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THE ABSTRACTING AND INDEXING OF BIOLOGICAL LITERATURE[1]

WHEN DR. LILLIE asked me to discuss some phase of the general abstracts-indexes-bibliographies problem in one of these evenings I hesitated considerably before accepting because it appeared to me such a discussion would be rather foreign to the general character of these evenings, occupied, as they are, primarily with the results of biological or related research. However, it was rather because of this difference that I ventured to accept. I found a certain justification on the ground that if in the main these evenings are given over to the reporting of advances in knowledge, one evening might conceivably be profitably devoted to a consideration of whether we are preserving these advances in such a way that the greatest use may be made of them with a minimum expenditure of time, energy, and funds. We expend considerable funds and enormous amounts of energy and time in ascertaining new facts and publishing them *in extenso*. I believe it is pertinent to inquire whether we have established adequate means for so recording these facts that the greatest and most economical use is made of them and progress made as largely cumulative as possible.

No doubt some of you are wondering what special license I have to discuss this problem. I can answer only that I have none. My contact with the subject has been a brief one. I happen to be one of a number who for the past four years have been carrying some of the responsibility in connection with *Botanical Abstracts,* and as such have been impressed with the magnitude of the problem of properly recording our information and have become convinced that in a large measure we have not in

[1] An invitation paper given at the Marine Biological Laboratory, Woods Hole, Massachusetts, August 4, 1922.

our present methods reached a fundamentally correct solution of this important problem.

The ideal—I take it all are agreed here—is to have all new information so recorded that any part of it, major or minor, can be located promptly and certainly. Classified bibliographies and indexes, in book or card form, abstracts with subject and author indexes in book form, etc., are some of the means in use to approximate this ideal. I should make it clear that I am here discussing only the recording of information, not criticism.

A review of most of these agencies, at least the biological ones, shows that they have been very inadequately supported, have been able at best to do the work incompletely, great as has been the service they have rendered. And, perhaps more important, continuity, because of inadequate financial support, has not been guaranteed, with the result that agencies have arisen, grown to great usefulness, declined, and disappeared, to be followed by gaps before other agencies have got under way. The result is that biological literature is not only inadequately recorded, but it is recorded in so many places that the task of rather exhaustively consulting the literature on many biological subjects is indeed exhausting. Moreover, an enormous amount of duplication exists, all agencies in the same general field covering the literature in well-known journals, but frequently being forced to neglect that in the less well known.

I believe it is worth while to inquire into the fundamental causes of the difficulty and just what sort of service the present worker demands. As the number of research journals and the amount of material published have steadily increased it has become more and more impossible for the individual worker personally to subscribe for an appreciable amount of the literature in his field. More and more he is depending upon bibliographic and abstract services to bring to his attention the contributions he must consult critically. It could not be otherwise. But in general the workers desire to own these bibliographies or abstracts, especially the latter, as they constitute, if well done, a sort of master key to the literature. I believe I am correct in saying that usually workers prefer a good abstract journal covering their field to a single or even several research journals. Granting that workers need and want most of all adequate abstract and index services, it is clear that if they are to avail themselves fully of such agencies these must be procurable at prices within their reach. In other words, the cost of the service must be relatively low—very low for most of us. Secondly, the service must approximate completeness. It should be of such character that reliance can be continuously placed on it to report adequately practically all the literature. Thirdly, the service must be prompt; the demands of the worker on his abstract journal are much like those on the newspaper. Fourthly, there should be reasonable guarantees of the continuity of the service.

As regards completeness and adequacy, I believe only one type of service has been developed which is generally satisfactory and that is the abstract journal with detailed indexes. Classified bibliographies, even though based on an examination of the texts, can at best but incompletely record the new information, though their utility has been and is very great, especially for libraries. In some instances, notably in the case of libraries, classified bibliographies in card form are preferred; but for individuals the expense and labor involved in filing and files have not made these very popular. Moreover, such bibliographies are cumulative and not periodic. The same objections presumably hold for abstracts in card form. Another objection to the latter is that it is difficult to accompany them by a usable detailed subject index.

