

SCIENCE

A Weekly Journal devoted to the Advancement of Science, publishing the official notices and proceedings of the American Association for the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

11 Liberty St., Utica, N. Y. Garrison, N. Y.
New York City: Grand Central Terminal

Annual Subscription, \$6.00 Single Copies, 15 Cts.

Entered as second-class matter January 21, 1922, at the Post Office at Utica, N. Y., under the Act of March 3, 1879.

VOL. LVI AUGUST 25, 1922 No. 1443

CONTENTS

<i>The Record of Science:</i> PROFESSOR WM. WARNER BISHOP.....	205
<i>The Depletion of Soils by Chemical Denudation:</i> DR. MILTON WHITNEY.....	216
<i>Scientific Events:</i>	
<i>The Pittsburgh Meeting of the American Chemical Society; Exhibit of Optical Instruments; Ventilating Code of the American Society of Heating and Ventilating Engineers; The Aquarium of the Zoological Society of London.....</i>	219
<i>Scientific Notes and News.....</i>	221
<i>University and Educational Notes.....</i>	225
<i>Discussion and Correspondence:</i>	
<i>The Food Habits of Swordfish:</i> PROFESSOR J. S. KINGSLEY. <i>Experimental Transformation of the Smooth-bladder of the Dog:</i> DR. EBEN J. CAREY. <i>An Albino Mutation of the Dematiaceous Fungus Brachysporium Trefolii:</i> DR. LEE BONAR. <i>A Damp Chamber for Microscopes:</i> PROFESSOR CLIFFORD H. FARR. <i>The Cost of German Publications:</i> PROFESSOR JAS. LEWIS HOWE.....	225
<i>Quotations:</i>	
<i>Science and the Tropics.....</i>	228
<i>Scientific Books:</i>	
<i>Keyser's Mathematical Philosophy:</i> PROFESSOR G. A. MILLER.....	229
<i>Special Articles:</i>	
<i>The "Winter Cycle" in the Fowl:</i> DR. J. ARTHUR HARRIS and H. R. LEWIS. <i>The Effect of X-Rays on Chemical Reactions:</i> A. R. OLSON.....	230
<i>The Fifteenth Annual Conference on Weights and Measures.....</i>	232

THE RECORD OF SCIENCE¹

One learns by adversity—at least such is the popular belief, although the press dispatches from Europe during the past few months would seem to give the lie to this old adage. It used to be my fate to encounter at frequent intervals a genial friend of great distinction in the field of physics and astronomy, long engaged in high administrative functions, an alumnus of this university—together a man of great weight and substance, who endeavored each time we met to overwhelm my cherished ambitions by bringing forth with great gusto this aphorism, "Bibliography is the platitude of research!" So much did this phrase please him that he paraded it on many occasions, and I confess I used to dodge around the corner to avoid its rotund and sonorous condemnation of my own ways and works. I hope to show you that bibliography is the *foundation* of research, and that however level and flat that foundation may be, however dull may be the task of laying it deep and strong, no lasting and lofty superstructure may safely be reared, save on the secure footing of a knowledge of previous work done by others, a knowledge resting necessarily even in the field of science on the much despised labor of the bibliographer.

There is prevalent on every university campus, I suppose, an impression—not among students alone—that the various branches of human knowledge are for practical purposes divided into two groups, the laboratory sciences and the book sciences. This is an extremely convenient and easy grouping—and it has certain elements of truth in its facile cleavage of the field of inquiry. But it is essentially inaccurate in that it ignores a fundamental factor common alike to research with the microscope

¹ Address at the annual meeting of the Michigan Chapter of Sigma Xi.

or the blow-pipe and research with the written word or philosophic logic as its instrument. That factor is the *record* of what has been known and spread abroad by previous inquirers. The processes of human inquiry depend fundamentally on memory—and in the case of the pursuit of knowledge in our own day on the *record in print* of what the race has done or thought or attempted. It makes little difference whether the inquiry be into the morphology of the early Italic dialects of the Latin tongue, or into the function of the ductless glands of guinea pigs—the essential processes are alike these: observation and the gathering of data by experiment or by compilation; a study of the previous work done in the same field with a critical examination both of processes and results; a synthesis from one's own observations and from the recorded observation of others; and finally such reflection (or theorizing) on the results as may lead to correlation of this piece of investigation with the sum of human knowledge, perhaps (occasionally) in a way to affect human activity. The so-called "book sciences" employ methods in no way essentially different from those long approved in the so-called "natural sciences." All of them alike depend on careful study of previous work as an initial step and on the publication of results as a final process. No facile popular division can separate "book-knowledge" from "experimental research." Experiment without "book-knowledge" is generally not research in the true sense, even though it occasionally leads an Edison into discoveries of untold value to the world.

