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Use of Computers in Information Systems

New information systems developed at Bell Telephone Laboratories lean heavily on computers.

W. Kenneth Lowry

The first serious use of computers by scientific and technical libraries started about 10 years ago. Some of the experiments were successful and the computer systems are still being used. In many cases, however, faulty preliminary research, inadequate planning, and a misunderstanding of the capabilities of the electronic equipment has resulted in failure and the projects have been abandoned.

While there was much that went wrong during the 1960's, computer use has increased in information systems. In the process, computers have induced subtle changes in information service concepts and challenged many well-established maxims governing techniques for using information by scientists and engineers. Information centers and libraries have begun to feel this influence both nationally and internationally, and substantial funds have been provided by federal agencies for studies, experiments, and development of computer-aided information systems. Major international conferences on the subject in 1958, 1959, 1965, and 1967 (*1*) are evidence of the growing interest in using computers as information tools. The principal international interest now is centered on a project of Unesco and the International Council of Scientific Unions (ICSU) known as Unisist which includes plans for a worldwide system of science information in which computer techniques are used (*2*). Some serious problems affecting international programs still must be solved (*3*). It appears that there will be a greater use of computers in information systems and progress has been made in some instances (*4*); the effectiveness of computers will become evident during the next 10 years.

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Initial Planning

During the mid-1950's Bell Laboratories found that they needed improved information planning because of growth in personnel and facilities, the impress of solid-state science and technology, a generally rapid unfolding of new research findings, and the growing importance of photography, communications, and computers as potential aids for improving information processes. These and other influences indicated a need to establish an information systems department. The department, set up in 1958, became part of what is now the Libraries and Information Systems Center of Bell Laboratories. This blending of operational information functions with information planning and systems development presents both advantages and possible hazards, but it seemed that close coupling could be achieved without loss of perspective for either function. This appears to be borne out by 12 years' experience.

A long-range commitment to exploit new technology for information purposes requires the development of a staff that is able to recognize the weaknesses and strengths of traditional information systems. It is also necessary to know when an existing system should not or cannot be changed, particularly when there is pressure to adopt new techniques. At the time, there were few people in the information field expert in both systems planning and computer knowledge. Until this combination of staff competence could be developed the information staff would need to find its technical expertise in other parts of Bell Laboratories or contract for outside help. The decision to obtain interim help within Bell Laboratories was not difficult because excellent assistance could be provided by several of our technical activities. Despite the availability of federal support for such endeavors we decided that, by financing the project ourselves, we would have the advantage of industrial budgeting processes which would give us a greater assurance of success. Careful fiscal monitoring almost always benefits new endeavors.

There remained the need to insure adequate technical monitoring and this was arranged with the assistance of J. R. Pierce and W. O. Baker. Pierce, as chairman of the library committee, enrolled that group in the effort; Baker encouraged the setting up of an informal information study group of technical people which met periodically and served as provocateur and critic in a series of discussions on the possible and almost impossible uses of computers in information systems. There was an additional value deriving from these discussions and the technical staff involvement they generated. Some years later, Vannevar Bush, at the Intrex Planning Conference, put it very succinctly when he discussed the mechanization of libraries (*5*): ". . . it

will move forward well only if intelligent citizens, in positions of influence, come to realize the potential benefits that exist. And this will occur only if those in a position to understand the whole affair speak out, effectively and often. I am not advocating some sort of promotional campaign, I am merely trying to point out that there are two parts of this job: first, the tough technical and professional task, which is indeed tough; and second, the burden of carrying the intelligent section of the public along toward understanding and, if possible, enthusiasm."

Early planning also supported our decision to emphasize the development of workable information systems rather than heed the natural inclination of many to explore tantalizing areas of research and experimentation. Although this pragmatic approach might appear less stimulating intellectually for some, the promise of developing useful aids to science is not entirely bereft of personal satisfaction. As Bush implied, the technical and professional competence needed for these tasks is great, but perhaps not greater than the administrative and management requirement to insure workable and useful results.

