditable. But reporters for the mass media can not perform the task of collecting, associating, and evaluating information about diet, exercise, surgery, drugs, or medication for selective users, especially scientists and health practitioners. Groups of scholars are needed to form judgments upon the available literature and to direct their findings through strategic channels. For the most part, such a service is available in some degree only through universities and research institutions.

Even without an effective clearinghouse operation for biomedical information, various societies and institutions have formed individual specialized information centers to collect germane documents and provide a focus of biomedical scholarship. Many are one-man operations: Others are supported with elaborate reference facilities. Eventually, it is to be hoped that all special information centers will be linked in a system which will enable them to share resources and knowledge. A set of clearinghouses would be a logical binding force in such a system.

It is a tribute to democratic institutions and to the professional dedication of those concerned that a remarkably effective information system for science as a whole already has developed in an informal manner, in part thanks to the Special Libraries Association and similar bodies. In a free society, moreover, it is to be expected that many specialized information

centers will be self-generating and autonomous. As Jerome Wiesner said,

We must take care that the Government information systems not overwhelm the non-Government activities, particularly those of the technical societies which are particularly sensitive to the needs of the users. The process of scientific communication with its long tradition of self-criticism plays an indispensable role. The existence of a healthy, impartial system of scientific communication helps assure the country that the science it supports is valid. The first scientific information panel of the President's Science Advisory Committee insisted on an articulated, rather than a centralized, scientific communication system to maintain independent avenues of scientific criticism. It is my strong belief that these considerations are still valid * * * (64).

An articulated system rather than a controlled system satisfies the need for freedom and flexibility and still provides the cooperation and agreement on standards, on interchangeable parts, which facilitates exchange of information. The present informal system, however, stands in need of more articulation.

Information Costs

Considering the economic significance of communication techniques, it is unfortunate that there is not more direct budgeting and accountability of these activities in Government. Although the Bureau of the Budget has attempted to encourage accountability, specific charges for science information remain imprecise.

ACCOUNTABILITY

Among the reasons is that it is difficult to agree on what constitutes a proper charge against science communication. For example, to what extent are printing costs chargeable to science information? Travel to meetings? Administrative operations? At what point are experiment and data collection overtaken by the process of communication? Are the creative and intellectual aspects of communication separable from mechanical and clerical services? Do the costs of searching for information count as charges for communication? Does one count as communication the costs of distributing information? Such questions are likely to occur to the budget officer.

Meanwhile, it is possible only to speculate on the total amounts paid to finance publication of scientific reports in professional journals, or the total amount of conference expenses which are allocated to travel, to operations, and to publication of proceedings. About 21½ percent of the PHS grant funds are spent on travel, but it is not known what part of this sum relates to travel to scientific meetings. Publication costs are on the order of \$20-\$50 a printed page. Herner found a cost range of from 6.4 to 10.4 cents a word. Some journals charge authors \$50 a page.

On the basis of 15,000 papers a year resulting from NIH-supported research, it may be assumed that about \$3 million was paid to put these into print. Out-of-pocket costs for abstracts and translations may be nothing, if performed by the author, but when such services are paid they are on the order of \$25 an item. Outlays by the Department of Health, Education, and Welfare for 1964 (fiscal year) were estimated at \$5,802,000 for publications; \$12,199,000 for bibliographic and reference services; \$4,842,000 for scientific meetings; and

\$7,067,000 for communication

In evaluating is easy to recognize, such as which will print instead of 10 copies quality. In our judgments hinge saving of 1 or 2 regular postage expedite exchange and Palo Alto worth \$200,000 neously from a picture service? up an automatic on tape and microfilm can be served by a viewer which would particular film as putting a nickel per viewer and worth \$20 million but authoritative reducing heart cost studies of \$1 a year to pay book: The total in dollars is all volumes in their library \$2 to be out (29).

The holding of a 5-percent interest is equivalent to valuing worth a dollar a the stacks on the requested once in 5 Such considerations principle that "the dimension a medical services cannot be the arc economic theory but we build our vigor and degree personal intentions

\$7,067,000 for research and development in communications.

