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THE GOLDEN AGE OF BOTANY[1]

By Dr. EDGAR N. TRANSEAU

THE OHIO STATE UNIVERSITY

THOSE of us who were so fortunate as to enter the field of botany about the beginning of the century have witnessed the period of its greatest growth and differentiation. In no other country and at no other time have there been so many undergraduate students of botany, so many graduate students and so many botanists employed in educational and research institutions. We vividly recall that this 40-year period began just after the Spanish-American war when America took over the Philippine Islands. We have likewise had a part in all the educational phenomena before, during and after the first World War. The period closes as World War II is thrust upon us.

This time the war is not "to make the world safe for democracy," but to keep democracy from being crushed against the wall at its back. After the first world war came the collapse of European credits and subsequently a variety of social revolutions that have ended in ruthless dictatorships. The state-supported Continental universities were first impoverished, then regulated and finally regimented or liquidated. Because of declining financial aid, teaching and research in botany have been possible only to men of independent means, and in many of the Continental

[1] Address of the retiring president of the Botanical Society of America, delivered at Dallas, Texas, on December 29, 1941.

universities both these pursuits seem to have almost disappeared.

In post-war America, war inflation and war profiteering brought immediate hardships to college teachers during the early twenties. The late twenties brought a period of illusory expansion and easy money. Wild mergers and speculation failed to produce the then promised "new era." Rather it culminated in the bank holiday and the long depression of the thirties.

During this interval shrinkage of endowments and reduction of direct contributions threatened the very existence of many colleges and curtailed the programs of most institutions. In certain colleges only the devotion of the instructors and their willingness to continue on a subsistence basis prevented the closing of college doors. Even to-day these colleges have not fully recovered.

To relieve the widespread unemployment and the sorry plight of agriculture our national government then instituted a far-reaching program of social and economic experiments with the definite objective of increasing the purchasing power of the lower income groups. These included: Old age pensions; unemployment insurance; flood control measures; CCC camps; construction of rural subsistence communities; pegging the prices of farm products; farm loans; resettlement of farmers; forest and soil conservation; community planning, and game management. These projects have affected every rural and urban community, and the supervision of them has provided an ever-increasing number of jobs for engineers, agricultural and economic experts, foresters, zoologists and botanists. These projects have been financed in part through large internal loans.

Long before we have had an opportunity to evaluate the results and consequences of these experiments we have been plunged into World War II and we have determined to free the world of Hitlerism at any cost. In the last conflict we spent the equivalent of the present valuation of all taxable property in the United States west of the Mississippi River. Federal expenditures for the year just closing are not less than this sum, and the estimates for 1942 are more than twice this amount. The necessity for these military expenditures can not be questioned, but we should clearly realize the effects they will have on college and university resources. With this background in mind let us also try to picture what has happened in our own professional sphere and what may happen in the near future.

At the turn of the century botanical instruction in America was the natural outgrowth of the experiences of American students who had studied in various European laboratories, especially in Germany. The points of view and the techniques of instruction and research were importations direct, or indirect, hallowed by an aura of Old World traditions. Some of these foreign-trained professors, their associates and many of their students soon inaugurated new lines of research and, utilizing every new discovery in chemistry, physics and mathematics, have made American institutions outstanding in their contributions to both the pure and the applied phases of botany.

Certain of the foreign trained men of the early 1900's acquired a feeling that they must avoid problems that have immediate practical use, or are of direct social importance. This attitude was expressed by one of these men, allegedly quoting Pfeffer, "that he would leave the practical problems for the lesser minds." To him the study of a plant inside a Wardian case or in a dark room might yield information of great scientific significance; but a plant growing in a farm field or in the wild could yield little or nothing of importance. He thought it praiseworthy to cultivate and identify fungi on petri plates in a laboratory, but to study these fungi with the purpose of controlling the diseases produced by them was an occupation for those who dared not venture on the more difficult roads of pure botany.

This attitude was not confined to botanists, for I recall discussions about the same time concerning the eligibility of certain Sigma Xi candidates. These were at times acrimonious and centered about the propriety of electing to membership men who were primarily engaged in the applied (or impure) phases of science. I mention these incidents not by way of criticism, but merely as a fact to which I shall again refer farther along.