Information Alerting and Control

New systems must be based on technical realities as well as on economic factors and operational needs. The IBM 7090 computer available in 1959 would not be well adapted to some of today's plans for computer-aided information systems, but it held promise for solving certain problems. One such problem at Bell Laboratories was a consequence of growth and geographic dispersion of the technical staff. For many years the research and development reports generated at Bell Laboratories had been kept in file cabinets by serial numbers, and a card file at Murray Hill provided an author and rough subject index of the collection. This was not too useful to an engineer in Pennsylvania or a scientist in Massachusetts since the card file was not available there. The 7090 computer offered the possibility of several improvements and the use of computers for information indexing, announcing, and retrieval purposes became a reality.

This first venture was perhaps most significant, in retrospect, because it explored the capabilities of automatic indexing, with a minimum of human intervention, rather than using machine facilities only for sorting and printing the results of human indexing. The technique, now widely used throughout the world, is called Permuted Title Indexing or Keyword-in-Context Indexing and was an early development of the System Development Corporation and IBM. In addition to providing author, report, and project number indexes, each word of each title is indexed in the context of other words in the title. The first product was a printed bulletin of new reports issued each month and available to anyone in Bell Laboratories no matter where he worked. Semiannual and annual cumulations of the monthly lists were easily prepared. Beldex, the name of our current program, is written largely in Fortran with about 70 subprograms for use on the Honeywell 6000 and IBM 360 computers. Its utility for the Bell System, however, has far exceeded our initial plans for using computers to provide monthly and annual announcement of research and development reports with appropriate indexes. A variety of options has been developed that makes it useful for many other purposes. These include, among other uses, such diverse functions as controlling the loan of laboratory equipment from central equipment pools, inventory control, and maintenance scheduling.

Some typical examples of Beldex use in the Bell System are:

Bell Laboratories: general executive instructions (operating procedures); catalog of journals held by technical libraries (26 libraries); index to Bell Laboratories computer programs; equipment inventory control; division correspondence files; Bell Laboratories talks and papers index.

American Telephone and Telegraph Company: index to general letters; index to engineering letters and memoranda; catalog of Bell System standard forms; data systems management index.

Telephone companies: correspondence control (Pacific Northwest Co.); planning project control (New York Co.).

In comparing Beldex to similar programs some features that have contributed to its usefulness are worth noting.

1) It is flexible and adaptable to the user's requirements at several levels, from control card declarations to insertion of new modules.

2) It is convenient and runs with no intervention by the operator or programmers. It completes processing according to the specifications contained in the user's control cards and places his information on the medium he has chosen for printout.

3) Close coupling exists between the authors and users of Beldex. As requirements or problems arise the authors adapt it to respond, thereby continuing dynamic development of the system for a wide range of applications.

An important application of Beldex is possible because of its capability for keeping information up to date in a scientific field such as solid-state magnetism. Requests for literature searches in this area became so numerous that a continuing brief of world developments was needed. In 1961 a semiannual report was started on the literature of magnetism; it is now provided regularly to more than 150 people in Bell Laboratories. We wished to make this information available to the whole scientific community, particularly to participants at the Conference on Magnetism and Magnetic Materials, so we arranged with the American Institute of Physics to reprint it under their cover, to sell it at cost, and to accept subscriptions. They distribute about 450 copies per issue (*6*). During the past decade about 20,000 papers have been listed and it is interesting to consider the effort that goes into the preparation of the index. It requires about 10 percent of the time of a qualified information scientist and an equal amount of a clerk's time. In addition, about 10,000 cards are keypunched each year. This is a good example of the benefits that computer-aided information systems can provide.

