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CONSERVING OUR HARVESTS[1]

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THREE and a half centuries ago Francis Bacon said "I take all knowledge to be my sphere." Though competent scholars state that Bacon was far from having full knowledge of the science of his day, his aspiration was not ridiculous or even particularly remarkable in his time, and had he given to science half the time he devoted to statecraft he might well have mastered all the science that was then known. An Italian contemporary of Bacon, Giambattista della Porta, made studies which are still mentioned in histories of optics, included in his extensive "Magia Naturalis," a chapter on producing new plants—probably the first organized article on plant breeding—wrote a work on plant signatures and in modern literary histories he is discussed as the leader of the notable group of writers of Italian comedies in a period when Italian comedy was the most notable literary movement in the world. A century later the best-known English writer on gardening, John Evelyn, by whom greenhouse heating was considerably advanced and gardening made respectable, was only a part-time horticulturist; he was also an authority on some of the fine arts and rather constantly engaged with public affairs. Most of the German pomologists of the early nineteenth century made their extensive varietal studies and wrote their monumental works in time spared from their labors as pastors or teachers. When our own agricultural colleges and experiment stations were organized, nearly two centuries after Evelyn, full-time horticulturists were rare in their

[1] Address of the president of the American Society for Horticultural Science, Dallas, Texas, December 30, 1941.

staffs; most of the pioneer teachers and investigators not only worked on the various phases of horticulture, but also served either as botanists, entomologists or pathologists and sometimes as foresters and superintendents of grounds. Many horticulturists now in active service have taught or investigated pomology, olericulture, greenhouse construction, floriculture, plant breeding and landscape gardening. They have in numerous cases seen one-man departments grow into sectionalized departments, with staffs of 20 to 30 men.

The two needs most conspicuous when this expansion began, research and extension, have received most attention, with results that are most gratifying. The successive volumes of *Proceedings* of this society provide a graphic presentation of cumulative increase in horticultural research. If all vehicles of publication of horticultural investigation were considered, the equation representing the increase might approach that of accelerated motion. Increase in horticultural research is not confined to the United States. Many other nations have research stations doing work of a high order, most of them comparatively new. As an example, it may be noted that pollination studies on the Bartlett pear have been reported in Australia, Canada, South Africa, Switzerland, Germany, England, the Scandinavian countries, the United States and possibly other countries. There need be no concern about quantity.

The *Proceedings* of this society also illustrate very well a great improvement in the quality of the work done; the increasingly frequent appearance of articles by horticulturists in the journals of the pure sciences furnishes additional evidence of the quality of the research done in horticultural departments and, conversely, physiologists and anatomists are increasingly utilizing horticultural material in their own research. It is true that improvement in quality is still needed, here and there, but the best promise of that improvement is the self-examining attitude of research workers, and their concern for the quality of their work. Some improvement in choice of problems, more concerted attack from various angles, are needed, but these concern direction of research primarily, rather than its excellence.

On the whole, then, our research work is sound and with proper support can be relied on to continue in that condition, so far as present signs are indicative.

The very productiveness of research and its advanced nature have, however, created a new problem, rapidly becoming acute, through the inadequacy of the existing mechanism to the task of digesting and assimilating research results, incorporating them into the existing body of information, with such modifications of this body as they may necessitate, to the end that the whole body of information is always complete and always ready for use. Thirty years or so ago, this problem was much less pressing. There is abundant evidence that the horticultural teaching of that period was far from utilizing all the information then in existence, largely because it was not in readily available form, and the horticultural teacher of those days had too many subjects to cover to permit him to develop any subject thoroughly by library research. In spite of this failure to utilize existing information already stored on library shelves, the horticultural investigator and teacher had no great difficulty in keeping abreast of current investigations on horticultural crops. The first comprehensive American experiments on orchard fertilization and orchard management were just approaching publication; spraying employed only three or four standard materials; the first serious studies on storage were still new. Most of the experiment station work was published in bulletins and these were so few that each one was studied and discussed by all horticultural investigators and teachers. The average investigator of that period worked on projects covering nearly the whole range of horticulture and could keep abreast of current literature on all of them without losing much sleep. A volume of the size of any of our *Proceedings* would contain all the horticultural research published in several years in the earlier period.