It must be perfectly evident, in this present period of rapidly changing emphasis and objectives, that the continued support of our departments of botany is dependent upon the contributions we can make by way of instruction and research to the welfare and standing of the institutions in which we work. The institutions in turn are dependent directly and unequivocally upon the services they seem to render to their students and their supporters.

During these four decades educational institutions have grown in resources and in student populations far beyond the hopes expressed by their most optimistic administrators. In 1900 there were about 168,000 students in all our colleges. By 1930 the number had passed the million mark, and by 1939 there were one million, four hundred thousand regular students and 430,000 summer school students or, roughly, more than ten times as many as in 1900. Enrolments in federally aided vocational schools of agriculture rose from 31,000 in 1920 to 539,000 in 1939, a seventeenfold increase in twenty years.

About the beginning of the century there was an average of 11 doctorates in botany conferred each year in the United States. The average to-day is around 110, just ten times as many. A majority of the degrees were, at the beginning, conferred by six institutions; to-day they are being conferred by at least 66 institutions, and the larger departments are granting from 5 to 16 in a single year. In addition, there are now given each year from 20 to 30 degrees that, if one may judge by the titles of the theses, are based on the results of pure botanical research conducted by departments of horticulture, forestry and agronomy.

Forty years ago the quarters occupied by botany departments were certainly not comparable to those occupied by the other fundamental science departments of the same institutions. The old saw that "a stranger can easily locate the botany department by looking for the poorest building on the campus" appeared in SCIENCE and in other periodicals of that time. This is in striking contrast to the modern fireproof buildings and greenhouse facilities in which many departments are housed to-day. In the matter of optical, physical and chemical equipment the departments in our larger institutions and in those associated with the agricultural colleges are now certainly comparable to those of other science departments in the same institutions.

At the time of the organization of the present Botanical Society of America in 1906 there were 116 members; to-day its membership numbers 1,360, of whom 840 are primarily engaged in teaching. In addition, the allied botanical societies list 1,125 plant pathologists, 625 plant physiologists, 500 plant taxonomists, 400 mycologists and 275 bryologists, not to mention botanical memberships in ecological, horticultural and agronomic societies.

The first edition of "American Men of Science" (1906) listed 169 botanists, while the sixth edition (1938) listed 1,677. This list indicates that not only have many doctorates been conferred each year, but it has been possible for the new doctors to find teaching positions in colleges, teachers colleges and universities; and research positions in agricultural experiment stations, private research institutions, land survey offices, game management programs and in forest and soil conservation projects.

Expansion within the fields of agricultural research and of conservation of land and water resources has been even greater than that in the colleges. If you have tramped the eleven miles of corridors in the Department of Agriculture building at Washington and visited the outlying structures at Beltsville, or attempted to contact men in the fourteen scattered buildings that house the Conservation Department you will know what I mean. These Washington offices merely house the centers of stimulation and control of thousands of field men operating in every part of the United States. Indeed, any district in the United States in which there is neither a minor nor a major project of this kind in operation is either unpopulated or very poorly represented in Washington. The government probably has never expended money that added more to our national wealth, health and happiness than the projects fostered by these agencies. In the matter of personnel, these enterprises have been a godsend to many a graduate student and poorly paid instructor of botany.

The latest summary (1938) of the annual resources of American colleges and universities shows that 30 per cent. of their incomes is derived from miscellaneous gifts, collections, sales and auxiliary enterprises, 28 per cent. from student fees, 26 per cent. from state and local government appropriations, 4 per cent. from the Federal Government and only 2 per cent. from endowments. This seems to indicate that 94 per cent. of the financial support received by the average college or university comes directly from the students and from the public that lives at no great distance from the institution. Since in the past the curve of college philanthropies and public support has paralleled the curve of general prosperity, this appears to be a most appropriate time for careful planning, not only by institutions, but by departments and by societies interested in graduate education and research. Will it be possible to continue to secure adequate local and institutional support during the coming years while the Federal Government is trying to prevent the accumulation of surplus funds by those citizens whose incomes are above the subsistence level? This group includes the forty million salaried persons, whose incomes are relatively stable and who probably contribute most to the financial support of collegiate instruction. According to the Brookings Institution the purchasing power of this salaried group in 1942 will be reduced about 25 per cent. below that of the present year.