Magnetism is only one of many technical areas of interest to Bell Laboratories. Computers are used regularly in our general effort to keep people informed by conducting literature searches that are specially designed to fit particular needs. The product of one search, for example, was a permuted empirical formula index in connection with studies of complex niobates and tantalates. In another case concerned with gallium phosphide and its applications in electronic and optical devices, an unusual corporate author-title index gave a very clear picture of which worldwide organizations were doing what work with gallium phosphide. As an instrument for gaining information control and for keeping informed in given fields, the computer has become an almost essential scientific tool.

Information Filtering and Dissemination

Information system developments in recent years have caused the accumulation of vast files of information (as evidenced by the growth of abstracting services) while at the same time schemes have evolved to reduce the problems of coping with the mass of information in these files. The use of computers has been suggested (*7*) as one means of handling the data and numerous systems for filtering the information have evolved. The results have met with varying degrees of success. Such systems usually are based on a statement of known or imagined information needs that are matched against a stream of incoming literature. By setting up appropriate algorithms, matching operations can be performed by computers. Two filtering and dissemination systems designed for this purpose at Bell Laboratories are Mercury and Belltab.

Mercury is a computer-aided system for the selective distribution of Bell Laboratories' technical reports to employees. W. S. Brown and J. F. Traub (*8*) have described Mercury as being ". . . based on the idea that the job of distribution should be divided between the author and the reader with each performing that part of the job which he does best. The author is asked to describe the interests of the readers to whom his report should be sent. The reader is asked to describe the reports that he wishes to receive. The descriptions are made from a small structured vocabulary. The matching of report to reader and the printing of address labels is done by computer."

Some distinguishing features of Mercury are noted in comparison with other selective dissemination systems.

1) Author participation is an important part of the system. System design, vocabulary construction, the use of these vocabularies to describe report content, and the request and review of distribution lists for reports involve direct participation by the authors.

2) Readers maintain most of the control over the amount and type of information received through Mercury by exercising any of many options available through the system. The reader, rather than the author or system operator, is very much in charge.

3) System programming and operations are controlled by a single group, the Libraries and Information Systems Center, thus ensuring proper monitoring and continuing development of the system.

Currently there are 2900 people participating in Mercury at Bell Laboratories. It operates on a Honeywell 6000 computer and incorporates an allocator which enables its computer core memory requirements to be changed, depending upon the volume of requests to be processed. Mercury also has data files designed in an inverted format and incorporates table-driven syntax analyzers which facilitate analysis of requests and make string recognition extremely efficient. A request string (a vocabulary subject or other authorized option) has the names of people stored on the file requested. This inverted format is contrary to usual practice where readers are stored as file headings with their interests listed under their names. We believe it enhances considerably the efficiency of computer processing in Mercury.

Although designed for efficient distribution of internal research and development reports at Bell Laboratories, Mercury has proved useful for many other purposes. It can be used for distribution of announcements of seminars, for example, to a group defined by the subject of the seminar. Special-purpose distribution codes are also available for regular alerting purposes, for example, the Bell Laboratories Research Calendar (a weekly summary of events and meetings for the technical staff). Mercury is used in conjunction with Beldex for distributing administrative documents by some technical divisions. For new bibliographies, suitable descriptors from the Mercury vocabularies are matched against its collection of interest profiles and the resulting mailing labels are used to send out announcements to potentially interested persons. The number of respondents who wish to receive copies suggests the print run needed to meet demands. These and other purposes are readily served as a result of computer aid in distributing information through Mercury.

Belltab, a second system for filtering and disseminating information is used for technical reports prepared by organizations outside Bell Laboratories. Following World War II the information community has needed to deal with thousands of reports issued by government agencies and their contractors. Most of these are published by or for the Defense Department and are sent to the Defense Documentation Center which issues the *Technical Abstract Bulletin* (TAB) announcing new reports it receives. The reports are available to qualified organizations and are used by many people at Bell Laboratories. Of the approximately 40,000 made available annually by the Defense Documentation Center, some 15 percent concern our interests. Until 1969 our filtering process required selection and keypunching of pertinent titles from TAB and the preparation of an internally circulated announcement bulletin using Beldex for computer formatting and listing purposes. In addition to Defense Department reports, our internal bulletin also lists some from NASA and other report-producing organizations.

