Considerations on Utilization of Scientific Literature

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THE ACCUMULATING BODY OF KNOWLEDGE in the scientific literature constitutes an essential factual basis for continued research and for human understanding and progress. The availability of the literature in forms best suited for utilization is thus highly important.

Present arrangements, however, fall far short of providing the literature in such a way that it can be most efficiently used, and the rapidly increasing output and complexities of science necessitate ever greater economy of effort, if the scientist is to keep informed in expanding fields. Moreover, as a consequence of the vastly greater output of information anticipated for the decades immediately ahead, conditions may arise which could not only limit the possibilities for adequate publication and utilization, but also stifle deliberation on possible solutions to the problem. Circumstances might lead to the setting up of arbitrary and undesirable practices; consequently, the need to consider possible changes in the means employed by the scientific information services is immediate. The solution of the problem lies, not in simple modification of conventional means, but in a broader approach. The situation may be most advantageously met if scientists accept the responsibility for designing a more practical service system, and for organizing and controlling its operation.

The purpose of this communication is (1) to suggest inauguration of a long-range planning program for the formation and eventual activation of a comprehensive system of services to provide permanently for adequate publication, distribution, and utilization of the scientific literature; and (2) to outline a specific plan that could serve as a basis for immediate consideration in such a program. Discussion will be restricted to comprehensive planning, on the premise that a single universal system functioning within a world association of scientists should, and eventually will, replace the many thousands of diverse and uncoordinated efforts now functioning as independent units.

Plans for reformation through comprehensive approaches have been advanced by Pownall (*1*) in 1926, Davis (*2*) in 1933, Bernal (*3–5*) in 1939, 1945, and 1948, Troy (*6*) in 1943, and Reid (*7*) in 1945. Bernal (*3*) mentioned that Federovsky in Russia and van Iterson in Holland had interested themselves in this problem, and that (*4, 7*) a group composed of members of the Association of Scientific Workers had put forward a fairly detailed scheme. Helpful discussions bearing on the general problem and some bearing more specifically on comprehensive plans have been carried on by Pirie (*8*) in 1945, an editorial (*9*) in 1947, Davis (*10, 11*) in 1945 and 1948, Jurgens (*12*) in 1949, Taube (*13*) in 1949, and Merrill (*14*) in 1950. The Royal Society Scientific Information Conference held in London, June 21–July 2, 1948 (*15*), considered the many varied aspects of the whole scientific information problem. Although the seriousness of the deficiencies was recognized, solutions were sought more in improvements within the existing services than in basic changes. I am of the opinion that questions that have come to my attention (*15, 16*) with regard to the practicability and effectiveness of these comprehensive plans can be satisfactorily resolved. My own conclusions as to what seemingly should constitute effective means, although arrived at independently, are basically similar to some of those already proposed.

The timely emergence of a satisfactory system through normal evolutionary processes is unlikely, but the purposive construction and eventual activation of a plan providing a practicable system appear feasible. As a matter of judicious foresight, therefore, an active, long-range planning program for the organization and institution, on a scientific basis, of a permanent comprehensive service system should be inaugurated by scientists within the near future.

The program should involve, first of all, the formulation of a general plan for an ideal service system to serve as an ultimate goal and as a guide for current planning, practice, and research. It should then take up the selection, standardization, and integration into the plan of all essential components, and the setting of practical limits of necessary deviations from the plan in interim and ultimate practice. Analyses of service needs, of deficiencies in the present arrangement, and of available instrumentalities, the determination on the basis of these analyses of desirable characteristics in such a program and of suitable attributes in an ideal system, and the accomplishment of the necessary steps toward fulfillment are subjects which must receive careful attention, although they need not be developed here.

A Proposed Basic Plan

The plan herein presented is designed to serve as a basis for the organization and elaboration of services functioning in the publication, distribution, and utilization of scientific literature. Essentially it embodies a basic rearrangement and adaptation of selected

means in current use, which have been proved satisfactory and are appropriate, and it extends the application of these means to provide a comprehensive, scientist-directed system suitable for universal application. My confidence in the suitability and necessity of such an approach as this has been strengthened by reflection on accumulating and varied experiences during the years since the plan's conception in 1931. Originating out of personal experience with problems of utilization, the attempt has been made to form an ideal yet ultimately realizable system.