Most graduate students in our institutions are partly or wholly supported through scholarships, fellowships and assistantships. Since there are usually five to ten applicants for every vacancy it has been possible to select a superior group of fellows and assistants. In those institutions in which such men and women are working as assistants in teaching or in research, the maintenance of these awards has not been a wholly philanthropic procedure. Some of these assistants, on the theory that they learn by doing, have labored as much as forty hours a week, and then pursued their graduate studies in their remaining leisure hours. Graduate assistants have been benefac-

tors to many poorly supported departments and to many a professor who felt that he was overworked or that he should not be bothered with laboratory instruction. Under these circumstances, the holders of assistantships have paid and often overpaid their way through graduate schools. Young men have been willing to serve these apprenticeships either because of their "satiable curiosity" or because of the promise of positions for which the Ph.D. degree is a prerequisite.

These are some of the outstanding facts concerning the forty years of expansion that may well constitute the *Golden Age of Botany*. Briefly, they indicate that the ten-fold increase in college enrolments, the more recent seventeen-fold increase in federally aided vocational schools and the enormous spread of agricultural and land-use programs have made possible the growth of graduate study in botany. Altogether, about 2,000 doctorates have been conferred during the period, and these doctors have found remunerative positions. We may well take pride in this accomplishment and in the results of the researches to which these men have contributed. But we should also be apprehensive of certain social and educational movements that may materially alter this picture.

The curve of growth eventually flattens, whether it represents the growth of plants, of populations or of post-doctorate positions. It has been a heartening and interesting experience selecting and promoting men during the upward swing of botanical prosperity. Will it be equally thrilling to plan for a change in the direction of the curve?

If I read correctly the handwriting on the federal wall, we in botany are rapidly approaching a plateau of post-doctorate employment. Under these circumstances, are we justified in continuing to encourage so many young men and women to spend four or five graduate years preparing for positions that may not exist?

We know now that the curtailment of most non-defense federal and state projects has begun. We may be pretty sure that college and university incomes will be somewhat less. We can likewise forecast that some of the men now working on so-called emergency projects will be looking for positions in permanent educational and research institutions. The availability of these men will not enhance the chances of employment for inexperienced young doctors.

Some educators predict a great post-war expansion of educational facilities by the Federal Government in the form of vocational schools. Some of my botanical friends have suggested that the larger high schools and vocational schools will absorb the botanical doctors for many years to come.

In this connection we must not be blind to the fact that the administration of these secondary schools is now almost completely in the control of professional educators, very few of whom have had training in the sciences. Most of them have a background of educational philosophies that have been developed neither through valid experimentation nor by scientific methods. Their procedures are based on the inferences of doctrinaires who have theorized about education for "the good life" or for "social welfare."

Field observation of these educators in action suggests that many of them still regard science courses as informative exercises. They overlook the most important contribution that science instruction can make, namely, training in the recognition of relevant data, prolonged student experience in the drawing of correct inferences from such data and the substitution of scientific procedure in thinking for wishful cerebration.

Many professional educators have even less confidence in the study of the subdivisions of science as a contribution to "the good life" and to the salvaging of mankind. Like many lay critics of present-day educational programs they neither understand the objectives of science instruction, nor grasp the fact that however thick the veneer of classical and ethical philosophy has been applied to a hundred generations of men, the gene complements of human beings remain very much the same. Sour apples and sweet alike have been nourished on sugar.

