tary, the scientists need prestige and respect. As it is, the scientists are not in a position to lead from strength. They are not even strong enough to look after their own proper interest or to combat effectively the anti-intellectualism that is ever present. The status of science can be lowered by a single naïve scientist in spite of the unprecedented accomplishments and contributions of science. Also, the general repute of scientists can suffer from the public activity of any small group that believes that all scientists should be supported automatically, and that whatever a good scientist does is good. Scientists would be in a much stronger position if they had the respect that society generally gives to the "practical" man or even accords to the gentleman and scholar who is a judge of the finer things of life.

In many of the sciences, the Ph.D. is a vocational degree, a preliminary step in getting a job. The acquisition of the degree, however, is no light task. It takes a minimum of five years away from the education of the candidates and devotes the time to their professional training. In spite of their native intelligence, many scientists show the effects of this sacrifice and, when they wander too far from the fields they know, they get lost.

Society also suffers from its inability to utilize fully the data that are now accumulating so rapidly. Decisions on the national level frequently have to be made suddenly, and those who act on the higher levels have to take calculated risks. Practically no individual is equipped for such a task, and we have learned to substitute small groups for individuals when crucial decisions have to be made—such groups as a cabinet or general staff, or even a research team. But all too often, when fundamental theory is involved, serious gaps of information appear in the collective knowledge of the group. Sometimes the knowledge that could fill these gaps is simply lost in the vast fund of our undigested learning, sometimes it is excluded by partisan thinking or by the human desire to evade what is complicating. Whatever the cause, the effect has been an inability to focus all the relevant data on the questions that so vitally concern our national well-being. Errors of judgment, of course, are inevitable. True, we are often able to correct our past mistakes—we have a major opportunity every 4 years—and this ability may be our greatest source of strength. It may give us the adaptation that we need for survival in the world of today. All nations do not have this ability; for example, Hitler and Stalin could be removed only by death, and death does not always arrive when it can do the most good.

Today we are faced with a real struggle for existence, and it is not just a competition between individuals, but a contest between systems—between different ways of life. The fit, of course, are not those who do no wrong, but those who can learn more quickly by experience. We may take some comfort in the fact that the enemies of the free world also make errors, but they cannot correct their errors as easily as we can correct ours. Our ability to correct our mistakes gives us a very real advantage, and we would be silly to throw it away. Since we do not have our facts well enough in hand to escape even the avoidable errors, we must preserve our freedom to change our course of action—we must preserve enough freedom to give our hindsight a chance. Our chronic lack of foresight then need not be fatal.

The Use of Material*

Ralph E. Cleland

Department of Botany, Indiana University, Bloomington

LAST year *Biological Abstracts* printed references to 33,498 publications. As science has grown in extent and complexity, the volume of scientific publication has expanded to phenomenal proportions. We scientists are busy men, and when we are confronted with the flood of journals pouring into our libraries, journals containing hundreds of articles that we should read to keep abreast of our fields, we are sometimes tempted to throw up our hands in despair and give up the one-sided fight—the fight to add our own share to the flood. Whatever we do, it is a safe bet that none of us read all the papers we should read or even all the papers that their authors hoped we would read.

Now it is obvious that this deluge of literature is not presented to the scientific public without a purpose. The purpose, of course, is a mixed one. The ego is inflated when one sees one's self in print. Besides, one gains scientific standing by means of published contributions, to say nothing of promotion in academic rank when the number of titles becomes sufficiently multiplied. On the other hand, there is an altruistic motive behind all of this publication. Scientists as a group do not attempt to gain financially by control of their product. For the most part they tend to present their findings to their colleagues as a gift, and scientific writing is their medium for making this gift available. The purpose of scientific communication is therefore a compound of the desire to get ahead and the desire to make a contribution to the progress of science and civilization.

* Read at a symposium, The Communication of Research Results, at the annual meeting of the American Institute of Biological Sciences, Gainesville, Florida, 7 Sept. 1954.

Whatever the objective, however, it is clear that this goal will not be achieved if the published material is not read.