There is, notwithstanding, a justification for this distinction popular among college students. The manner of teaching the natural sciences has been completely revolutionized in the last forty years. Every one knows that subjects formerly taught from text-books are now taught chiefly in laboratories. Emphasis is now laid on accurate observation, correct inference from observation, ability to report the sum of observation succinctly and truthfully. An equipment elaborate in itself, impressive in amount and cost, is properly thought needful to the task of teaching the natural sciences. Each student is considered

(I suppose) an embryo Pasteur or Rowland, and is laboriously inducted into scientific methods by requiring him to develop manual dexterity in the use of instruments, and training him to produce neat and correct note-books. Naturally the mass of students is found in the elementary courses. It is only the smaller number resulting from a process of natural (or at least academic) selection which ever gets to the "journal club" stage, and becomes personally aware of the existence of the enormous and multifarious record of scientific knowledge. That the method of teaching should of itself influence the student's conception of the subject-matter of instruction is both natural and inevitable. That undue weight should be given by their elders to manner and form of presentation is quite another matter. It is, however, impossible to escape the conclusion that many a scientist thinks that he is freed by the very nature of his work from a supposed taint of bookishness. He gives thanks that he is not as other men, as these historians and philologists—or even this librarian.

There is a real danger lurking in this attitude; and we are not without evidence that (whether from this source or more subtle workings of the laws of auto-suggestion) this tendency to pride himself on being strictly a scientific and not a book man has bred a habitual attitude of neglect of the record side of scientific inquiry which has already been disastrous in too many instances. The conviction that apparatus and laboratories are essential—a perfectly sound and indeed a fundamental thesis—has somehow led to the notion that they and they alone constitute the requirements not only of instruction, but of research as well. This tendency—and I do not exaggerate it in the least—has made too many folk unmindful of the long history of science, has bred an attitude which can best be described as almost wholly lacking in the historic sense. And without a sense of the historic setting of his work, a man is almost as hopeless as is the man who lacks a sense of humor! You can not argue with one or the other! In fact I dare go farther and affirm that only by the combinations of the historical and the experimental methods can any work of first-rate

importance be produced in any field of knowledge.

By this time, I fear you may be saying to yourselves that whatever the platitude of research may mean as applied to bibliography the bibliographer is in truth indulging in platitudes! No one need set up a man of straw for the pleasure of knocking him over. There is no point to my contention, if it be true that students of the natural sciences in America have rigorously employed both the historical and the experimental method. The great leaders have unquestionably done just that. But how many *great* leaders have we produced in America? May not one reason for our surpassing excellence in the practical arts and our rather scant array of great names in pure science lie exactly in the absence of the historical record of science from American institutions in the past century? It is difficult, perhaps one may say it is impossible, to get a correct historical perspective without a really good and strong library to furnish the means of study. No amount of second-hand information will ever take the place, for the real student, of the original documents. This is just as true in the pure and applied sciences as it is in history, economics or letters. Imagine an astronomer trying to carry on intelligent research in the observational field alone, without the great publications of the nineteenth century at his hand for previous study and occasional consultation. Yet that is precisely what scores of astronomers have done in this land, and are doing to-day. The example might be multiplied ten-fold. Really good libraries of scientific books are scarce enough in America to-day. Before 1870 they did not exist, save perhaps at Cambridge in Massachusetts. No one of them is yet fully equipped to meet all the reasonable demands of scientists for a record of the progress of knowledge. I say this from my own experience. For eight years I labored—too often in vain—to serve the scientists in the various bureaus in Washington with books they needed. My work was in the third largest library in the world. This fact is significant. May I enlarge upon it?

America is not a nation alone—it is a continent. Distances are enormous. Because Mr. Henry E. Huntington has in San Gabriel in

California a very rare early English book on American fishes or plants, it does not follow that it is of much use to a Harvard student who requires the exact language of the original description of a particular species. The extraordinary collection of early botanical works in the library of Notre Dame University is not easily helpful to the botanists of the Bureau of Plant Industry. These are but two concrete examples of the physical size of this land. You know what it means to journey to Washington in the hot weather of summer—yet you must make the trip in vacation to consult some volume found in America only in the Library of Congress and too rare or too fragile to permit its loan. The situation is quite different in Europe. No university in the British Isles is as far from the British Museum as Ann Arbor is from New York or Washington. Even from Aberystwyth or remoter Aberdeen the trip is less in time consumed than from here to Albany. No French university professor is so far in time from the Bibliothèque Nationale as we from our national library, and we (be it remembered) are much nearer than our colleagues to the west and south. In Germany the Prussian State Library and in Austria the great libraries at Vienna are relatively near the universities. If one goes to London, it is but eight hours to Paris. Between the two largest libraries in the world a scholar can usually find *all* he needs in the way of books. I need not point out the contrast in this country and in Canada. These distances from great library centers have not been without influence on American scholarship.