The reason for the popularity of abstracts with detailed indexes is obvious. Unlike bibliographies, abstracts, if well prepared, quickly give the reader definite information as to the exact content of contributions. In many cases the titles can not do this even though formulated with care; and many of them are not formulated with care. Indeed, many are distinctly cryptic. From complete abstracts virtually complete subject indexes can be prepared, based, of course, on a careful analysis of the abstract as well as of the title. By and large, the complete subject index is perhaps of the greatest importance. But its preparation necessitates complete abstracts, unless indeed the indexing should be done wholly from the

originals—which would not at the same time yield the much desired abstracts, indispensable for current and reference use. It seems logical, therefore, to prepare the abstracts, and from them the indexes. Annual indexes furnish periodic reference sources which may be cumulated from time to time, as desired, to furnish the cumulative reference sources.

If we are correct that the most useful instrument in general is the abstract journal, how are we to produce it completely, thoroughly, promptly, continuously and sufficiently cheaply to answer the requirements? Obviously the task requires funds.

At present there are a great many abstracting journals in biology, not to mention scores of research journals that make more or less abortive attempts at abstracting. The subscription list of each is small, as most of them serve small groups. We have set up a great many special abstracting journals—in bacteriology, physiology, entomology, endocrinology, systematics, phytopathology, etc., etc.,—in most cases without correlation, with the result that each can claim only a small list of subscribers and is forced to charge a high subscription rate. It is a fact too often lost sight of that composition, or type-setting, is expensive and that its cost per page is the same whether one or one hundred thousand copies are printed. The fewer the subscribers, the larger the share of composition charge each must bear. With a large subscription list, the amount borne by each becomes negligible and a copy costs little more than the paper, press work, binding, and distribution. An abstracting journal with a subscription list of one thousand or fifteen hundred, as is the case with most of them at present, can not hope to yield a surplus sufficient to carry on the large amount of exacting routine necessary in a good abstracting journal. Little wonder, then, that almost all our special biological services are embarrassed financially and unable to carry their work forward as it should be carried.

Let us at this juncture examine what has been and is being accomplished by another science group going at the problem in another way. I refer to the chemists, who are probably handling the proposition more successfully than any other group. Instead of abstracts of industrial chemistry, organic chemistry, pharmaceutical chemistry, analytical chemistry, inorganic chemistry, etc., etc., they have one chemical abstracts. They have made it one of the official organs of the American Chemical Society and thus insured a minimum circulation of well over 13,000. The following are the remarkable facts in this undertaking: *Chemical Abstracts* publishes annually approximately 5,000 pages of probably the best abstracts and indexes produced anywhere; it maintains an editorial office, consisting of an editor-in-chief, two associate editors and a clerical staff, and pays its abstractors at a per page rate, at an annual cost of approximately $26,000; but even so, the journal is produced at an annual cost of about $6.80 per member, this including entire cost of manufacture and distribution, support of the editorial office and compensation of abstractors.

Consider for a moment another journal, *Botanical Abstracts,* with which I happen to be familiar. It prints about 1,200 pages of abstracts annually at a cost of $12.00 to each of its 1,100 subscribers, and has not only yielded no income for editorial purposes or for compensating abstractors, but instead has been accumulating a deficit. In other words, *Chemical Abstracts* publishes four times as much material at less than half the price and is able to carry its work forward continuously and efficiently and be relatively free from serious financial embarrassment. Most of our special abstracting journals are being carried on by a few enthusiasts willing to devote much time and energy without compensation. But, however willing these individuals may be, such organizations are subject to frequent partial or complete breakdowns. Their continuity and uniform quality have no reasonable guarantees.

Is it possible for the biologists to profit by the experience of the chemists and achieve something equally good or better in the way of this important accessory mechanism? At once we realize that the biologists lack an organization sufficiently comprehensive and strong to grapple with so large and difficult a problem. There are in this country fifteen to twenty societies of biologists with an aggregate member-

ship of over 6,000, but, with the exception of the Federation of American Societies for Experimental Biology which involves four societies, these have been almost wholly uncorrelated.

Recently, however, there has developed a movement which may provide an organization comprehensive enough to measure up to the task. I refer to the proposed federation of American biological organizations which are of a research character and which are essentially national in scope. This movement, as seems not generally realized, began over a year ago when the Botanical Society of America, the American Society of Zoologists, and the American Society of Naturalists endeavored to work out some plan to provide for the organization desired by the geneticists without at the same time increasing the already large number of separate and distinct biological organizations and thereby making it still more difficult to handle problems of common concern to all biologists. It was recognized that the opportunity for the organization of special groups must be provided, but also that there are certain large problems which can be properly handled only by a larger, stronger organization, including, if possible, all the societies. As regards the immediate problem of the genetics organization, the committee of the three societies recommended that sections in genetics with common officers be created in both the American Society of Zoologists and the Botanical Society of America. This recommendation was carried out by both societies, and programs of the joint sections were held at Toronto.