All of us have two major needs to be satisfied when we go to the literature. On the one hand, there is a relatively small number of papers that we must read in their entirety because of their importance in connection with our own research or teaching. On the other hand, there is a large number of papers, in our general field or in fields that are important to us in one way or another, with which we should become familiar in order to be aware of what is going on. We cannot possibly find the time to read all these papers carefully and thoroughly, nor are we sufficiently concerned or conversant with the work to require such detailed scrutiny. What we desire from them is their general conclusions, and we need to have them presented in such a way as to give a brief informative summary of the reasoning and findings. We therefore want two rather distinct things from the literature: (i) detailed evidence from a relatively few papers, and (ii) general summaries of a much larger group of publications.

To take care of these needs, the best method so far devised has been to publish most papers *in extenso,* thus providing for the needs of the specialist; and to include in each paper a summary which those less immediately concerned with the research can read. This is a very costly process, and it may be questioned whether it is the most efficient and practical system that could be devised. Take, for example, the case of a biological society that publishes annually a journal of 1000 pages, comprising some 100 separate articles. At $20 per page, a 10-page article costs $200 to publish. But this article is read in its entirety by perhaps not more than a score of persons. The society is spending $10 for every reader who reads this particular article from beginning to end. Multiply this by the number of articles published and ask yourself whether the results justify the expenditure.

The question I raise is this: Should an article that is read in its entirety by only a few persons be published as though it were to be thoroughly perused by many? Why give a circulation of 2000 to 3000 to an article that will be critically examined by only 20—or even by 100?

I wonder whether the time has not come for us to apply ourselves to the development of a more economical and practical system, one that will give the specialist access to the detailed information which he needs and at the same time relieve the individual scientist of the cost of publishing *in extenso* a multitude of papers that are of little or no interest to him.

In order to insure that our papers will be read by those who should read them, most of us in biology follow a practice of exchanging reprints on a rather extensive scale. In this way, in exchange for our own publications, we receive many or most of the articles of primary concern to us. Suppose a journal, instead of going through the costly process of publishing our papers in their entirety, required us to prepare for each paper a condensed version, omitting detailed data and documentation, and would accept for publication in the journal only this version, at the same time providing some other mechanism by which the full paper would be made available to those to whom we would ordinarily send reprints. Thus, we would depend upon some substitute for reprint distribution to get the fully documented paper into the hands of those who needed it, and the journal would be relieved of the necessity of printing the whole paper for the benefit of a relatively few persons. Is it possible to visualize a process by which this could be accomplished?

Two programs now in operation will illustrate the type of arrangement that I have in mind. First, there is the American Documentation Institute, which will prepare microfilm editions of full-length papers, shorter editions of which can then be published in journal form. Perhaps the facilities of the institute could be expanded in cooperation with the various journals, and perhaps a pattern could be developed whereby these journals published only condensed versions of papers, the full-length editions being available to all interested persons at minimum prices on microfilm. A second plan of this sort is also in operation, but at present it is limited to doctoral dissertations. University Microfilms, Inc., of Ann Arbor, Mich., now cooperates with a large number of the leading graduate schools of the country. The first copy of each thesis is sent to University Microfilms for microfilming. An abstract of the thesis accompanies the manuscript, and this is published in the journal *Dissertation Abstracts.* At the end of each abstract the price of a microfilm copy of the full dissertation is given.

A third possibility would be to effect a comparable arrangement using microcards. I, personally, would like to see microcards used rather than microfilm since they are easier to read, one can move from one page to another more readily, and cards are much easier to file than microfilm. With few exceptions, journal articles could be included on a single microcard, which can accommodate almost 50 pages. Even at 20 ct per card (and the price could be brought down if the scheme became widely adopted), it is probable that it would cost the average productive worker no more to buy microcard editions of the papers he wished to receive than to buy and distribute reprints of his own papers in the hope of receiving these papers in exchange. For example, I recently paid $35 for 400 reprints of a 15-page article. To this must be added the cost of mailing, an estimated $15. For this total of $50, I could buy, at 20 ct per card, 250 articles by other authors.

I have published about 50 scientific articles over the years. At present printing prices it would have cost me at least an average of $50 apiece to buy and distribute reprints of these articles. For this amount I could have bought 12,500 papers by other authors on microcards. My total reprint collection now includes about 14,000 items of which at least 2000 or 3000 are papers that I would not have bought and for which I

will probably never have use. Thus, I would be at least as well off financially today if I had bought reprints of other authors on microcard and had sent out no reprints. And I would be far better off insofar as shelf space is concerned.