Thus little more than thirty years of horticultural research and teaching have developed a stage of specialization so advanced that in the institutions with the larger staffs each member, it has been said, continually knows more and more about less and less. Sheer abundance of information is increasingly circumscribing the field in which each man can keep thoroughly or even well informed. In many fields the investigator could spend so much of his time reading pertinent literature that he would have scant time for research of his own. It is doubtful whether any student of hormones could read all the papers on hormones that have been printed in the last ten—or even five—years and still do research. The student who would read all current literature on citrus fruits in the original papers would need command of at least English, French, German, Spanish, Portuguese, Italian, Russian, Dutch and Japanese. If the literature on limited fields taxes or exceeds the time and energy of the specialist in those particular fields, it is manifest that he must fail to keep well acquainted with related fields and his reference to them throughout his working life is in many cases based on what he learned in college.

Changes in the techniques of investigation have been even greater than those in quantity. Chemical methods, plant physiological techniques, virtually un-

known in horticultural investigation 35 years ago, have become common. Statistical analysis was then new in the biological sciences, and no horticultural research had been placed under its scrutiny. Genetics was a new term. Little was known about plant viruses. Each of these techniques is ever progressing, each has its own growing literature. Thus modernization of implementation requires that the investigator be constantly alert; this in itself is a considerable task. The increasing requirements of attention to methodology inevitably limit the time available for thoughtful study of literature of those phases of horticulture that do not occupy the investigator at the moment. Little by little each of us has been forced to neglect readings we should accomplish. No other course is open. That we may retain even approximately complete command of some subjects, we must leave others rather largely in status quo, and before long our occasional dealings with them are made with incomplete knowledge.

Wisdom is not a new invention. If research is sound its value is not ephemeral. None the less the very machine that was created to produce facts is by its own exacting requirements and its productivity burying facts under other facts unless they have an immediate cash value. It would be very comforting could we believe that some vaguely defined buoyancy kept everything valuable afloat on the surface while the trivia were engulfed; unfortunately this is not the case. Discoveries of great value have been ignored because their importance seemed small at the moment of their enunciation. When Nicholas Longworth induced the son of a Cincinnati market gardener to reveal the secret of securing crops from pistillate strawberries, the use of pollenizers quickly became general and was not forgotten, because pistillate varieties were being grown commercially. This "secret" had, however, been published in England in 1815 and in France nearly 50 years earlier than that and had been forgotten because it had no important immediate application. These reports were not in obscure journals; one had been published in the Transactions of the Royal Society; the other in a standard book. Mere publication evidently is not enough to insure continued recognition.

We who are here present will collectively hear literally hundreds of papers at this session; these will be neatly printed and the collection will take its place on library shelves, alongside thirty-odd similar volumes. But this is not the end. Research will not die with the closing of this session. Another volume will be added next year and the next and so on. The students who come into the field in 1951 will be so busy reading the new volumes that few of them will ever get back along the shelf to the 1941 volume unless specific reference sends them to it. Thus the study that can not at once be tied to something useful can become buried in 1941 as in 1760. If this material is worth the time, effort and resources that have gone into its preparation and publication, it is worth the additional effort that will be necessary to keep it accessible.

This confusion—if not chaos—into which we are proceeding at a rapid rate is due to our failure to recognize our increase in wealth. We are still using the machinery and methods that were reasonably adequate 40 to 50 years ago, unconscious that we have outgrown them.

Specialization has beyond question been productive of good results, but doubt may well be raised as to whether, in its present form, it can continue to function smoothly when the influence now exerted by the older men with broad experience is no longer felt. Already there are disturbing signs. Sometimes recommendations are made to alleviate one difficulty, without due consideration of all the effects of these recommendations, simply because the other effects lie beyond the specialist's purview. When staffs are composed entirely of specialists the lack of integration is likely to become acute. On the other hand, wide areas, thousands of farmers, still take their immediate guidance from horticultural staffs so small that one man may be their reliance in a wide diversity of subjects as, conceivably, rootstocks, winter injury, boron deficiency and fruit storage. A position with this responsibility needs a more capable man than is required for any single position in a large staff. Usually a man in this situation has the most meager library facilities and the greatest imperative demand on his time. It is not surprising, therefore, that in occasional cases a practical grower has quoted published research of which the investigator had not heard.