In fact we may safely say that up to about 1900 there were very few strong scientific libraries in America, libraries in which the record of science could be traced with precision. There has been an almost startling change since the opening of this century. We have much yet to do. We can overcome the obstacles of distance and youth only by further heroic efforts. But we have most surely made progress. We have now a round dozen libraries really strong from an absolute standard. And they are growing stronger every day. We have many special libraries in various fields of science which have been highly developed in their own line—of these the most conspicuous is prob-

ably the great medical library of the Surgeon General's Office in Washington. We have developed library technique and library service far beyond those of Europe. But we have not developed to the point where the historic sense is necessarily fostered and the historic instinct adequately satisfied. That will come with time. Meantime we may perhaps expect that instruction will take cognizance of this changed situation and will by its pressure aid to improve further the resources in the way of books.

For, of course, instruction in historic method and in the use of books as tools is utterly impossible without really good libraries. It is folly to expect students—even advanced students of high promise—to acquire a proper attitude toward their predecessors and their contemporaries without the publications of both at hand in full numbers. It is useless—or nearly so—to teach exact methods of ascertaining the present state of knowledge about any particular problem, when you know it is being worked on in New Zealand and South Africa—and your library lacks the New Zealand and South African transactions and journals. I need not dwell on this painful fact. You know more about it than I do. I suggest, therefore, that the production of truly strong men in your various lines of study depends to a very considerable degree on a sufficient provision of books in our libraries here on this campus. That provision depends on many factors—of which money is by no means the only one, as I hope to show you in the course of these remarks.

For the publication of the results of observation in the field of science has taken many (and frequently strange) forms. We ordinarily think of books as just books—perhaps unconsciously influenced by the manufacture or the perusal of text-books. Ordinary monographs of the text-book type do, it is true, make the staple contents of book-sellers' stocks and ordinary library shelves. But they are perhaps the least important element in the complicated record of science. They are too generally compilations—not the results of original research. And their tendency to accumulate on those very shelves has perhaps had no small part in that neglect of the historic aspect of scientific inquiry to which allusion has just

been made. The large and imposing monograph is the exception. True, it generally remains valuable and "well-spoken-of" long after the smaller books have passed to the limbo of things with a "merely historical" interest. Moreover, the huge monographs which have appeared in some scientific fields—such things as Audubon's *Birds of North America*, for example, or the monumental publications of von Humboldt—have been so costly that save to a favored few they have been merely names and names alone. I am inclined to consider this costliness in relation to our American libraries (until a recent date) a very real factor in the neglect of the older literature. It has simply cost too much to be known by the average student.

Perhaps the most extremely particularized form of monograph is the doctoral thesis. Most folk whom I have met have lost interest in theses within a few years after their own have been promptly forgotten by their colleagues. It is hard to get any money for a lot of dissertations—particularly for the thin German products. The more extended French dissertations usually masquerade as real books. But historically theses for the doctorate have a great value—particularly those printed before 1800. Few people recall the pleasing habit of the earlier centuries which practically compelled the candidate *respondens* to pay for the publication of the work of his *præses* under the guise of a doctoral dissertation. A few years since a committee on botanical nomenclature—or rather, members of it resident in Washington—began to torment me for the dissertations of the pupils of Linnæus, which, they averred, contained some of the great master's best work. It was an interesting quest which became exciting when I discovered a bundle of these much desired little Upsala dissertations carefully tied up and labeled among a group of several thousand Smithsonian exchanges from Sweden. By the liberal use of the photostat, reproducing copies from the Harvard Library and the Torrey Botanical Club the series was made, I believe, complete, and the committee supplied with those original descriptions so essential in determining nomenclature.

One of the extremely important groups which has been too often denied our budding

scientists is that formed by the publication of museums the world over. The catalogs and series, the monographs and bulletins published by important museums are in a very real sense the foundation stones in many branches of science. And it is not only the great museums such as the British Museum, the Berlin group, the National Museum at Washington, the Peabody Museum at Cambridge, which have issued vitally important publications. The local and the special museums have issued publications both serial and monographic which become of vital importance the minute a piece of work done here demands them. You can never foretell when one of these will seem to some professor exactly the one book in the world whose absence from our shelves is fairly blocking his studies. He could not tell you himself a week before his need suddenly arises that he would ever care for such a report or catalog. But he can make his wants known without any difficulty when the demand comes, I assure you. What has seemed a fairly good library up to this morning instantly changes to a very mediocre establishment in the afternoon after a consultation of the catalog! It is a great pleasure to be able to report to you that for five years past the income of the Octavia Bates Bequest has been chiefly devoted to the purchase of museum publications, beginning with those of the British Museum. We could use a permanent fund twice as large to very good purpose in supplementing this work, which up to this time has only begun.