Essentials. The plan is based on the following points:

a) Its objective is to bring about through a unified system of services a high degree of improvement in the availability of scientific information as an aid to the fullest possible realization of its value.

b) The system envisaged is simple, flexible, universally applicable, and comprehensive of all services and all instrumentalities; it employs standardized and unified instruments and methods and is coordinated and integrated within itself and with scientific research institutions and scientific associations; and it performs all possible universally required services in a single processing at the time of original publication.

c) Unit contributions are to be published separately.

d) Editorial functions are to be unaltered.

e) The subject matter of all fields of science and of all the world's scientific literature is to be included.

f) Each unit contribution is to be classified, indexed, and coded within major categories and provided with a distinguishing serial number. This information would form part of a standard layout in the medium of publication.

g) Articles and abstracts are to be published in a common language, as well as in the original language.

h) Distribution is to be by subject-matter categories selected by the subscribers.

i) The formation, activation, and continued direction are to be exclusively within the control of scientists acting through a world scientific association.

j) Costs are to be borne, as now, by those directly benefited by the services. Over-all costs are not expected to be increased.

Publication media. The journal system lacks the flexibility essential for adequate distribution, manipulation, and utilization. Since contributions of related subject matter are scattered throughout and bound in a large number of diverse organs of distribution, accessibility is greatly restricted, and the contributions cannot be satisfactorily handled. Many papers are virtually inaccessible when they appear in obscure journals. The worker is delayed in receiving such items, and may forego their use altogether. Usually neither the worker nor his library can afford subscriptions to all the journals that may publish articles in the field. Much material distributed in journals is not related to the specialist's field of immediate interest, and much that is related might best be reviewed in summary form. Handling and storage of this unneeded material are also serious problems.

A basic change in the method of publication to provide for separate and independent treatment of each unit contribution would give the requisite flexibility for meeting the demands of an efficient service. Forms of media appropriate to the requirements could be derived from forms in current use, such as the brochure employed by the Biological Society of Washington, and the permanent library reference and abstract card used by the Wistar Institute of Anatomy and Biology; or there could be more suitable new developments.

The form or brochure that is to be used primarily for full articles reporting research would serve also for translations, summaries and reviews, discussions and collections of scientific notes of permanent value, cumulative indices, classified abstracts, and advertisements. Local society news, announcements, accounts of proceedings, and remarks of temporary interest could be included, but might more appropriately be distributed independently.

The form, such as the library card, that is to be used primarily for combined reference and abstract information pertaining to the unit scientific contribution could serve also for publication of very short articles (notes) in their entirety in place of the abstract, and for brief announcement of work in progress as an aid to general organization of current research. The separate card system would serve the purposes of the central agency and of the scientific libraries, and would probably be the preference of many researchers. Cheap and rapid processes, such as microfilm and photoduplication, would be used for reproduction, according to requirements, of any information whether in manuscript or in one of the published forms. These would serve as the only method of publication in some cases, as well as for reproduction of information from reference cards assembled in subject-matter blocks, for preliminary announcements of forthcoming contributions, for detailed and "raw" data supplementing the published paper, for temporary working copies, and for distribution after the original supply of the regular issue is exhausted.

All media would be in standardized formats and would carry as a standard layout a complete orderly arrangement of reference, classifying, and indexing information, the acceptance date, and the name of the sponsoring organization.

The advantages to research scientists of having separates, references, and abstracts readily accessible in a working file are universally recognized. In the proposed system workers could have practically all desired current literature in specified subject-matter categories immediately available in forms that could be assembled, classified, cited, reviewed, filed, bound, and used in whatever ways seem best suited to their diverse needs and preferences.

Editorial. The editorial functions of the central agency would relate exclusively to routine processing. Content review and other strictly editorial functions for all articles and accompanying abstracts would be completely discharged, with full responsibility assumed, by originating agencies, as at present. Final approval of manuscripts would remain within the jurisdiction of the scientific societies.

In the same manner, a board of the world association would discharge editorial functions for all articles submitted directly to, or originated by, the association. The preparation of scientific and public information summaries could be sponsored by the association through the societies.

Subject matter classification and indexing. The range of subject matter would include all fields of science and all types of scientific literature: original articles, abstracts, lists of forthcoming and current articles, indices, reviews, and periodical summaries and interpretations. As part of the routine processing for issue, the subject matter of each contribution would be classified as to major categories, preferably with the collaboration of the author. The article would be indexed and coded and would be provided with classificatory symbols, an identifying serial number, and the acceptance date.

The scheme of classification would be basically stable, but modifiable on its periphery as required by changing emphasis and extensions of research fronts. The scheme would form a broad basis for further breakdown into specialized categories, for library use, for reviews, for use of mechanical and electronic devices such as a rapid-selector machine for sorting, for distribution by subject-matter blocks, and for citation purposes.

Languages and translations. The time and expense involved in translating articles from many different languages to the reviewer's own are very serious factors retarding research progress. Duplication of effort in this field is common and particularly wasteful. Far too often translations are inadequate, because sufficient preparation in several languages is impossible for most scientists. Distribution of prepared translations is almost nonexistent. Effective review demands that the literature be available in a language most easily and most quickly read; hence the use of a common language is the only practical solution.