The essence of these suggestions, then, is that journals cease to publish papers *in extenso,* and publish only digests of articles. The page limit would be reduced from 10 or 20 pages to one or two pages. At the same time, by cooperation with an organization prepared to manufacture microfilm or microcard editions, full-length editions of the papers would be available to those who wished them. Presumably, journals would still be willing to print longer papers if the authors were willing to pay the excess cost. In many cases, on the other hand, authors would probably find that they could say all they wanted to say within the reduced page limit, thus avoiding the necessity of writing two papers—a long and a short edition. The art of brevity would thus be cultivated more assiduously.

A plan of this sort would transfer from the author to the recipient the cost of placing fully documented and authenticated articles in the hands of experts. This is perhaps the fairer and more efficient way of handling the matter. A person would then buy what he needed instead of making gifts of his own publications and hoping that he would get what he needed from others as gifts in return. Furthermore, he would accumulate a library of papers wholly of his own choosing, instead of a library chosen for him by those who decided to favor him with gifts. I am sure that his library of articles would be considerably smaller than it now is; but it would be better chosen, it would include just what he wanted to have, and it would omit what he had no use for. An additional advantage to the investigator would lie in the space saved. This would be especially true if microcards were used. These would be filed in ordinary card files and would take less than 5 percent of the space that printed reprints of the same articles would occupy.

The reader's needs are not wholly met, however, when he has at his disposal journals containing digests of longer papers, with the longer papers available on microfilm or microcard. Often he runs across a reference to an article that may be important or not—he has no way of determining until he has seen it. Furthermore, he wishes to see the article at once and not wait for several days until he can get it on card or film. He needs what the university library now gives him—a rather complete coverage of the articles *in extenso*. Even this can be achieved with the proposed system. A journal which published only digests should be able to reduce its subscription price to libraries to such an extent that university and college libraries would be able to subscribe to the microfilm or microcard edition of the journal as well as to the journal itself. Thus the investigator could consult articles on card or film in the library, and if he later wished to purchase copies could do so.

This suggestion envisages the continued independent existence of the various journals and society organs. It might be fruitful, however, to look ahead a little farther into the future and visualize a possible additional step.

Most of our journals are issued by a small group of men, often only one or two, who are not trained journalists, who do the job on the side, often without compensation, on top of a full professional program. They are not particularly expert at the job and by the time they gain some competence as editors or business managers they resign and turn the work over to other novices. Under the circumstances the operation cannot be fully efficient. It is bound to be costly in time, energy, and money.

In contrast, the average newspaper is a vastly more efficient organization. For example, a weekday copy of the *New York Times* selected at random contained 141.2 columns of printed material, excluding advertising and illustrations. This material averaged 960 words per column, or about 135,834 words of news material. This is about twice as many words as would be published by the *American Journal of Botany* in an entire year if it published only digests. Yet this amount of material is written, assembled, edited, printed, and distributed every day, and much of it in a single day's time. Obviously the editorial and manufacturing staffs are huge, but the costs per word printed are low in comparison with what it costs to put out a scientific journal.

I have wondered whether we might look forward to the time when most of the biological journals in this country would join forces and go together to put out a single journal, which might take on something of the format of a tabloid newspaper or the magazine section of the Sunday *New York Times*. It would appear weekly and would be departmentalized, in a manner similar to *Biological Abstracts*. Each department could be under the editorial supervision of the society or organization now producing the journal in that field. Selection and review of articles would be under the direction of these editors. The journal would accept digests rather than extended articles and would provide microfilm or microcard editions of all papers for purchase by individuals and libraries. It would contain, in addition to these digests, editorials, symposiums, news items, letters and discussion, book reviews, and advertising. Individuals could build reprint files either by clipping articles and pasting them on standard size sheets, or by purchasing microfilms or microcards. It would no longer be necessary or possible for authors to buy reprints. The journal would presumably be printed on ordinary newspaper stock, and half tones would be handled as they are in newspapers—they would be adequate but not of deluxe quality.