This condition has developed, obviously, through nobody's intent and many are still unaware of its existence. The investigator naturally does not advertise his failures to keep fully abreast of the times. The administrative official can not know many fields as well as the specialists in those fields know them, and as long as their work is good he must assume that it could not be better. If he has suspicion that some phases are being neglected his usual remedy is to hire another investigator.

Responsibility for this situation rests basically even more on the colleges of agriculture than it does on the experiment stations. They have followed the pure sciences in exalting the investigator and ignoring the scholar. The whole structure of the requirement for the advanced degrees—particularly the doctorate—in agricultural subjects as in pure sciences reflects this with the greatest clarity. In the days when advanced

degrees were first awarded, the literature of science was so comparatively limited that mastery of it was easily attained by the candidate and his thesis was required to demonstrate his ability to conduct independent research. Thus, the early doctors of philosophy could legitimately claim to be scholars and investigators. For some time it has been apparent that doctorates are being awarded to men who do not know thoroughly the literature of even their own science beyond the field of their theses, but no official recognition has been made of the polite anachronism involved in welcoming doctors of philosophy into fellowship of scholars. Despite the great change in lines of work followed by graduates of agricultural colleges, despite their influx into industries connected with agriculture, the graduate student who wishes a degree, whatever his purpose, must still demonstrate his ability to conduct independent research. A teacher in a Smith-Hughes agricultural high school who wishes to supplement the studies covered in his undergraduate curriculum may need advanced courses in many branches of agriculture, but if he wishes the master's degree as a token of extra study beyond the baccalaureate degree he must abandon thought of advanced courses in various agricultural subjects, concentrate on one and demonstrate through a thesis that he can conduct investigation. When he has done this, he may secure an increase in the stipend he is paid for teaching. A youth contemplating a career in industries related to agriculture is likely to secure better preparation for this career by taking the bachelor's degree in two institutions than he will by taking graduate work. Many respectable institutions are now conferring the master's degree for advanced course work, but agricultural colleges rather uniformly seem to be content to pour all their material into the old moulds. Agricultural study was once hailed as an escape from the rigid requirements of the old classical curriculum; with age it seems to become rigid in its own way.

Every institution which awards the doctorate in literature and in history grants it for work which in the scientific field would be called discussion of the literature. There is no question of the value of this kind of work or of its repetition; the factual records of history may not change, but their interpretation changes with every generation. Only in pure science and in agriculture is this type of study without formal recognition. Official agriculture, whose every effort is sincerely in the direction of making the world's knowledge available to the humblest farmer, expends great effort on research and in extension but assumes that systematization of information is an autocatalytic reaction.

Were the effects of this present traditional grooving confined to the misfortunes of the individual students who do not fit into it, they would be deplorable enough. Actually they reach much farther and affect us all. The standard requirement for the advanced degree exalts research work and inevitably establishes some unfortunate implications of relative values of different legs of the table. This notion is all too common. Naturally it leads to differences in preferment. Extension men have their methods of securing reward, often through "pressure groups," and administrative officials appear to secure a glow of mellow feeling from rewarding the work of the successful research man, who, presumably, exerts no pressure. When these groups are cared for, if there is any balance, part of it is given to the teachers—unless the campus needs new sidewalks. Scholarship fares better in the humanities than it does in the sciences—or in agriculture.

Thus the cycle is maintained. The horticulturist soon becomes aware of the directions in which lies preferment and he "builds his fences out in the state" or he pushes his research—in any case he neglects his teaching in greater or lesser degree. The bright ambitious young man seeks ardently for full-time research or goes into extension, and the passing of time finds considerable numbers of men doing teaching because they were complacent and lacked aggressiveness, rather than through any special aptitude. Teaching done by the research man is all too frequently very minute, detailed and exact in the portion of the course that pertains to his particular field of research and very shabby in the other portions. Sometimes two thirds of the student's time in the course is given to the teacher's research field and the remaining third to the rest of the subject. This is an easy way of discharging an unwelcome task.