I propose that each article with its abstracts, upon acceptance, be considered for distribution in the language in which it was originally submitted, in a common language, and in other accepted languages. Most articles with their abstracts would be published in the original language, although some of them, instead, could be distributed in the common language only. Requests for the article in the original language could be filled by reproductions from the manuscript. Some articles and many abstracts might be translated into various other languages, depending on the circumstances.

All abstracts and practically all articles would be translated into one accepted common language. The language chosen need not necessarily be accepted as a universal language. Publication could be, as needs dictate, in printed form, or as reproduction by cheaper processes.

Advantages are obvious. The subscriber would receive all literature in a familiar language. Translations would be superior, as they would have been done by professional language specialists (with appropriate scientific backgrounds) in the country of origin and, whenever possible, would have been made with the active collaboration of the author. The language problem of individual investigators would be greatly reduced, since proficiency in only one language other than their own would ever be necessary. The intent is not to underrate language study for its practical and cultural value, nor for its value in interpretation of translated articles, but simply to recognize that accurate translation is a field for the professional.

Over-all costs would be greatly reduced. The translation, once published, would serve all researchers, everywhere, for all time. Once the plan is established, very likely an increasing number of articles would be originally submitted and published in the common language. Users, knowing that the author and central agency will be familiar with the single official translation, will be in a better position to obtain aid in its interpretation when needed.

Printing, reproduction, and binding. Printing and reproduction would be a responsibility of regional associations and of the world association, as appropriate. Suitable means would be provided for collecting and binding published articles. Both permanent- and temporary-type binders would be used. Binding would be in subject-matter or serial groupings, and would be done by the distributing agency or by the recipient, according to choice.

Distribution. Distribution would be by subscription and by special request. Subscriptions would be entered independently for each of the different services, such as for original articles in designated categories of subject matter and in specified available languages. Distribution would be a responsibility of regional associations and of the world association, as appropriate. Advertisements would be distributed as elected, which in most cases probably would be with the articles of appropriate subject-matter categories.

The system would assure all participants throughout the world of the equal opportunity for receiving any requested current literature as issued, as well as reproductions of any previously issued articles at any time on special request. The service would provide special bibliographies. Abstracts, references, and title announcements would be released and distributed immediately upon acceptance of articles for publication, serving to announce the articles and to invite special requests for specific publications.

Administration. Responsibility for administration would rest with an established *world association of scientists.* This might be accomplished through an expansion of the activities of the International Council of Scientific Unions. Actual direction would rest with a *central directing agency* created by, representing, and responsible to, the association. This agency would function according to standards and policies established by general agreement.

Service functions would be performed by a *central action agency* responsible to the central directing agency. All functions would be reduced so far as

practicable to routine processing, and full advantage would be taken of the high degree of mechanization to which the system would easily lend itself. The application and extension of currently available aids and the development of wholly new aids would be encouraged. The central agencies would work through local administrative branch units in the various societies.

Successful operation must derive entirely from basic soundness and satisfactory performance, not from governmental subsidy or from any form of coercion. The administration of the system must be free from entangling affiliations or commitments. The "monopoly" the world association might seem to possess would be balanced by the freedom of participants to dissociate and, if they so wish, set up independent services. This arrangement constitutes sufficient safeguard to insure that the system would be provided and maintained in a manner satisfactory to the users.

Originating agencies—authors, scientific associations, and research institutions—would, of course, be under obligation to comply with the general requirements of the system, but other than this, they would experience little change as regards administration. Their rights, freedom, and responsibilities should be no less than now.

Costs and financing. Over-all lowered costs and increased revenue may be expected to offset additional costs of new and extended services. Lowered costs should be realized from savings inherent in standardization, in elimination of duplication, in distribution according to need, in large-scale operation, and in mechanization. Costs of many times repeated services, particularly translations; of transportation, handling, and storage of much excess literature; of purchasing, mailing, and requesting reprints; and of library operation, would be greatly reduced. Much valuable time of investigators would be saved in all the manifold activities involved in using the literature.

Increased revenue should come from some of the same sources that now support publication. Complete service should stimulate an increase from subscriptions. Wider and more efficient distribution should enhance the attractiveness of the service for advertisers. Contributions should be increased from originating agencies in proportion to use, and from commercial and nonprofit institutions in recognition of the value of the service in time saved and in lowered costs.

Utilization. I believe that users and authors of scientific literature would find a comprehensive system best suited to their needs and to the advancement of scientific and public interest. A subscriber would be enabled to build up his reference file according to the special requirements of his fields of activity; his selections could follow his own developing specializations. A usual procedure at any point in his career would be selection of categories providing original articles in the immediate field of interest and such portions of related fields as appear appropriate, abstract-reference information covering broader areas, and periodical summaries and reviews covering as wide a scope as he wishes. The opportunity to select the material to be received would obviate coercive purchase of unneeded literature, and permit his acquisition of a useful selection in its place. Needed references beyond, and to fill gaps within, the subscriber's selection, and literature for broader general reading should, as now, be obtainable from scientific libraries.