The advantages of such an arrangement would be speed and economy. Speed would be achieved by the adoption of newspaper manufacturing techniques. For instance, such a journal could be printed on rotary presses that would cut the time of actual printing to about 10 percent of the time necessary when flat

presses are used. Economy would result from utilizing newspaper techniques and also from increased advertising appeal. If subscriptions were permitted only to the journal as a whole, and not to individual sections, advertising appeal would be increased to a maximum; the amount of advertising should then be such as to make possible a substantial reduction of subscription rates to individuals.

If such an arrangement could be made, one American biological journal would take the place of several now issued. Society dues could be reduced, for a large share of the dues of many societies goes to the support of their journals. Thus the average biologist would be able to afford a subscription to the combined journal and at the same time he would be able to buy microcard or microfilm copies of all the extended papers he wished to have.

I have tried to do a little guessing about probable costs. My guesses are probably inaccurate, but perhaps they are roughly approximate to the truth and will suggest the desirability of further study. I have based these estimates on an article in *Editor and Publisher* for 17 April 1954, entitled "50,000 circulation daily." At intervals this journal reports on income and expenditures of a typical but unidentified newspaper. The particular newspaper treated in this article last year had a circulation of about 50,000, an income of $2,657,468 and expenditures of $2,265,135. Two items of expenditure would not apply to a scientific journal —taxes and the cost of gathering material. Most material would not have to be solicited by a scientific journal. The cost of subscribing to the various news services, which is a major expense for newspapers, would be eliminated, and substituted for it would be the relatively minor cost of sending manuscripts through the reviewing process.

The newspaper referred to in this article issued 307 numbers during the year, containing 706,887 column inches of editorial matter averaging about 50 words/in., or about 35,344,000 words. This is more than 500 times as many would be published by the *American Journal of Botany* in a year's time if it printed only digests. It would be 50 times as much as would be printed in the combined scientific periodical which I have visualized if 10 journals the size of the *American Journal of Botany* went together to form it. Let us assume, to be very conservative, that it would cost twice as much per word to publish a journal with one-fiftieth the content of this daily newspaper as it does to publish the newspaper itself. This would mean roughly an annual expenditure of about $100,000 per year. Assuming a combined circulation of 30,000, this would mean a cost per subscriber of between $3 and $4 a year. If circulation were only half that, or 15,000, the cost would be between $6 and $8. When one considers the return from advertisements, and the fact that libraries can be charged more than individuals, the subscription price to the individual could probably be kept as low as $3 to $5 per year even if the circulation were not more than 15,000. For this, the individual would receive the equivalent of a subscription to 10 journals, which at present would cost him 10 times as much.

Although these figures may not be wholly accurate, I believe that the general order of magnitude is essentially correct and that biologists would be far better off financially under such a system of joint publication. It is probable, of course, that the quality of printing and especially of half tones would not be the equal of that in the best scientific journals at present. I believe, however, that they would be adequate for all but the most critical cases, and there would probably still be some journals that could handle papers requiring special treatment. It might not be impossible for the combined journal, at the author's expense, to provide illustrations on special paper by special methods; or illustrations could be segregated into a special section comparable to a rotogravure section.

What I have said does not take into consideration the probable economies that will be brought about when newer photoengraving and electronic techniques begin to supplant letter-press methods. These newer techniques may help materially to solve the cost problem. I do not think, however, that we will solve the problem of rapidity of publication until the various journals consolidate in such a way that copy-editing and manufacturing functions are in the hands of full-time skilled experts—and the nearer we can come to adopting the streamlined manufacturing methods of the average newspaper, the better off we will be.

But all of this looks into the future—I hope that, with the aid of the American Institute of Biological Sciences, it may not be the too distant future. In the meantime we have the immediate problem of presenting our material in such a way that it will be read. As the reprints and journals pour in, most of us glance through them. Many of those which are short and succinct we read at once. Others which are longer have good, informative summaries, and we read these. Still others have no summaries, or their summaries tell little or nothing about the findings and conclusions, merely indicating the problems attacked and the questions considered. These we set aside for a period of leisure that often never comes, and finally many of them get buried, unread, in the reprint file. Still another category, surprisingly common, includes the papers that are so obscurely and ambiguously written that one cannot just sit down and read them through, but one has to study and analyze them to find out what the author means to say. Some of the most prominent biologists are among the worst offenders in this respect. I am told that one prominent biologist goes off to the country over the week end and comes back on Monday with a new paper ready to be typed. The result is an obscurely and illogically written paper that can be understood only by the expenditure of much precious time by even the expert reader. I believe that the practice followed by some authors might well be adopted by all. This is to salt a manuscript away when it is finished and forget about it for a month or two, then pull it out when the details of expression have been forgotten and read it over.