In July 1969 the Defense Documentation Center offered magnetic tape editions of its bulletin for computer-processing purposes and Belltab utilized these for Bell Laboratories' specific information needs. Our aim was to mechanize bulletin preparation further by reducing keypunching and proofreading and to upgrade the bulletin from a listing of titles to an abstract journal using TAB abstracts.

We developed procedures to extract our subset from the TAB tapes, and Belltab computer programs were written for processing the tapes on the Honeywell 635 computer using the GMAP assembly language and Fortran IV. The output was written on magnetic tape and merged with keypunched information for reports from other sources through a Beldex option written for this purpose. The first bulletin using the Belltab system was published in January 1970 and subsequent semimonthly issues have presented no major problems. Because of changes in the TAB tape format and also to gain greater flexibility, a second version of Belltab is now used. This is designed for the IBM 360/85 computer and is written in PL/1. Belltab is not only a useful device for filtering and disseminating information from a large data base; it is also attractive because it makes the best use of work done by others and permits blending multiple sources of input to provide the specific information we need.

On-Line Information Systems

There has been more interest in on-line, interactive, computer-aided information systems than in almost any other type of computer activity. Rela-

tively few such systems are operating in libraries and information centers, but the literature describes many proposed systems and prototypes.

Bellrel (*9*) is Bell Laboratories' real-time library loan system. It serves the company's three largest libraries located at Holmdel, Murray Hill, and Whippany, New Jersey, as well as the AT&T library in New York City. A fifth library will be added in May when our new Raritan River Center is completed near New Brunswick, New Jersey. Twenty additional library locations are served by Bellrel in an off-line mode of operation. The system maintains up-to-the-minute accountability for 120,000 books and 67,000 bound journals. Its primary objective is to improve the total response of the libraries to the users by pooling resources of geographically dispersed libraries, following up on borrowers' reservation queues automatically, automating clerical functions, and providing enriched feedback for effective management of resources and services. Inaugurated in early 1968, Bellrel has routinely handled over 250,000 on-line transactions per year.

At the heart of Bellrel are on-line accessible disk files which identify all library book and journal titles and all of the 19,000 potential borrowers at Bell Laboratories locations. It records all active loans and reservations for the three primary locations. A history tape of completed transactions and some 70 application programs, written in Cobol, work with the files to support the on-line transactions and batch reports.

Each of the primary libraries has two IBM 1050 remote terminals linked by data sets and telephone lines to a 370/155 computer operated at Murray Hill. Transmissions from the terminals are received by a message-editing program that checks the coded transactions for correct format and calls the application programs as needed. Library clerks have 22 transaction codes available for sending messages to the computer: 10 of the commands are involved with making loans, renewals, returns, and reservations; 12 are for queries. Both keyboards and card readers are available for input, the card readers accepting prepunched cards associated with all books and bound journals.

For each message sent into the system, Bellrel returns a concise response, typically within 3 to 4 seconds. Several transactions will imply alternative courses of action, depending on certain conditions, such as when renewals are not made because reserves are waiting; but in all cases the terminal operator can override any initial decisions by the system. Computer responses to the terminal always answer queries, acknowledge action taken, provide additional information, or diagnose invalid transactions.

Examples of on-line transactions include queries made to determine the loan status of each copy of each title, the identity of all people waiting for a given title, or the items on loan to a borrower. Concerning loan status, copies are identified as available, on loan to a particular person, on order, missing, in transit between library locations, on the new book shelf, or at the bindery. If someone is waiting for a title, the first copy returned is automatically loaned to him, regardless of location.