Museum publications are generally issued in limited numbers and at high prices. It is a serious task to secure them. But it is easy compared to the job of getting the publications of expeditions. There is a peculiar fate which attaches to the printing and editing of the scientific results of expeditions of all sorts. Usually some member publishes a popular narrative which frequently sells rather well, particularly if any notoriety or celebrity attaches to the expedition. This very quickly gets into the libraries, as witness the host of popular accounts of polar expeditions which you doubtless all know by name. Far different is the fate of the publication of the scientific results. They are inevitably the work of dif-

ferent men. The labor of preparation requires vastly more time for some subjects than for others. Parts of volumes appear from time to time—members of the expedition go off on other expeditions with their first work half-done or half-published. Editors change, or die. A fire in a store-room or a residence destroys another's notes—or even the specimens themselves. Years pass and the expedition's publications are still unfinished—perhaps they are never finished. Volumes remain unbound because of a missing part never issued, but still hoped for. Publishers fail and the stock is sold for paper. Governments grow weary and withdraw subventions—then vote them again. Heaven blesses a few scientific expeditions with capable members, vigilant editors, a government's purse and completion of publication within a few years. But they are few. I could tell you tale after tale of heart-breaking delays, inconsistencies, changes of forms, failures, deaths—and all involving untold trouble for the librarian who must first *get* these things and then take care of them. Altogether a difficult and perhaps a useless job, you might say.

But then—remember the momentous results of some expeditions and voyages;—yes even of some which have never been completely published! One need only recall a few names, La Perouse, The Challenger, the Beagle,—need we go on? Take but one example—The Wilkes Exploring Expedition. You recall its history, the famous controversy over the Antarctic Continent, the numerous narratives, the slow appearance of the stately folios containing the scientific results. This was the first scientific publication on a large scale of the government of these United States, and an entire evening could be spent in a most interesting way in detailing its vicissitudes. I need mention only one volume to show its importance—Dana's great work on the Zoophytes, a book so important that seventy years after its appearance it is still regarded as fundamental. But how few libraries own a copy of the original text and plates! Printed in only 200 copies, never sold, distributed solely by resolution of Congress, what chance has there been for the newer libraries to secure a copy for their clientèle? To be sure, not all expeditions

encounter such a series of accidents in publication as this of Wilkes—but as a class they present a most difficult problem. They are alike hard to get when issued, slow to appear, slower to be finished, costly and even (occasionally) not sold at all, but only given to a select few. Later, years later, the task is much harder. If I were given a round sum and told to get in three years all the important scientific expedition publications of the past hundred years—I should decline to promise success in that time—perhaps even in five years. But I can think of but few efforts so well worth attempting.

If expeditions present difficulties alike to the librarian and the scientist, what shall we say of international congresses? That they mark the progress of research in many lines is a truism. They are absolutely needed—but they too are very hard to get. In the first place, there is no good list of them—even the brief list issued about a year ago is most incomplete. Then, the congresses seldom have permanent offices and officers. They are held at irregular intervals, generally in a different place each time they meet. If one attend, he generally gets the proceedings. But very seldom does any library get a notice of the meeting in advance. Usually the papers and proceedings are published in the place where the congress meets—at Madrid one year, three years later at Washington or Moscow or Stockholm, or where you please. The publisher of course varies with each move of the congress. An attempt to place an order for subsequent issues usually fails of execution. Three or five years is a long time for any secretary to carry an order. So if some professor from Michigan goes to the geological congress at Brussels this summer, we *may* get on the mailing list—but otherwise we probably shan't—despite our efforts. The difficulty is vastly increased by the habit of European governments of giving subvention to private publishers to aid in printing reports of congresses instead of issuing them through the governmental printing office. So they may appear in the publisher's list as his own publications—or they may never be listed anywhere. It can not be denied that the hunting down of international congresses adds zest to the librarian's

life—but when you are held accountable by science for the results of your hunting it ceases to be sport. Then, too, local societies and savants have a pleasing habit of offering volumes *to* the congress as a sort of testimony alike of their interest and of their own activities. These are almost never to be confused with the Report of the Congress itself—except in the minds of booksellers who manage to introduce no end of confusion into orders as a consequence. You may imagine, therefore, that international congresses are a bug-bear to library folk—a sore topic. You may also imagine my own delight in securing over one hundred and fifty reports of various international congresses on my book-buying trip last fall. Few acquisitions have given me more solid satisfaction. And yet, I suppose I have simply created more trouble for myself—every department will now demand that these reports be made absolutely complete! In the language of the street, “I can see *my* finish!” Partial success always brings its own penalty.

Who originated the idea of the “Academy”? Whoever he was, whether Plato in the groves of Academe, or some Renaissance imitator, or even the gentleman who conceived the Royal Society, he let loose on mankind an institution making for publication—if we appraise it in no higher terms. And particularly in the nineteenth century did the academy flourish in print. Here again Europe has an advantage over America, and advantage more of age than of enterprise, of geographical smallness as contrasted with continental sweep and range. Most scientists in Europe have easy access to files of academic publications, files which have been slowly accumulated with the passing years. Here we have had to work hard in the past two decades to establish half a dozen centers in which fairly complete series may be found, a process still going on and proving increasingly costly each year. But we must continue and complete it. The interests of American scholarship simply require it of us. The greater academies are now well represented at Michigan, with here and there a gap, it is true, but still with full ranks for the most part. What to do about the minor academies and societies from the whole world? That is a

vexing question to which I may refer again in a few moments. I pause merely to remark that a minor academy is minor only so long as you do not want its transactions in your own work.