The committee went further, however. It recognized that similar organization problems would continue to arise and that something should be done to make such organization of special groups possible and at the same time maintain a certain solidarity of biologists for handling problems of common concern requiring concerted action for their successful solution. It was felt that this could be accomplished by a federation of at least the national research biological organizations.

The Division of Biology and Agriculture of the National Research Council was requested to call an informal conference at Toronto of officers of the national societies to consider the possibility of a federation. This meeting was held[2] and, after a general discussion, it was voted to hold an adjourned meeting in Washington in the spring. This was held in April of this year[3] and was participated in by official representatives from the following organizations:

American Society of Zoologists.
American Genetic Association.
American Society of Naturalists.
American Phytopathological Society.
Ecological Society of America.
Botanical Society of America.
American Society for Horticultural Science.
Society of American Foresters.
Society of American Bacteriologists.
American Association for the Advancement of Science, and its Sections G, F, O, and N.
American Association of Economic Entomologists.
American Society of Agronomy.
Entomological Society of America.
Federation of American Societies for Experimental Biology.
American Dairy Science Association.
American Society of Animal Production.

An executive committee *pro tem.* was appointed to draw up a constitution to be submitted this fall to the societies represented in the federation conference. While I am not authorized to speak for the committee, I think it may be said with perfect propriety that the federation, if established, will not in the least affect the autonomy of the member societies and that it will concern itself with problems of common concern to biologists.[4] The Washington conference recognized that one of these problems, perhaps the chief one at present, is publication, and, in particular, abstracts. It therefore appointed a committee to study the problem of providing all of biology with adequate abstracting and indexing services. This committee is a joint one, half appointed by the Conference and half by the Division of

[2] See Shull, A. F.: "The Proposed Federation of Biological Societies," SCIENCE, 55, 245-246, 1922.

[3] See Shull, A. F.: "Proposed Federation of American Biological Societies," SCIENCE, 56, 184-185, 1922.

[4] See Shull, A. F.: "Proposed Federation of Biological Societies," SCIENCE, 56, 359-361, 1922.

Biology and Agriculture of the National Research Council, and consists of the following:

Representing the proposed federation: A. Parker Hitchens, D. R. Hooker, C. A. Kofoid, I. F. Lewis.

Representing the Division of Biology and Agriculture: E. D. Ball, C. E. McClung, J. R. Schramm, A. F. Woods.

This committee is at work ascertaining the exact situation in abstracting, indexing, and other agencies for recording biological information throughout the world. Several facts are already obvious. Considering for the moment only the agencies published in English, we have in this country *Abstracts of Bacteriology, Index to the Literature of American Economic Entomology, Botanical Abstracts* (containing in addition to plant research animal cytology and genetics), *Endocrinology,* etc.; in England, *Physiological Abstracts, Review of Applied Entomology, Review of Applied Mycology, Zoological Record* (Part N of the International Catalogue of Scientific Literature), etc. The subscription list of each is small and in many cases the financial support is inadequate to insure that the work will be done thoroughly and in perpetuity. Zoology especially seems in a precarious position since the breakdown of continental agencies and the suspension of the International Catalogue, with the exception of Part N (Zoology), which, however, is financially handicapped. Only in physiology and entomology, and perhaps genetics, is the situation reasonably satisfactory at present. Many of the agencies are hanging on a relatively slender thread; some are likely to break down at almost any moment, indeed, are breaking down. The question is, shall we continue to leave the recording of biological information, only a mechanism, to be sure, but an absolutely indispensable one, to such a precarious existence?

Primarily there appear to be two methods of handling the situation. (1) The present one of a large number of special abstracting journals or bibliographic services. For such special journals there is a relatively small demand and a correspondingly small support. Here, too, it should be pointed out that the more numerous the journals and the narrower the field covered by each, the greater the amount of duplication—necessary duplication under this system since each specialty grades insensibly into neighboring ones on which it depends to a large extent. Furthermore, the conventional line so often drawn between plants and animals is no longer recognized in many lines of work, and rightly so. Separate botanical and zoological abstracting journals will not satisfy the geneticist or cytologist, and only imperfectly many pathologists, physiologists, and ecologists. (2) The other method is the publication of a single comprehensive biological abstracts, corresponding to *Chemical Abstracts.* Let us consider the second alternative in more detail.