These and other features provide a number of advantages, but perhaps most significant is that Bellrel makes all libraries in the system equally available to any who wish to use them. The quickness of modern communication systems coupled with computing power has improved our ability to provide immediate information access and retrieval. Another contribution of Bellrel derives from the feedback of operational experience it provides, which is essential to improving library operations.

A second interactive system has been developed for the internal publications program of the Bell Laboratories library system. Of eight publications regularly issued by the libraries, five utilize computers in one way or another and two employ on-line computer composition and text editing. The ATS (Administrative Terminal System) offered by IBM was modified and operates on an IBM 360/50 computer at our Holmdel Laboratory. Access to the system is from IBM 2741 terminals by dial-up connections over regular telephone lines. There are facilities for text entry, document storage and retrieval, and updating. Editing capabilities include line deletions, text insertions, and corrections. Output may be obtained through the terminal or by high-speed printer in the computer center which is equipped with an upper- and lowercase print train. Optionally, output may be made on punched cards, magnetic tape, or written directly to disk for use by other programs. A range of formatting options is available.

The system prepares the *Computer Abstract Bulletin* which announces new computer programs written by the Bell Laboratories staff and includes abstracts and indexes. Cumulated on a bimonthly basis for a year, annual editions are then prepared as an *Index to BTL Computer Programs.*

Beldex prepares final copy for the publication. The ATS system provides upper- and lowercase punched card input to Beldex and prepares the format, edits, and composes the bulletin. Similarly another publication, the *Library Bulletin,* is formatted, edited, and composed by the ATS system and issued on a monthly basis. The convenience of easy copy correction is particularly appreciated here because of numerous entry revisions to the manuscript while it is in preparation. The bulletin announces new books, journals, translations, and bibliographies recently added to the libraries. Two additional on-line systems for multiple purposes are currently under development.

Information Systems

Feedback and Management

Most effective information systems include proper feedback and monitoring features to detect the need for adjustment and to cope with changing conditions. Computers are particularly well adapted to this requirement and their use for planning and operational tasks has been extremely valuable. Bellrel offers 30 types of management reports useful in monitoring the needs of library users and tightening inventory control. Lists of items with five or more book reservations, with reserves waiting for 4 weeks or more or with reserves waiting and all copies missing, are used in weekly teleconferences of the library supervisors to rush-order additional copies or investigate bottlenecks. Such lists include for each title the number and location of all people on reserve, all copies held, all copies on order, and all copies missing. Other reports list missing books and journals, for systematic searches; list books which haven't circulated for over 2 years, for possible purging; tabulate circulation by subject or by borrower's department; and list by subject the number of titles held. A subject listing of all books borrowed by members of a department being transferred to a new location is helpful in developing the collection at the new location. As an example of the automation of clerical

activities, overdue notices are printed and distributed daily, along with listings for following up by telephone when second notices go unheeded.

Statistical feedback also regulates the input to three library publications that provide current coverage of journal literature in physical sciences and engineering, life sciences, and management science. Since requests for the papers announced in these bulletins are computer processed it is convenient to correlate numbers of requests with each journal and to compare items requested with the number input, and other information, from that journal. It is also possible to associate the use of the journal with the requesters' organization, physical location, and other useful parameters. These data help in making adjustments in journal coverage so that improved "hit rates" can be achieved. Correlation of data on journal use with those of book use helps to project needs for a new library collection.

The request-processing system that provides these data matches individual man numbers with specific technical paper numbers and prepares work orders and address labels for each article requested. Correlation of man numbers and addresses invokes subroutines offered by the Mercury system. The work order specifies the number of copies of articles needed for each issue of a journal. The program is written in Fortran IV for use on the Honeywell 6000 computer and employs specific GMAP subroutines. These are typical examples of a computer's usefulness in management actions. Others include many in-house examples, such as union lists of journals, a list of subject headings for cataloging purposes, and fiscal and statistical reporting. They are essentially business operations, and it is not surprising that computers, as business machines, should be valuable assets.