EVALUATION

In evaluating outlays for communications, it is easy to recommend money-saving expenditures, such as purchase of a copying machine which will print reproductions for 1-cent a page instead of 10 cents a page, with no sacrifice of quality. In other circumstances, however, judgments hinge on uncertain values. Will the saving of 1 or 2 days justify airmail instead of regular postage? Is it worth \$20,000 to expedite exchange of messages between Bethesda and Palo Alto with a teletypewriter? Is it worth \$200,000 to send documents instantaneously from coast to coast by a long-distance picture service? Is it worth \$315 million to set up an automated system of science abstracts on tape and microforms? Will continuing education be served by a desk-size sound movie viewer which will enable a physician to see a particular film (in cartridge form) as easily as putting a nickel in a slot, at a charge of \$400 per viewer and \$20 per film cartridge? Is it worth \$20 million a year to broadcast popular but authoritative and accurate information on reducing heart disease?

Cost studies of libraries indicate that it takes \$1 a year to pay simply for the storage of a book: The total outlay of university libraries in dollars is about equal to the number of volumes in their collection (65). It costs the library \$2 to borrow a book and \$2 to lend it out (29).

The holding charge of a book, if compared to a 5-percent interest charge on capital, is equivalent to valuing the average book at \$20. Is it worth a dollar a year to maintain a \$5 book in the stacks on the odd chance that it will be requested once in 5 or 10 years?

Such considerations force reliance on the principle that "the fundamental determinant of the dimension and character of our effort in medical services and medical research is not and cannot be the arcane formula of cost-benefit economic theory but the set of values around which we build our great national purposes and the vigor and degree to which we pursue these national intentions in the context of the needs and

opportunities to improve the quality of life * * *" (66).

In the words of the Right Hon. J. Enoch Powell, then Minister of Health for Great Britain, "the progress of medical science and the increase in outlay upon medical services must render this outlay more and more uneconomic. On many fronts the progress of medical science consists not in doing things more cheaply and simply than before but in discovering complex and difficult things to do which previously could not be done at all. On these fronts medicine is buying life at an ever-increasing marginal cost."

At the same time, the cost-benefit school can argue that there is a chance the one neglected volume may contain the one bit of information which will more than repay the years of cost of its maintenance. Moreover, this cost is shared for the purposes of an entire information system: It is not a "loss leader" in a department store.

CONSTRUCTION COSTS

A core library of 100,000 volumes (67) at \$45 a square foot would cost more than a million dollars to build (68). Although technological ingenuity may reduce this cost, the development of the technology will require considerable investment.

In the feasibility report on automation of the Library of Congress, the survey committee recommended an appropriation of \$750,000 to develop specifications for partial automation of the Library, with an investment estimated eventually to reach from \$50 to \$70 million (52).

An information center in a hospital would require space for lectures, publishing activities, and broadcasting, as well as for search and reading. Broadcasting facilities alone would cost on the order of a million dollars for closed circuit television, including auditorium, storage, and studios at \$30 a square foot, and equipment at \$250,000.

These facilities, the library and the broadcasting studio, are only two components of a center that could be operated to support continuing medical education. Other facilities would include a film exchange and viewing room; a depot for reference slides, tapes, and radiographs;

an audiovisual workshop; and demonstration laboratories. Considering that a medical school, with 64 students entering, needs a short-term general-special hospital of from 350 to 500 beds for teaching, there are enough hospitals of that size to accommodate twice the present number of medical schools.

The total cost of construction for a national biomedical communications system may be calculated by assuming a total of information facilities based on 150 major medical centers, beginning with medical schools with teaching hospitals. Assuming that such a system would not have to be built entirely from the ground up, a 10-year capital outlay of \$300 million, or \$30 million a year, would at least approach fulfillment of the need. This sum stands in the perspective of annual outlays of more than \$30 billion in the United States for health services, including more than \$4 billion spent by the Federal Government.

OPERATING COSTS

Library operations in a medical center with at least a core library would cost not less than \$100,000 a year. Another \$100,000 might be spent on collecting documents.