And last in this array of forms of scientific publication comes the largest group of all, newest and most insistently demanded, the journals. To me the rise of the special periodical devoted to the interest of a special group is one of the most significant social phenomena of the past fifty years. Let no one here think that this tendency to periodical publication is confined to science or to the more learned groups. By no means—the brick-layer, the barber, the banker, the baker, the builder, the book-binder (to keep to one letter only) all have their journals fully as much as the biologist, the botanist, the biochemist, or even the bibliographer. And they all have to be ordered, entered, paid for, cataloged, bound, and stored. Periodical publication is the one modern form for telling the world what everybody has done and what other people think about it. We take in over twenty-two hundred journals in the University Library. A goodly number—do you say? Well, it is just about half what other libraries of our size subscribe for, and about a quarter of what the Library of Congress receives each year. Perhaps the medical faculty is satisfied with its four hundred and sixty-six journals received. But I fear no other group really has enough. Certainly that great department loosely known as the social sciences does not have at hand here anything like an adequate supply. I see no end to this modern form of publication. Every quarter I read with sadly disappointed hope the record of "Births and Deaths in the Periodical World" appearing in the *Bulletin of Bibliography*. The births always outnumber the deaths and the marriages of journals. My one consolation is my firm conviction that wood-pulp paper has a very definite limit of stability. But then I reflect that some chemist is sure to discover some process of preserving this wood-pulp mass for an indefinite period. There is no way out. Journals and transactions, reviews and proceedings we have ever with us in ever increasing numbers. These the

investigator simply must have. Can he have them all at hand currently and in bound form? Obviously not, unless we multiply our library budgets about ten-fold, and our storage quarters five-fold.

This leads us very naturally to consider this problem of supplying the full record of science to our men of science. It is not a local problem merely. It is also a national problem. The difficulties in the way are partly those of finance, partly those of time, partly competition, not alone among American libraries, but with those of Japan and China, of South America and South Africa, of New Zealand and Australia. Very much of the material required by this group before me was published in but a small edition, running from a couple of hundred in the case of certain very costly books, to a thousand or more for certain journals. In their beginnings journals and transactions are frequently issued in only sufficient numbers to meet the actual number of subscribers. You all know how the wastebasket yawns for odd numbers, and what chances of destruction stray copies must run, between careless or absent-minded owners, house-maids, janitors, the frugal house-wife and the rag-man. Wars and disasters intervene to reduce the numbers of copies in existence. I have no hesitation in saying that the possibility of securing sets of certain very much valued books and journals is diminishing even to the vanishing point with each year that goes by. The world war was destructive of reserves, caused restriction in the number of copies printed, and increased enormously the cost of printed matter of all sorts. In some cases known to me no copies were printed beyond the actual home demand, totally ignoring foreign or enemy subscribers. I know of one American journal which actually printed last December one hundred and fifty copies less than its regular subscription list, because paper took a sudden jump in price and only the stock on hand was used. This sort of thing makes the task of securing sets anything but easy. The chief source of supply is the libraries of deceased professors as they come on the market—and professors who own and bind long files of journals and transactions are becoming

rarer with the high cost of living and the decreasing amount of shelf space in modern houses and apartments. The necessity of quick action can not be stressed unduly in view of the present circumstances. It is not a question any longer of waiting for a favorable opportunity. Rather are we faced with the necessity of getting what we need whenever the chance comes up. The competition from the newer countries and the newer libraries is keener every year. Thirty years ago there was no large scientific library west of us—not one. Now we may mention the Universities of Chicago, Illinois, Wisconsin, Minnesota, Iowa, Nebraska, California, Leland Stanford, Washington, and the John Crerar Library, without even exhausting the list of institutions of the first rank—for special libraries in a small field are equally dangerous competitors for the valuable books and sets in their own line. In those same thirty years South America, South Africa, Japan, Australia, and Canada have come into the field eager to provide their scientists with the record of science. McGill University bought just before me last fall very many sets of journals long on our list of desiderata. I found Japanese buyers had been everywhere with the government purse to draw on. The fact is that we must both hasten our own purchases and combine with our neighbors if American learning is to be kept on an equality with that of Europe.