One comes at it in this way in very much the same position as the person reading it for the first time. As a result the ambiguities, the omission of logical steps, the redundancies, are likely to be caught.

The most important points to consider, then, in preparing a paper so that it will be read are (i) to make it as brief as posible; (ii) not to be too hasty in sending it away, but to set it aside for a time before making the final revision; and (iii) to include an informative summary or abstract that succinctly outlines the major findings and conclusions. I believe that even a short paper should include such a summary; in fact, I believe that all editors should require summaries for all papers that exceed a page or two in length.

The late C. R. Stockard used to classify people into what he called "linears" and "laterals." Linears had as one of their traits a tendency to be conscious of the impression they were making when speaking or writing—they were conscious of listener or reader reaction. The laterals tended to be too much wrapped up in themselves and their ideas to think much about how others were reacting toward their speeches or writings. The plight of the scientific reader, and that includes all of us, would be much improved if more authors were more conscious of their readers when they put their thoughts on paper—logical sequence, clarity, and brevity would become more characteristic of our literary efforts if we had more ability to look at what we have written from the standpoint of the person reading the material for the first time.

Human nature being what it is, however, perhaps we will not reach the point where the needs of the reader are fully met until we devise some system for the publication of shortened forms of scientific articles supplemented by devices for making full length publications available to those who need them. Possibly the suggestions that I have offered, while too radical in the eyes of many, will start some individuals with more fertile imaginations and more technical knowledge than I possess to thinking and planning, and maybe we will in time achieve a world which will be at least as much a reader's as a writer's world.

Papers of Wilbur and Orville Wright

Nicholas J. Hoff

Department of Aeronautical Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn, New York

FEW, if any, technical developments have brought about changes in transportation, commerce, international relations, and warfare to the same extent as the airplane. Since the greatest contribution to this development was made by Wilbur and Orville Wright, a detailed account of their lives, work, and thoughts is of immediate interest to every educated man. The story of the Wrights has been presented in two volumes under the title *The Papers of Wilbur and Orville Wright.** The particular attraction of this presentation is that the story is told by the Wrights and by their friends and business acquaintances in their own words; almost the entire book is a verbatim reproduction of correspondence and of diary entries in chronological order. Even though the papers are full of technical detail, the human story emerges from them in a dramatic manner.

In the late 1890's two young men became interested in the possibility of human flight. Fortunately, their business, a bicycle shop in Dayton, Ohio, provided them with a long slack season beginning in September and allowed them to devote a good deal of their time to developmental work on airplanes without undue financial loss. At the very outset, in 1899, they invented the device of warping the wings for control about the longitudinal axis of the airplane; this became the foundation of their later patent claims. In the spring of 1900, Wilbur Wright approached Octave Chanute, 35 years his senior, a successful civil engineer and businessman as well as author of the famous book on aviation, *Progress in Flying Machines.* His letter began with these words:

> For some years I have been afflicted with the belief that flight is possible to man. My disease has increased in severity and I feel that it will soon cost me an increased amount of money if not my life.

This was the beginning of a long friendship in the course of which many problems of aerodynamic lift and drag, wind-tunnel measurement, airplane stability, glider design, performance calculation, and the like, were discussed in a correspondence that takes up the greater portion of the first volume.

As is shown by the letters, the Wright brothers attacked the problem of flight in a systematic manner. They started by reading all the relevant literature, continued by constructing and flying model airplanes, and proceeded to gliding and soaring. At Kitty Hawk, North Carolina, chosen for its soft sands and steady winds after a careful survey of the reports of the U.S. Weather Bureau, they were disappointed in the performance of their first glider in 1900. To discover the reasons for the discrepancy between expected lifting power and that realized, they constructed, after their return to Dayton, a wind tunnel

* *The Papers of Wilbur and Orville Wright.* Including the Chanute-Wright letters. 2 vols. Marvin W. McFarland, Ed. McGraw-Hill, New York–London, 1953. 1278 pp. $25.