The costs of broadcasting are elastic, but they may be expected to run not less than \$50,000 a year for closed-circuit television on an intermittent schedule. A unit composed of 144 half-hour programs in 36 weeks, 4 a week, costs about \$20,000 to produce, on an extremely modest scale. With an investment of \$16,000 in tape, good for about 100 passes, or about \$1.40 per half hour, the entire unit may be broadcast at a cost of \$15 a half hour, including technician salaries, recording, and amortization, if the cost of the studio and equipment is allocated on the basis of 50 weeks a year, 40 hours a week (69).

With a production budget of \$140 for each half-hour program, it is obvious that Hollywood standards would not prevail. If the advice of experienced producers is to be heeded, the investment of time and talent in the original production could materially exceed the figure given, which is based on the full-time services of one teacher, half-time services of a producer/director, two camera men at \$1.50 an hour, and only \$2,500 for art and props. Reten-

tion of master tapes would also increase costs slightly. The figures given, therefore, would appear to be rock bottom. On the other hand, the present resources of medical films, once evaluated and carefully selected, can possibly provide programs at figures as low as those given.

Much interest is evinced in 8-millimeter films with sound to be exhibited simply by inserting a cartridge or cassette in a viewer and pressing a button. The viewer costs \$485 at present, with negligible maintenance and operation charges. In volume production it may be less. The cassette costs less than \$3 and the film may be printed at 6 cents a foot. Therefore, educational films at \$15 each in the 8-millimeter size are a practical possibility in such cartridges. They may be used more than 100 times each for as many as 30 viewers at a time. One may contemplate a catalogue of 10,000 basic medical films, at a cost averaging \$10,000 each, or \$100 million for production, built up over a period of 10 years, for viewing at 1,000 stations, costing in total \$500,000 for equipment, booking prints out of 100 distribution centers, with a stock of film cassettes costing \$150,000 at \$15 a cassette.

The total costs of the information program in each center are likely to overshadow such audiovisual services. Bloomquist (67) reported the busiest medical school library provided more than 10,000 hours of student assistance in a year. If to this workload one adds a program of continuing education for practitioners, alerting services for scientists, and health education for the public, even the medical school library with the present maximum of 11 professional employees would need more help. Considering that the medical school libraries at the median have only three professional employees and pay them a median salary of \$6,000, the number of such professionals in the information sciences and their average salaries may be expected to double.

The human charges for science information, for the training and employment of teachers, librarians, writers, editors, searchers, translators, indexers, and audiovisual teams may be the most costly, as well as the most important, component of the biomedical information system.

Conclusion

The review of biomedical communications offered here is no more a true picture than a stroboscopic photograph which arrests Niagara Falls. It is impossible to capture the fluid and human components of the informal biomedical system in motion. These pages are aimed at outlining the information processes: The production of information based on research and development, on data and experiment, and the methods of evaluating, categorizing, collecting, storing, searching, recalling, reviewing, packaging, distributing, and assimilating this information.

If there has been undue emphasis on libraries, on mass media, on automation, on language, on research, or on user needs, the asymmetry was not intended. The process as a whole was the object in view.

It is impossible to avoid, if only by implication, a bias in favor of one kind of remedy or another. There are many proposals for improving the system, from the grand design of the Crawford report to the basic plea of the Presi-

dent's Science Advisory Committee to take information seriously and to compose informative titles (27).

Such small improvements are not separable from a grand design. The writing of a title has its impact on the structure of an index and the performance of a clearinghouse. Each consultation at an information center is dependent on such resources as MEDLARS and a film library.

Opportunities for improving the handling of science information unfold from hour to hour (70). Given the backing of the medical community and the taxpayer, science information services can provide scientists, practitioners, and the public with instruments of intelligence as productive in their way as the electron micrograph, electrocardiograms, or radiotracers. In an age when a message travels around the world in a second, it is unthinkable that it should take months or even years for physicians and their patients to learn essential medical truths.

MARCUS ROSENBLUM.

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