(1) *Cost.* The joint committee has not yet completely determined the approximate volume of biological literature, after delimiting it roughly from clinical medicine, chemistry, physics, geology, psychology, etc. But it is safe to assume that it is at least as large as chemical literature. Let us assume, then, that a journal fully as large as Chemical Abstracts (5,000 pages annually) would be required. If such a journal were made the official organ of the proposed Federation, going to each member of the constituent societies as Chemical Abstracts goes to each member of the various sections of the American Chemical Society (thus insuring a subscription list of 7,000 or 8,000), I believe I am safe in saying on the basis of information in our hands on manufacturing costs that such a journal would cost little or no more than most of the special abstracting journals and considerably less than some of the larger ones like Botanical Abstracts. In other words, a very large journal with a large subscription list would cost less per subscriber than a small one with a small subscription list. Let me remind you again of Chemical Abstracts with its 5,000 pages annually and an overhead of $26,000 yearly produced at a cost of $6.80 for each member.

It may be objected that most biologists would be interested in but a small part of such a comprehensive journal. The same thing may be said of Chemical Abstracts. I doubt whether there would be greater diversity than in Chemical Abstracts, which includes anything from

routine commercial analysis to theoretical physical chemistry. The material would, of course, be organized into sections according to the judgment of the biologists and the section or sections of interest could be as easily consulted as in a special journal. This objection resolves itself, I believe, into the relatively small item of space occupied on the shelf; this may perhaps be met by some plan of issuing parts without involving a sacrifice of the fundamentally important principle of uniform support by all members of the constituent societies of the proposed Federation.

(2) *Duplication.* Most of the duplication existing in special abstracting journals would be done away with and the problem would narrow itself down to the necessary overlapping with a few large abstracting journals in the other major fields—chemistry, physics, etc. Moreover, with such a widely distributed abstract journal, research journals might well discontinue their abstract sections and either devote such space to the publication of additional research, or to criticism, or both; or effect a reduction in size, and consequently in cost.

(3) *Cross referencing.* Though the material be segregated into special sections, as many as necessary, suggestive and pertinent material from other sections could be conveniently referred to by cross references, each sectional editor having complete control over cross references by having access to a complete duplicate galley proof. (In the special journals this can be done only by duplicating in large measure the abstracts appearing in other specialized journals.) This cross-referencing would make possible the very complete utilization, with practically no expense, of the valuable leads from related fields on which so much of progress depends.

(4) *Current files.* A single, large, strong journal could acquire by exchange or purchase much of the current serial literature in which its material appears. *Chemical Abstracts* now receives 550 serial publications, by exchange and purchase, which are available for abstracting purposes. The small journal does not have the resources to accomplish this, and yet such files are indispensable for properly carrying on the work. It is to be hoped that some day all American abstracting agencies at least may be brought into correlation in order that they may share each other's facilities; all the services would inevitably profit by such correlation.

(5) *Support.* Fundamental to the ultimate success of such a comprehensive undertaking would be the adoption of the journal as an official organ of the proposed Federation. Granting that it can be manufactured, as I believe it can, for from $6.00 to $8.00 annually, I am inclined to believe that practically all of us would be willing to pay that amount annually for a virtually complete abstracting and indexing service of the world's literature in our respective fields, especially when it brings in addition equal service in other biological fields in which we have an interest. If this were done, in other words, if a Biological Abstracts, or whatever you choose to call it, had the solid backing of the biologists of America at least, support, perhaps a permanent endowment, might be secured sufficient to cover the overhead, in which case the journal could be sold for practically manufacturing cost. Moreover, such an endowment would reasonably guarantee that the work would go forward properly under practically all conditions. There is little hope that the numerous separate journals with small backing can command such support. Indeed, the history of these shows that they can not.

Let me make it clear, however, that the joint publications committee has no power. Its function is to ascertain and report the facts. The decision rests with the societies. The committee is by no means ready to report, and I have little idea as to what will be the nature of its report when all factors have been taken into consideration. But I personally venture to predict that the permanent solution of the problem lies in the direction of the establishment of a single biological abstracting journal having the unified support of all, or practically all, American biological organizations at least. Obviously, such a solution would necessitate the merging of several existing biological abstracting and bibliographic agencies, and this, of course, should not be done unless it is certain that a real improvement will be effected thereby. We may rest assured that those controlling the ex-

isting journals will not proceed in this direction until such guarantees are forthcoming.

