any comparative accounts of Soviet and American R&D. He argues effectively that much preparatory and basic work on the level of individual countries must be completed before significant comparative studies become feasible. The major difficulty at the present time lies in the imprecision with respect to categories of analysis. Such categories as *basic research, applied research, development,* and *design* are not discrete and precisely defined units but parts of an open-ended continuum and are also subject to tangible cross-cultural variation.

Unequal access to relevant data of different categories has made it impossible for the author to examine each major problem with the same thoroughness. And his task has been made more difficult by the fact that the book covers one of the most dynamic periods in the history of the Soviet scientific establishment. The volume does not treat in significant detail the institutional mechanisms facilitating a systematic and thorough inflow of scientific knowledge from abroad and its distribution among the interested agencies and scholars. The geographical decentralization of scientific institutions, a major development under Khrushchev, deserves much more attention than it has received in this volume. The rapid building of the Siberian Department of the Academy of Sciences into a new research giant could have been profitably correlated with the intensive economic development and demographic movement in Siberia.

Korol has written the most important book so far published in the West on science as a source and an index of Soviet power. He has established himself as a pioneer in the study of R&D—an academic field of vital importance.

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The Information Explosion: Aquatic Sciences Version

It has been suggested by someone (and I am unable to retrieve the reference at the moment) that Johannes Müller, the last great universal naturalist, died by his own hand out of frustration because he was unable to keep up with developments in biology. Such a possibility need no longer exist in our time, if we are to believe some of the publicity that comes with the descriptions of new information retrieval systems. For a modest $700 to $1250 per annum, one service is available which will tell us, if we are fortunate enough to remember the name of the author of a paper, whether his paper has been cited, reviewed, applied, extended, confirmed, or otherwise treated. Since this service has been previously reviewed [*Science* **145**, 142 (1964)] by Steinbach, little more need be said about it except perhaps to raise an additional eyebrow at the implication that this service will be of value in helping the user decide whether to read the entire paper and that it will convey to interested people (for example, deans and provosts) the comparative importance of an author as indicated by the frequency with which his paper or ideas have been cited. (How would Willard Gibbs have fared in this system for the first 20 or 30 years of his career, one wonders.)

It appears that the amount of published information is increasing exponentially at a rate exceeding that of the population explosion; when the world's population is doubled the "world's output of scientific and technical literature would be 16 times the existing output. There is little reason to think that this is an overestimate." [B. C. Vickery, "Scientific information: Problems and prospects," *Minerva* **2** (1), 21 (1963)]. Obviously no one will have time to look at the fraction of the information that applies to his own field or is of tangential interest to him, and some recourse to abstracting journals, reviews, and retrieval systems is necessary.

One of the fields that appears to be expanding more rapidly than the general rate of expansion is that of aquatic science, principally oceanography and marine biology, and there have been several attempts to cope with this. The most conventional, and still the most generally useful, is the "Oceanographic Extracts" section of *Deep-Sea Research,* which is supplemented by a listing of current papers, "Oceanographic Bibliography." But one can easily become mentally waterlogged reading abstracts no matter how well prepared they may be, and a number of services have been started to cut down the scanning and retrieval time by storing the information with coded indexes or thumbnail references.

The most comprehensive of these is the *Current Bibliography for Aquatic Sciences and Fisheries,* prepared under the auspices of the FAO (Food and Agricultural Organization of the United Nations) Fisheries Biology Branch and published by Taylor and Francis (Winchester, England) at $27 per volume. This bibliography lists journal contents alphabetically by authors for each journal examined seriatim, with paraphrased or translated titles. It goes beyond the scope of "Oceanographic Extracts" in that it lists mimeographed reports from meetings and the grey world (in the publication sense) of the flood of mimeographed and multilithed progress and technical reports that virtually all laboratories now produce to satisfy their granting fathers. It does not, however, clearly specify in every case whether the original publication or a review of the publication is being cited. The volumes end with a complete author index and solid phalanxes of numbers under the topics of the subject index. These numbers are not codes but the number of the paper as accessioned in the text of the bibliography. As a result, the information may be well stored, but it is not always simple to retrieve, especially when one is incautious enough to leaf through the bibliography, spot a comment that sounds interesting and then try to find it again if the author's name has not been noted. But as these things go, the bibliography is fairly inexpensive.