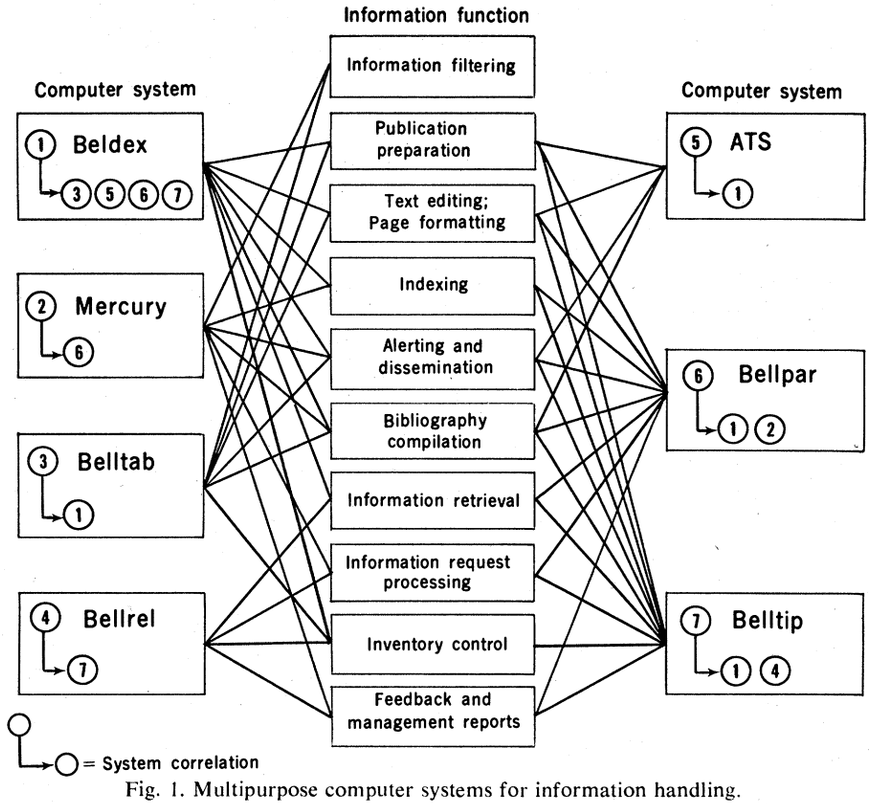

Fig. 1. Multipurpose computer systems for information handling.

New Developments

Two new computer-aided systems, Bellpar and Belltip, currently under development hold considerable promise for improving our information operations. Both use on-line techniques as well as offering off-line batch products. Segments of these systems are now operational, and the rest will become so by the end of the year.

Bellpar provides publication, alerting, and retrieval services for 40,000 technical papers selected from journals each year for announcement within Bell Laboratories. The publication module is designed to produce printer-ready copy for *Current Technical Papers*, the announcement bulletin. Keyboarding in machine-readable form provides both copy for the bulletin and the development of a data base for other information services. The alerting function of Bellpar provides an individualized current-awareness service that notifies participants of specific new articles matching their computer-stored personal interests. Initially, experiments will be made to determine satisfactory ways of doing this. The retrieval capability will use the stored data base for bibliographical searches and other pertinent data.

The system operates on the Honeywell 6000 computer using essentially Fortran IV and GMAP programming routines. Input is through either off-line or on-line Teletype 37ASR terminals. A second hardware unit is used to produce off-line paper-tape output. The keyboard of this terminal simultaneously codes data onto a cathode-ray display and into a buffer memory. Auxiliary keys permit the operator to correct or rearrange this data while it is on screen and to transfer it to tape when editing is complete. When copy is ready, programs for computer-sorting, formatting, and printing are brought into play and reproduction copy is made.