Unfortunately a teacher's success can not be measured accurately until the students he had in his middle age have themselves become middle-aged. Administrative officials have some real difficulty in this appraisal, for they can not widely rely very much on student opinion. They could, however, assure themselves that the candidate teacher is a scholar through the guarantee of his mastery of the literature of his subject that is implied in a degree awarded for scholarship, far better than by his standing as an investigator of a limited portion of the subject he teaches. Attainment of a degree awarded for scholarly mastery of a subject, without reference to research proficiency, should be the preferred standard for selection of teaching personnel. Were all agricultural students prospective investigators, the present arrangement would be satisfactory; they are not, and it is not.

Scholarly systematization of knowledge and its

publication could well form a part of the program of every institution. Publication of such works should not drain seriously the publication funds, for if proper standards are maintained, contributions of this sort will be far less numerous than the research papers. Publication of critical literature reviews would have several beneficial effects; it would make readily accessible in a few minutes information whose gathering and collation required months and years; it would grant recognition to those who perform these labors and it would invite appraisal of the quality of their work, as do the papers written by investigators. Unwisely executed, this effort would be perilous for it could become misleading. High standards should be exacted and consultation with many specialists would be necessary; the work should be critical review and not unquestioning compilation.

The influence exerted by men whose chief responsibility and greatest distinction lay in providing complete, digested and evaluated information would be felt in many directions. It would constitute a strong force in a direction needed now more than ever, namely, coordination of research. It would relieve investigators of much of the labor of searching through great masses of reading to glean a small grist of pertinent matter, though it should not relieve them of responsibility for study of this modicum. More than one productive new line of investigation has been suggested only after assembly and review of all the available pertinent facts. With specialization becoming more advanced, men of this somewhat more general training could be of great value to administration of horticultural organizations.

Investigators are relying increasingly on abstract journals to bring their general information down to date. Therefore it is most humiliating to be forced to acknowledge that lack of support is making abstract journals increasingly inadequate. To secure reasonably complete coverage of horticultural literature, its student must resort to foreign abstract journals, admirably conducted, but still abstracted abroad and principally for use abroad. As a rule, abstracting done abroad is a paid service; in the United States it is almost entirely voluntary. This may have some influence on the results, but much more inhibitory on the usefulness of our abstract journals is the limit placed by lack of funds on the space that can be allotted to any subject. This situation could doubtless be remedied by proper presentation of the value of the service and of its present inadequate coverage. It is possible, too, that abstract journals could increase their usefulness and their revenues by adopting a format lending itself to printing and sale of reprint separates that could be distributed readily into various files.

Though improvement of our abstract journals is very important and should be pushed energetically, principally by better support, these journals can not, however well conducted and however voluminous, be more than an adjunct in keeping our information continuously organized. Let any one who doubts this statement drop all pertinent notes on any one subject into a file for ten or even five years, and then try to comprehend the mass in time to answer a telephone call. Librarians' lists of titles give only a start in this direction, for titles are often misleading as to content. Sporadic literature reviews introducing reports of investigation are increasingly inadequate, for they properly ignore material not relevant to the investigation and they do not constitute a uniform progression covering a whole field. Whatever devices may be tried, there is no escaping the need of men trained in horticultural scholarship. These men should know the art of horticulture and know the supporting sciences; their linguistic attainments should be extensive; their geographic and historical knowledge should be adequate to permit evaluation of any piece of research in relation to its background; they should be proficient in finding, collating, organizing and presenting information. They should find their chief delight in doing work of this nature. They must be able to consult freely with appropriate specialists for critical evaluation of research reports. This is, to be sure, almost the identical set of specifications that should be used in developing a good teacher. It involves far more, however, than it did a few years ago in preparation, attainments and experience and it deviates rather considerably from the work reasonably expected of an investigator. That it is not often realized at present is due to our persistent effort to make teachers out of men trained to be investigators. Work of this sort needs, therefore, official recognition as a definite career, honored equally with cognate lines of effort, with a definite line of approach, a definite outlet for its products, definite allowance of time and resources for its pursuit and definite reward for excellence in attainment. The man thus trained and thus employed could well become more than a specialist engaged to cure the effects of specialization; he is the most likely of all to develop into the architect who builds structures from materials made by many men. Let us remember that Darwin accomplished as much or more by putting together scattered bits of information brought forth by others than he did by his own personal investigations.