These educators have not been satisfied with the kinds of courses offered either by zoologists or botanists when these courses consisted of learning the names of microscopic structures, their alleged functions and the Darwinian proofs of evolution. They wanted something more directly related to the lives of the students and to community welfare. Their prayer was first answered by various zoologists who offered unit courses and wrote text-books of biology. One of the reasons why many schools adopted biology was that the biology books chose to present a variety of units of popular appeal. They emphasized food and energy, personal hygiene, sanitation, familiar plants and animals, interdependence of organisms, conservation and the relation of each of these topics to human affairs. Many of these unit courses were informative, but they were more in the nature of propaganda than of science. Since they served to acquaint students with a variety of pertinent biological questions and answers, school administrators seized upon them as a way to replace the former evolutionary courses of botany and zoology.

In these biological catechisms the botanical units were usually very sketchy and occupied only a fourth or a fifth of the books. The principal emphasis was placed on animal biology because these units formed a basis for the further study of human anatomy and

physiology. They were also better adapted to be taught part time by the athletic coaches. Where these biology courses went into the schools, botany came out, and only the larger schools provided a supplementary course in plant science. Because of the relation of biology and zoology to medicine, many of the smaller colleges find it profitable to offer premedical curricula, and here again instruction in botany appears to be a luxury.

Because of the demand for biology teachers, colleges of education have asked that biology courses supplant the more specialized botany and zoology courses. In part this is a method of cutting down on the time allotted to subject-matter studies; in part it is a method of providing the student with a ready-made pattern of biology instruction at the college level, that he can apply immediately and with little effort in the sphere of the secondary school. Educators assume that plants and animals are so similar in physiological processes, cell structures, essentials of reproduction and heredity that they can not see why we should insist on dividing the instruction into two "compartments." The answer is too obvious to be discussed here.

Survey courses afford another economical means of imparting science information to large groups of students. They bear the same relation to laboratory and field botany courses that seeing the movies of football games bears to participation in the game. They may stimulate interest in science, but the students can not acquire the habit of scientific thinking by these methods any more than they can acquire the techniques of playing football by looking at the movies.

In times of financial stress, however, administrators sometimes decide upon course offerings without benefit of consultation. Arts colleges, as in the past, may grasp the straw of premedical studies and drop all botanical instruction. Teachers' colleges that insist on the teaching of biology followed by supplementary courses on birds, insects and human physiology will find zoologists far more useful than botanists.

Granting that there do exist secondary schools in which some of the teachers have doctor's degrees, many educators are at the present time definitely opposed to the employment of teachers who have specialized to this extent, unless perchance the degree was conferred for studies in the teaching of biology. One state administrator made this clear when he said that science Ph.D.'s should be kept out of secondary schools because their training had made them interested in science rather than in the education of boys and girls. This attitude may be radically changed, however, when most of our superintendents and principals themselves are ornamented with doctor's degrees.

Retirement funds and pensions were lauded at the time when private foundations and state governments established them. Pensions were supposed to encourage teachers to devote their lives to instruction in spite of the comparatively low salaries. In general this effect has been attained. However, there is a demon in every benign formula. College administrators whose institutions were contributing to these funds soon began to study the actuarial tables to see how much of their incomes would be absorbed by the promised pensions. Some institutions found that they were harboring too many men approaching the retirement age. If there seemed to be no way to enlarge their budgets the institutions have two other ways to meet the actuarial situation. One is to encourage older men to leave when they receive an offer elsewhere, and replace them with beginners; the other is to limit all new appointments to young men.

This procedure will literally put numerous competent, but older men on the spot if they should lose the positions they now hold. None of these colleges now wishes to increase its liabilities when it can decrease them by hiring beginners at subsistence salaries. In general, these beginners can be most easily recruited from those of their own recent graduates who have not secured positions elsewhere and this leads to servile inbreeding. Prospective pensions also have been factors in the release of older faculty men, regardless of their health and competence on various flimsy pretexts, and the substitution of young men. Pensions seem to favor the young doctors.

Returning now to the so-called "lesser minds," or to those men who have always been interested in the applications of botany to agriculture, horticulture, forestry and conservation—these are the socially minded botanists, and the results of their work are apparent everywhere. They have made it possible for two blades of grass to grow where none grew before, and they have transformed the practices in every art related to plant growth. They have enriched us with fruits, grains, vegetables and ornamentals from other continents; they have provided us with new and better varieties; they have discovered methods of preventing or controlling parasitic devastations, and they have found new ways to augment the growth of plants and increase the returns from the land.