The scientific information would be more truly available for use, being classified and indexed for rapid and certain selection, in a familiar language, more suitably distributed, and in convenient forms for handling, filing, and transporting. The greater ease in use made possible by this arrangement would greatly reduce time and effort, permit the user to direct his energy to higher levels of activity, aid him to perform much more purposive reading more easily, and enable him to increase his breadth of general reading. The system should prove particularly helpful to those whose fields of interest are widest and whose literature is now most widely scattered.

Advertisements could be classified and filed permanently, with advantages to both subscribers and advertisers.

Authors of scientific articles would be aided by facilitated reviews and by knowledge of articles soon to appear. Citation would be greatly simplified, because the serial number identifying each article would serve as a brief form of reference. For example, it alone could be used in the text, or in a subject file. Followed by classificatory symbols, article title, and author, a complete bibliographical citation would be formed. The finding of an article in a list or file would be easy, since its location would be fixed by the serial number in a strictly numerical filing system, and by the classificatory symbols plus serial numbers in a subject-matter filing system.

Priority would be determined by the acceptance date, which would be included with the indexing information. Authors would be assured that their contributions would become known immediately to those most concerned, through advance abstracts and title announcements.

The agency might well serve as a central depository of unpublished, as well as published, scientific information. Authors might deposit their raw experimental data and supplementary material with the central agency, thereby making it a matter of permanent record, available for duplication by any suitable process and for distribution at any time on special request.

Anticipated advantages to science and public interests follow from the advantages extended to individual users. The provision of a complete service under the guidance of a world association of scientists would resolve most known and anticipated problems, and bring within the realm of realization many needed functions and services now impossible. Expansion of established activities would automatically follow increasing numbers of scientific contributions and increasing service demands.

Scientific libraries would be relieved of much unnecessary routine work to undertake higher types of

activity, such as extended informational bibliographical summarizing, procurement, preparatory, and interpretation services. Literature would be more systematically filed in the library and would be better distributed among the units using the library. Elimination of thousands of journal titles and complicated reference procedures and the provision of prepared references and simplified citation would greatly reduce effort.

Research progress would be accelerated, because universal availability, greater facility in documentation, and improved correlation of information from individual contributions would give new value to the scientific literature. Duplication of research efforts and of the functions of the information services would be reduced, and over-all research planning would be greatly facilitated. Research activities could be extended and improved at greater distances from the great centers, and the problem of international exchange and dissemination of scientific literature would be resolved.

A challenging functional objective for an expanded world association of scientists would be provided, contributing toward a further unification of the activities of scientists, raising the prestige of science and the scientific method, and, incidentally, engendering closer social and political unity throughout the world.

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Technical Papers

The Resistance of DDT-resistant Drosophila to Other Insecticides[1]

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The literature of the past few years contains many examples of the development of strains of insects resistant to various insecticides. This resistance has been explained on the basis of the intense selection that occurs in treated areas. There is some variation in the results reported on the specificity of the resistance. Whereas early reports refer to a general hardiness with resistance extended from DDT to other insecticides (*1*), or to a specific resistance to DDT and very closely related compounds (*2*), the more recent investigations indicate that cross-resistance in DDT-resistant houseflies is neither highly specific nor broadly general, but of an intermediate nature (*3, 4*).

The purpose of this investigation was to determine the extent of the resistance of DDT-resistant *Drosophila melanogaster* to other contact poisons. Drosophila were used as test insects because of the ease with which they can be reared in large numbers in the laboratory and because of the possibility of much more precise genetic analysis than would be possible with any other species. The resistant strain was obtained by growing the flies in a Teissier-type population cage (*5*). This enables the growing of a virtually undisturbed population of a few thousand flies with a continuously changing food supply.

Fine crystals of DDT were scattered in the cage in gradually increasing amounts as the flies became more resistant. At the end of a year, only about 5% were killed by a concentration of DDT that killed about 95% of the control flies. This selection procedure is not as efficient as could be used, particularly because of the uniformly greater susceptibility of males, and a more rapid increase in resistance undoubtedly could have been obtained by better selection methods. But it appeared to be the most nearly comparable to the situation as it occurs in nature and was adopted for that reason.

The flies to be tested were the descendants of flies taken from the selection cages and from a control population. They were tested at an age of 4 days with 5 doses of the insecticide to be tested. The dosage levels were equally spaced logarithmically, 150 flies of each sex and strain being tested at each dosage level. The insecticides were prepared as acetone solutions, and 0.5 ml of the solution was pipetted onto a rectangular filter paper 6 × 7 cm which was fitted into a glass vial. After the solution had dried, 20 flies of the same sex were placed in the vial at 26° C. Studies in this laboratory have shown that differences in hu-

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