A somewhat similar compilation is the **Oceanic Library Coordinate Index** (Mission Bay Research Foundation, San Diego, Calif.; bi-monthly, $600 per year;

50-percent discount to educational institutions). This lists the contents of some 400 to 500 periodicals by journal, with full titles rather than authors seriatim. It is combined with an author and subject index. Each title is indexed under several subjects, apparently in order of importance. The attempt is made to list papers of interest to oceanographers from such journals as *Science*, but not conference reports and similar transitory material. All articles listed are microfilmed, and "Xerox copies are made available for a small service charge" (to member subscribers, that is). A preliminary test of this compilation indicates that the comprehensive subject indexing system may lead one to acquire a copy of a paper in which the subject of interest may receive only a brief mention, but perhaps this is better than the attempt to make value judgments by the compilers. In the first 1965 issue of this Index, which was received while this review was in proof, notice is given that U.S. Government research and development reports will be included. I also note that the contents of those hardbound objects which are neither books nor serials ("Advances in this or that") are now being listed; doubtless copyright restrictions will prevent distribution of Xerox copies of these.

In any event, although not as comprehensive in some aspects as the FAO *Current Bibliography*, the *Oceanic Library Index* provides a copy service (as does FAO, Rome) and is easier to use. However, the FAO bibliography is being compiled in cooperation with the Aquatic Sciences Information Retrieval Center at the University of Rhode Island and eventually, I suppose, one may command sets of microcards of all possibly appropriate papers from that enterprise. Such a copy service, however, is still in the future. At the present time the Retrieval Center is equipped to produce a print-out response to a search request, based primarily on the FAO compilation. This service is described by O'Connor and Saila ["A developing aquatic sciences information retrieval system," *Trans. Amer. Fish. Soc.* **91** (2), 151 (1962)].

It would appear from these various services that aquatic science (especially oceanography) is being as adequately served as possible at this time. At least the three services referred to are under the supervision of people within the field who obviously have some sense of proportion and basis for making the judgments necessary to list information in a retrievable manner. This can not be said, unfortunately, of another project, "The Biological Sciences Communication Project." The first part of this is a mimeographed list of aquatic laboratories of various kinds followed by an alphabetical list of aquatic biologists. Unfortunately, this appears to have been compiled primarily from a register of federal grants and contracts, with the result that the specialties of many of the persons listed are simply the subjects of the grants they happen to be administering. There are many small mistakes in spelling the names of people and organisms. One part of this project was a sort of bibliography, *Books on Aquatic Biology*, that has more mistakes than can be politely mentioned.

It would seem that with the several services generally available (each providing something somewhat different and not completely duplicative), still another is unnecessary, especially when the criteria are selected and applied by persons whose primary end seems to be a system itself rather than trying to approach the needs of the field through the use of a system. As Vickery stated in the conclusion of his essay on the subject:

> Analysis and synthesis of information, though it may be aided by the machine, can only be carried out effectively by skilled human labor. We shall cope with the information explosion, in the long run, only if more scientists and technologists are prepared to commit themselves deeply to the work of collecting, indexing, reviewing, and correlating information, and to studying the problems of handling information.

One thing is certain about computerized retrieval: it can not replace the human factor or think for people. What people think when they store things in computers may influence thought in unexpected ways, but if the entire paper can somehow be retrieved, that should offset this disadvantage. Perhaps the most serious danger of a comprehensive retrieval system built up of neatly coded information is the inhibition of serendipity that could result. Or, can we hope that the computer will inadvertently provide some serendipity of its own?

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A History of the School of Medicine, University of Pennsylvania

Any American institution that achieves its 200th anniversary must reflect in its history the stages of national growth from colonial to major industrial status. The Medical School of the University of Pennsylvania, founded a decade before the Revolutionary War, ranks as America's oldest school of medicine. Its development has paralleled that of the city and nation of which it is a part, but also has reflected the special problems of medicine and medical training of the past two centuries. George Corner's **Two Centuries of Medicine** (Lippincott, Philadelphia, 1965. 373 pp. $7) is an exciting history of a medical school as well as an important document in the social history of the United States. By turning to the final sections of this book and reading of the complex structure of the present University of Pennsylvania Medical School—stretching from the scientific through the clinical subjects, from the laboratory and classroom to the operating table and the ward—we gain a fuller appreciation of each of the innovations along the way.

In 1765 Philadelphia was one of the largest cities in the British Empire and the most populous of the American colonies. Its college, although not among the oldest, was flourishing. The education of physicians, however, was left to an unregulated system of apprenticeships. Only those men willing to go abroad, to the universities at Edinburgh, Leyden, or Paris, or to the teaching hospitals of London, could