The need of cooperation and of a policy looking to the elimination of certain forms of competition is brought home to me more keenly each year. We should be able, it would seem, to agree on certain fields which we can cultivate intensively, securing everything of moment in them, as far as we can raise the funds. Certain general works, general society transactions, journals of a wide appeal we must *all* have. But must we—to take a concrete case—*all* try to buy the publications of the smaller and less important societies? May not half a dozen sets spread over the country suffice with the development of the inter-library loan and of photo-duplicating machines? Can we not agree with Chicago, Urbana, Cleveland, Columbus, Pittsburgh, and Ithaca on a limit in purchasing such local society publications? Thus we might *all* save

money, keep down prices, gain in the total number of sets available, and lend freely between ourselves. This matter seems to me highly important—even vital to our success. It has been much discussed among librarians. There would be small difficulty in arriving at a policy, if it were a matter to be decided by librarians alone. But it concerns far more deeply the faculties of the various universities and their governing boards. We librarians can not, for example, get together and agree on a limitation of our several fields of specialization. We must first gain adherents to a policy of limitation, then form an agreement through some joint committee of professors, and finally secure the consent of boards of regents and trustees. The facts are most clear and patent. We simply can not all have everything. There isn't enough to go 'round, nor money enough to buy everything. What we must do, then, in common sense is to stop trying to get everything in each library, and go for the things we can reasonably expect to secure in cooperation with our neighbors. If any one doubts the success of this plan, I refer him to the results of the agreement between the Chicago libraries made in 1895 and carried out since to the lasting benefit of scholarship. There is every reason why we should enter into a similar pact with neighboring libraries.

For what is our position now? We have no near neighbors among universities. We stand half-way between Cornell and Buffalo on the east and Chicago and Northwestern on the west. Western Reserve, Ohio State and Oberlin to the south are in a manner comparable with our collections—but as yet hardly formidable rivals. There is practically nothing north of us—(Remember that I am speaking now of libraries whose chief interest is the furthering of scholarship). We have two large public libraries fairly near—Detroit and Cleveland, both owning certain valuable special collections, and both likely to specialize in technology and in the applied sciences. There are a few specialized libraries of distinction, such as that of the Western Reserve Historical Society at Cleveland, which owns what is probably the best collection on our Civil War in existence. We may safely say, then, that we have fewer neighbors on whose aid we may rely than have the eastern universities or those

in the northern Mississippi Valley. But there is no reason that I can see why we should attempt to duplicate and surpass, for example, the White Collection of Folk-lore in the Cleveland Public Library, or the Burton Collection of local history and genealogy in the Detroit Public Library. Nor should we fail to agree with the Chicago libraries and those of Ohio (and even perhaps of western New York and Ontario) as to certain fields of learning which they will leave to us, and others in which we shall not aim at more than general works. I should like to see the Association of University Professors, or some other body representing various universities, take up this problem in a practical fashion. The inter-library loan and the photostat put the resources of each library at the disposal of its neighbors. Why neglect so obvious a step as conference and agreement on subjects of specialization? But, of course, when it comes to self-denying ordinances, only the men concerned may pass them. It is not for me to say what any group of professors shall forego. It is "up to" them in the interest of science as a whole and of its progress in our land. I can merely point out one very obvious step to be taken—and perhaps push a little towards that step.

Our present situation here at Michigan is better than it was, but it is far from satisfactory. We have a goodly list, for example, of journals and society transactions—but we have far too many gaps in the sets, gaps that are very hard to fill. We have a fair lot of expedition publications—likewise badly defective. We have a few of the great monumental publications, and very incomplete sets of congresses and museum publications. I have already indicated that our collections of monographs are reasonably large. But we are distinctly worse off in the pure sciences and the applied sciences than we are in literature or American history. We are far worse off as regards economics or philosophy than in scientific fields. We have a faculty and a student body probably third in size in America. But the library ranks about eighth among universities in number of volumes. We have, therefore, very much to add before our book collections correspond to our size in students and faculties. Harvard, for instance, has more than four times as many

books as we have, Yale three times as many, and Columbia and Chicago about twice our holdings. This is a situation not to be remedied in a day—even were adequate funds in hand, as I have tried to show. All the more reason, therefore, why we should think clearly and plan wisely, and should cooperate with our neighbors.

The country as a whole is in about the same relative state as regards the record of scientific work the world over as is the University of Michigan. That is to say, by diligent effort we can find the obscure and the rare, and without too much trouble can secure the obvious and ordinary run of books. But taken as a whole, the country is decidedly worse off than most European lands. Our scientists are at a distinct disadvantage when it comes to books as compared with those of Great Britain, France or Germany, or even Italy. We can only overcome this handicap—which is very real—by the most careful bibliographic work and by lending freely.

This brings me to that aspect of our topic which was probably most in my friend's mind when he spoke so disparagingly of bibliography. Most people ignore the practical and administrative side of the bibliographer's labors. They think of him merely as one who records what other men have done and said. That he is also the gatherer of material, and to a large extent its interpreter they forget. But the major function of the scientific bibliographer is that of indexing the record of science, after he has got it together. This is a highly technical job and has been very well done in certain fields, and very poorly done in others. Perhaps medicine has the best indexes. The great catalog of the library of the Surgeon-General's Office in Washington forms one of the most remarkable pieces of index work ever attempted. The *Index Medicus* is a wonderful clue to the currently appearing work of the world of medicine. Both have proven frightfully expensive. Both are due to the energy of one man, John Shaw Billings, and the extraordinary skill and devoted patience of his associate and biographer, Fielding H. Garrison. Neither has ever paid expenses and both have had a hard struggle to survive,

despite government aid and the purse of great foundations. Even now we are threatened with a curtailment, if not the ending, of the catalog. Such books are very costly, but without them, science must perforce halt its progress.