Belltip is a library technical information processing system which creates machine-readable records for books at the ordering stage and uses these records for multiple subsequent purposes. Among the functions served are book acquisition, financial control, management reporting, cataloging, preparation of announcement bulletins, and the production of printed book catalogs. Remote teletypewriter terminals are used to enter into the system information about books to be ordered, books received, invoices, and cataloging details. The system sends back appropriate responses and notes exceptions to good practice if these occur. Batch products include status reports on expenditures, work flow progress, and change data.

Belltip will assume support of the publication disk files for the Bellrell loan system, in a completely coordinated manner. More importantly it will provide the data base for the production and maintenance of printed book catalogs to replace card catalogs in Bell Laboratories' 26 libraries. Both the monthly and annual volumes of the book catalog will be printed by a computer-driven, video-composition technique.

Most of the developments reported here result from efforts at Bell Laboratories to improve its information apparatus for research and development tasks. The seven systems described are taken from over 30 computer-aided technical information services and functions currently in operation and indicate the wide applicability and utility of computers in information systems. Throughout the account there is ample evidence of the hospitality one computer system offers to another. Modules of existing systems may be used in new systems. Another common feature is the multiple information purposes served by each system. Figure 1 is an attempt to graphically display these relationships.

There has been only minimum reliance on several recently offered national and international computer-based information services. The value of these new services as a substitute for in-house information systems is still unclear. Adjustment of ongoing in-house systems to exploit the national systems will be explored carefully during the next few years and efforts to achieve compatible intermixing will, of course, be made. There is now an inadequate coordination of standards, formats, and other factors among the new computer-aided services being offered (*3*). This incompatibility, plus the tendency of national systems to cover only specific disciplines, poses problems for organizations that want to use these large-scale data files. By the end of the decade, there may be some light at the end of this particular tunnel. Despite these problems, the computer will continue to strengthen its kinship with information systems and may prove to be the most important development for dissemination of information since the time of Johann Gutenberg.

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Esophageal Cancer in the Caspian Littoral of Iran: Initial Studies

Detailed studies of geographical pathology are opening new vistas in cancer epidemiology.

Janez Kmet and Ezattollah Mahboubi

This article deals with a peculiar pattern of distribution of esophageal cancer in the ecologically diverse regions of the Caspian littoral of Iran. However, the deciphering of the complex extrinsic and intrinsic factors that are most likely responsible will require highly sophisticated research techniques and are not dealt with here.

Whereas large parts of the world have changed from the simple soil-man relationship to very complicated systems, there are, nevertheless, still vast areas in which entire population groups depend heavily on the food grown or found locally. It is here that we should seek the clues to understanding those basic conditions that lead to well-established disease patterns in the indigenous population. If a given cancer site in the body in a given area of the world could be linked with environmental characteristics, new ways of understanding this particular cancer site might open.

The esophagus is a case in point; the distribution of the incidence of esophageal cancer seems to be particularly promising for pointing out those areas of the world in which special studies should be carried out. This site has many advantages. First, it has a peculiar pattern of incidence, with 100-fold differences between the highest and the lowest rates, and even 200-fold differences in men from the ages of 35 to 64 (*1*). Second, the incidence may vary markedly in areas that are only a short distance apart (*2*). Third, the male-to-female ratio varies greatly throughout the world (it is, for example, 20 to 1 in France and near equality in Liverpool), and a high incidence is not invariably associated with a high male-to-female ratio (*1*). Fourth, in some areas of the world the incidence seems to have risen greatly very recently (*2*).

Background Information

From the available hearsay information on the incidence of esophageal cancer in Iran, it appears that the disease is common in most parts of the country, particularly Khorasan, Iranian Azerbaijan, and the Gorgan plain, to the east of the Caspian coast. The probable high incidence in Iran is not isolated, but represents part of a vast area of high incidence that extends from the Middle East to China and includes, besides Iran, Afghanistan, and Soviet central Asia, parts of Siberia, Mongolia, and northern and western China (Figs. 1 to 3).

That the frequency of the disease is

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