One of the results of the cooperation of the "lesser minds" with the agricultural and conservation interests, with the various grower's associations and with the public, has been an increasing demand for the support and continuation of their own research projects. A second result has been that they have fur-

nished the only basis for the continuation of research by the esoteric botanists who looked askance at them not so many years ago. How large an audience and what kind of equipment would these academic botanists have to-day were it not for the cooperation of the botanists in the public service and the enthusiasm they have transmitted to young men looking for a career?

Another consequence of the activities of the "lesser minds" has been the securing of funds for experimentation and research on a scale never dreamed of by the older botanists. They have become the principal source of information about the growth of plants out-of-doors. They have transformed the old indoor botany, with its "bean, pea and popcorn" demonstrations in Wardian cases, into a science of plants as they grow in fields and orchards, as well as in forests, grasslands and deserts. At the same time, they have probably contributed as much to botanical theory as have the occupants of the ivory tower.

I have briefly sketched some of the changes in point of view that have occurred during the past four decades, and I have pointed to some of the dangers that attend the impending overproduction of doctors in the field of botany. The present year-to-year increase must sooner or later lead to many personal catastrophes.

We the members of the Botanical Society constitute the only group that can anticipate and ameliorate this situation. By mutual cooperation we can suggest more intelligent preparation for graduate study of botany, and we can insist on a higher and a broader foundation for admission to candidacy for the Ph.D. degree. By this method alone we can also gradually adjust the number of graduate assistants and fellows to the number that can secure permanent appointments upon graduation.

If, in the near future, an outlet for our doctors develops in the secondary schools we should be prepared to certify that every doctor can not only meet the State Board requirements, but that he has a background in the allied sciences that will enable him to visualize the field of plant science as a whole and that his perspective is not limited to the narrow confines of his research interest.

All that I have said up to this point was written a month ago before we became active participants in the life-and-death struggle between Hitlerism and Democracy. The future is even more complicated than it was a month ago. The implications of an all-out war further emphasize the need for a new qualitative and quantitative appraisal of our procedures both in the field of graduate studies and in the enlistment of continued public support through the education of undergraduate students.

In the face of the sacrifices of our young men, the dissipation of our natural resources and the threat to all our ideals of "life, liberty, and the pursuit of happiness," the future of our profession may seem trivial and irrelevant. Nevertheless, there will be an end to this war just as surely as there was a beginning, and now is the time to plan for the aftermath.

EVOLUTION AND KNOWLEDGE

By Professor WILLIAM E. RITTER

UNIVERSITY OF CALIFORNIA

I AM incited to the following remarks by the difference, concerning the evolution theory, between R. Goldschmidt and F. B. Sumner as manifest by Sumner's recent article "Is Evolution Inscrutable."[1] These zoologists are fellow colleagues of mine (or would be if I were not a mere emeritus) in the University of California, and both have my high esteem, personal and scientific. And I make the remarks with less hesitation in that I do not pretend to mediate the seeming difference between them.

If we biologists—especially the zoologists among us—look at ourselves closely, it strikes me that most, if not all of us, would see that we have steered a rather queer intellectual course relative to the evolution problem since Darwin gained, for the general theory of it, acceptance by almost every student well grounded in the fields of research in which it chiefly lies.

And perhaps the queerest, if not the most unfortunate, thing about it is that so much of our procedure has reversed the order, so far as knowledge is concerned, followed by Darwin in working out the theory.

It would seem quite uncalled for to remind any educated person to-day of the origin of the theory from Darwin's experiences as the naturalist of the famous *Beagle* voyage. But there are aspects of his experiences, as an observer of the vast and varied phenomena he came upon, that call for a sort of attention that they get all too little of, even by many of the most highly educated persons.

For instance, I was rather shocked lately by being called down quite emphatically in a group of natural scientists, for quoting Darwin's well-known statement that he worked on true Baconian principles and "without any theory collected facts on a whole scale."[2]

[1] SCIENCE, May 30, 1941.

[2] "Life and Letters," I, p. 68.