The pure sciences have had no such American record as these two in medicine. The Royal Society's *Catalogue of Scientific Papers*, appearing years after their publication, is the most conspicuous British effort. And then, after years of incubation, came the great international undertaking known as the *International Catalog of Scientific Literature*, bearing the Royal Society's imprint and prepared by regional bureaus under an international council. This was to begin with the twentieth century and to be the final word in all branches of pure science. Now unhappily the world war has brought it to a standstill, probably to an end. But it was already breaking down of its own weight before the war. The plain speaking of the few librarians who were given any chance to be heard between 1895 and 1900 was utterly disregarded. They insisted, if I remember correctly, that without some provision for cumulation of entries at intervals of about five years the scheme would defeat its own ends. And their prophecy was amply justified before the war brought a halt to the already huge series of annual volumes. The set remains a monument to the difficulties of the task of an adequate index to the published work of scientists.

A few attempts at overcoming this difficulty by card bibliographies have been made. Of these the most conspicuous is the work of the Concilium Bibliographicum in the field of zoology, paleontology and anatomy—an undertaking which is likewise due to an American, the late H. H. Field. This is, as you doubtless know, a classified bibliography printed on cards, arranged in very minute sub-divisions of the decimal classification. When you once learn how to use it, it is most valuable. It usually takes us about a year to train a girl to file the cards, and how long it may take a zoologist or an anatomist to learn how to use them to full advantage, I can not say. This bibliography was also stopped by the war, but

will soon be resumed with money supplied by the Rockefeller Foundation. I know of no other current card subject bibliography on a similar scale.

The tendency has been, on the whole, to develop special annual reviews in rather minute sub-divisions of the general field. Of these by far the most conspicuous have been the *Jahresberichte* appearing in Germany. There was formerly no end to these special bibliographies—often accompanied by critical notes on the scope or value of the works listed. They, too, were mostly stopped or curtailed by the war, and various efforts have been made to revive them or produce new ones. You each know your own favorite bibliographical review—but do you know the difficulties under which they have labored and which are well-nigh fatal at the present day? The chaotic condition of the world from an economic or political viewpoint is well matched as regards the record of science. Publication of results is still slow and defective—indexing of publications is more so. The obligation rests on America to provide both the means of publication and the proper clue to recorded work. I can hardly stress this too strongly, as I necessarily am forced to take a broad and general view of the whole situation. If the needed indexing of scientific (and indeed all learned) literature is to be done at all—it must be financed in this country. I can think of nothing more important for the attention of the American Association for the Advancement of Science than this very problem of adequate successors to those special and general indexes which have been so useful and which are now either suspended or definitely dead.

May I, as a layman, venture a suggestion to you who are experts? I feel that most of you tend to ignore in the organization of your work of instruction any presentation of two things which help to mark a scientist of real distinction. The first of these is a knowledge of how to use to the full the various bibliographic tools provided. It seems to me that such instruction in their use is a real necessity—perhaps not for elementary classes, but certainly for any study of an advanced character.

The loss which comes from an ignorance of what has been done on any given problem is pathetic—loss of time, unnecessary labor, discouragement. It is a loss which can be avoided by very simple means. The gain which comes with full knowledge of previously published results is uncounted. It marks the successful from the halting start on any task. The complexity of the bibliographic indexing in most fields is so great that there is real need for formal instruction in handling bibliographic tools. No one of you ignores instruction in laboratory method. Should he overlook the need of instruction in bibliographic method? The second of my two marks of distinction is a broad, general view of the history, methods and scope of his subject, what in my youth the Germans used to call "Encyclopædie." Few men are willing to take the time from their own particular researches to lecture on a general introduction to their subjects. But I venture to point out that precisely such a broad, sweeping view of the whole topic is what the younger men need most. It can be given only by one whose reading has been wide, whose grasp of the whole subject is firm, whose judgment is matured, and whose experience entitles him to speak with authority. What in a master makes disciples? What qualities in some men enable them to found a real school? Is it not precisely that grasp of method, that sense of relations of parts to the whole, that historic view and that prophetic insight which comes from a deliberate attempt to survey the whole of one's subject, to weigh its importance, to contemplate not alone its past but its present and future? My suggestion is that students should not be left to pick up either bibliographic method or a general view of their subject from incidental allusion or chance comment. The need of both is too great and too serious to warrant the indifference or neglect which they now seem to encounter.