J. R. SCHRAMM
NATIONAL RESEARCH COUNCIL,
WASHINGTON, D. C.

DOES NITRIFICATION OCCUR IN SEA WATER

DESPITE the meager, observational and experimental data which are available on the subject, the idea of the occurrence and activity of nitrifying bacteria in the opea sea is widely prevalent among bacteriologists and botanists. This idea is based, in part, on the reasoning that ocean water should contain the bacteria discharged into it by the sediments and the drainage waters from terrestrial sources; more particularly, however, it is an outgrowth of certain studies which have been made in recent years on the bacterial flora of sea water which, as above indicated, are far from exhaustive and satisfying. For example, Thomsen[1] has discovered nitrite and nitrate producing bacteria in the ooze of the bottom of Kiel Fjord. It has also been reported that nitrite and nitrate forming bacteria have been found in the slime at the bottom of the Bay of Naples. In both cases, however, it is definitely pointed out that the samples studied were obtained from near land surfaces. Moreover, Thomsen failed to discover the nitrite or nitrate forming organisms in sea water or in the plankton or the fixed algæ. In commenting on the studies of Keding[2] and Keutner[3] on nitrogen-fixing bacteria of the sea, Drew[4] made the following statement which shows him to have been confused on the subject of two distinct groups of bacteria wholly different from each other in all respects. He said, "The existence of *nitrifying* bacteria which are *capable of absorbing and combining with the free nitrogen of the* air[5] and eventually give rise to nitrates, has been shown by Keding and Keutner, but these have so far only been found in the bottom close to shore or apparently living in symbiosis with algæ or plankton organisms." Later on, however, Issatchenko,[6] whose original papers are not available to me, claims to have found nitrifying bacteria in the Gulf Stream near Ekaterininsk 72° N. He observed, however, that the presence of such bacteria in the Arctic Seas is still unproved. Issatchenko made this statement eight years after having stated, as reported in a brief note,[7] that he had discovered a nitrifying bacterium in Arctic sea water. With these unsatisfactory results before him, Berkeley[8] decided, in the course of other studies on marine bacteria, to make some tests for a possible nitrifying power of sea water. He inoculated 2 per cent. solutions of ammonium sulfate in sea water with samples of the sea water to be studied. He does not state how much inoculum was employed, nor anything else relative to the technique of the experiments, but the result was that even after three months none of the cultures showed even traces of nitrite or nitrate.

In connection with a series of critical studies on the possible connection of bacteria with $CaCO_3$ precipitation in sea water, which are to appear in the reports of the Department of Marine Biology of the Carnegie Institution of Washington, the writer of this note, unaware of Berkeley's work which appeared at about that time, determined to make some tests for the possible nitrifying power of sea water.

[1] Thomsen, R.: "Ueber das Vorkommen von Nitrobakterien im Meere," *Wiss. Meeresunters*, Vol. XI, Kiel.

[2] Keding, M.: "Weitere Untersuchungen über stickstoffbindende Bakterien," *Wiss. Meeresunters*, Vol. IX, Kiel.

[3] Keutner, J.: "Ueber das Vorkommen und Verbreitung stickstoffbindende Bakterien im Meere," *Ibid.*, Vol. IX, Kiel.

[4] Drew, G. Harold: "On the Precipitation of Calcium Carbonate in the Sea, etc." *Papers from Tortugas Laboratory*, Carnegie Inst., Wash., Vol. 5, 1914.

[5] Italics mine.

[6] Issatchenko, B. L.: "Nitrogen Fixation, Nitrification, Denitrification and Production of Hydrogen Sulphide by Bacteria in the Arctic Ocean." *Rev. Agr. Expts.*, Vol. 17, pp. 175-9. Cited in *Bull. Agr. Intelligence*, 7, 1753 (1916).

[7] Issatchenko, B. L. Cited from *Centr. Bakt. etc.*, 2th Abt., No. 13-14, p. 430, 1908.

[8] Berkeley, Cyril: "A Study of Marine Bacteria, Straits of Georgia, B. C." *Trans. Roy. Soc. Can.*, Vol. 13, p. 15.