To sum up, then, this attempt at some reflection on the record of scientific inquiry, particularly as it concerns us at the present hour and in this university: We have made a fair beginning at providing our men and women with the printed record of the more immediate past. We have at least the rudiments of a

good collection of the important work of the remoter periods. We know rather precisely the direction which our efforts in buying should take, and more than a little as to the difficulties in our path. We are ready to do our part (I take it) in any cooperative scheme for furnishing to this Great Lakes region a fuller measure of books and journals. We know the imperfections of our bibliographic tools. (We have most of them in constant use!) And we stand ready to contribute in this field also our own share of cooperative labor. In other words—we know our defects and we are trying to overcome them, and all we need is time and money—and perhaps wisdom!

What of the future? What may we hope for in twenty years, supposing no great disaster checks our labors?

We may, I believe, expect to find here (available to a large region) the major academic and society publications in absolute completeness. We may further expect at least double the present amount of journals, both current numbers and bound files. We shall be part of a regional group of libraries, owning our share of the minor society publications and journals, with a fairly complete whole ready for rapid use, distributed by air-mail in response to wireless telephone requests, every few hours. It ought not to take a man here in 1930 any longer to get a book from Columbus or Chicago than it now takes him in many European libraries—that is, six to twenty-four hours. We shall have a completed printed list, kept up to date, of all the periodicals and transactions (and perhaps all the books) available both in the libraries of our region and the whole United States. (This is almost in sight now! With two hundred thousand dollars it could be done in two years' time!) We should have also a bibliographic equipment which will furnish with the minimum of effort a practically complete list of all articles and books on any topic, arranged in inverse chronological order, the latest to appear coming first. This is solely a matter of organization and money. It represents merely the marshalling of a sufficient number of trained people to supplement work already begun on methods already worked out. It means ap-

plying the method of storing linotype bars and using them as needed, for example, in the cumulation decade by decade of the Royal Society's International Catalog. This work could be organized for the future in three years and printing of the first two decades of the twentieth century finished in five or less. I am less sure that it will come than I am confident of the future provision in the way of books. But if and when the key to the record does exist, then no budding scientist may fail of confidence in his start, of the help in his labors as they go on year by year which comes from knowing what has been done and what is being done by his fellows. We shall have them ready at hand—not alone the record in print of human efforts to comprehend the universe, but also such an effective and useful key to that record that we may reverse the old saying, and affirm he who reads may run.

WM. WARNER BISHOP

MAY 26, 1922

THE DEPLETION OF SOILS BY CHEMICAL DENUDATION

THE rate of chemical denudation of soil and rock material has been of vital interest to geologists and soil scientists. The geologist has been interested in an attempt to establish a unit of time for estimating the age of the ocean, the time periods of geologic processes and incidentally the time periods of the life of man, animals and other forms of life on the globe. He has been ably assisted by hydrographers and oceanographers. The soil scientist has been interested in relation to time measurements of soil productivity and of methods to be taken to prolong the life and the endurance of the soil for the agricultural needs of the people.

Unfortunately the vast amount of information that has been collected has been based mainly upon the translocation of material in true solution, disregarding all material in colloidal solution. The results of the methods used have shown surprisingly little silica, alumina and iron lost from the soil in comparison, for instance, with the amount of potash lost. In fact, the soil scientists have assumed that the three first named elements,

which form by far the larger proportion of the soil, remain in the soil because of their slight solubility. There has been a lack of evidence of any considerable loss of these through solution.

The hydrographers have determined, from the average composition of the soluble salts carried to the sea, that SiO_2 constitutes 8.60 per cent., Al_2O_3 and Fe_2O_3 together constitute 0.64 per cent. and K_2O 2.13 per cent. This gives a ratio of one part of potash to 4.4 parts of silica, alumina and iron. As the ratio of potash to silica, alumina and iron in igneous and in shale rocks is about 1 : 25, there is an apparent selective loss of potash; that is, the loss of potash is relatively much greater than the loss of the main soil constituents. From this fact, together with the fact that plants appear to have the same selective power of absorption of potash in much greater proportion than of the original proportion of the main soil constituents, soil scientists have taken a very pessimistic view of the length of time the soil will remain fit for agricultural use.

Opinions have been advanced by some that our most productive soils will only last for one hundred and fifty years or so without replacement, because of this selective loss of plant food material due to their greater solubility and assuming further that the silica, alumina and iron are removed in very small proportions from the soil because of their relative insolubility. Such is briefly an outline of the situation up to a short time ago.

If silica, alumina and iron are removed from the soil in proportion to the loss of the so-called more soluble salts the losses could not be determined by chemical analysis any more than the removal of a cartload of soil would affect the chemical composition of the material that remains. Recent investigations of the soil colloids by this bureau suggest that this may be actually what takes place. It would appear that, in the breaking down of the silicates to a point where the potash goes into solution, silica, alumina and iron also go into solution in the same proportion as they bear to the potash content in the original material. There is, however, this very important difference which has not heretofore been recognized or properly appreciated and that is that the solution of