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SEED-BORNE PARASITES—A GENERAL CONSIDERATION OF THE PROBLEM[1]

INTRODUCTION

AGRICULTURE is the basic industry of the world. The problems relating to the improvement of this industry are therefore of vital interest universally, even though this fact may not be recognized generally by the mass of humanity.

While agriculture has progressed steadily during the past few decades it has not kept pace with the progress of certain other industries which *may appear* to be more generally dependent upon the progress of the fundamental sciences. One reason for this seems to lie with the farmers, who have not generally reached the point where they realize the need and the possibilities of improving their industry through the adoption of better practices based upon sound scientific principles. An example of such an attitude on the part of the farmer may be taken from one of the best established disease control principles. It has been known for years that the spraying of fruits is one of the most profitable practices for the orchardist, but in spite of this it is doubtful if more than a relatively small percentage of the fruit trees on this or any other continent are systematically sprayed. The spraying of potatoes was known before 1900 to be very profitable in the regions where the late blight or rot prevails, but even to-day there are many thousands of acres of potatoes which are unsprayed annually in these same areas. More recently we have been able to show that spraying potatoes, with the proper materials, at the proper time, and in the proper manner, is extremely profitable in most large potato-growing sections of the United States, but still the great majority of potato-growers hang back and fail to take advantage of this knowledge. The chief remedy for this situation of course lies in more effective extension work, although we must admit that further investigation is needed to clear up some of the more obscure phases of the spraying problem.

The examples above are cited for the purpose of showing how slowly the agricultural industry takes

[1] Invitation address delivered before the Canadian Branch, American Phytopathological Society, Kingston, Ontario, December 20, 1923. Contribution from the Department of Botany, The Pennsylvania State College, No. 45.

advantage of practices, the profitableness of which are well known. If one can generalize from such conditions it is quite clear that we have far to go before any very general program of plant protection can be put into practice. This condition, however, must not discourage the workers in this field. They have their field of endeavor lying ahead and the conquerors of this field are yet to be crowned.

Of the numerous phases of plant protection which are of major importance, that of the dissemination of parasites has received little consideration, except from the academic standpoint. It is my hope, therefore, that the presentation of a special phase of parasite dissemination, *viz.*, by means of the seed, may at this time serve to emphasize the necessity of further consideration of these matters and prove an incentive to basic research along these lines.

IMPORTANCE OF PLANT DISEASES IN AGRICULTURE

The phytopathologists and economic entomologists are well aware of the extreme importance of plant parasites to the agricultural industry, but there are many other scientists and millions of farmers who have no adequate concept of the magnitude of the losses occasioned by such parasites. The phytopathologists of the United States have taken the lead in compiling statistics on crop losses caused by parasitic bacteria and fungi. Canada and England have followed this lead and are now publishing annual estimates of such losses. The entomologists in the United States have quite recently initiated a similar service, and it appears that within the next decade we shall have some fairly accurate statistics on crop losses for North America and Europe. For the United States the following statistics have appeared in "The plant disease bulletin" of the U. S. Department of Agriculture.

Crop	1918	1919	1920	1921	Averages
Wheat	33,171[2]	192,275	104,129	80,592	102,542
Barley	16,533	10,445	9,747	9,249	11,987
Oats	63,396	78,353	78,199	99,159	79,777
Corn	158,533	200,050	220,862	297,561	219,251
Potato	78,094	86,997	119,474	79,518	91,021
Sweet Potato	47,136	58,841	39,150	38,879	46,001
Tomato	841,763	307,168	....	....	....
Cotton	2,160	1,742	2,002	1,568	1,868
Apple	19,273	18,920	47,474	12,380	24,512
Peach	3,664	7,026	10,505	5,918	6,778

These figures represent only a small part of the total losses to our cultivated crops in the United States from disease. We may assume that the situation with respect to vegetable, forage, ornamental and forest crops is about the same. In the field of economic entomology it has been estimated that the annual loss from destructive insect pests in the United States is not less than two billion dollars. In some cases the control of the diseases of a single crop alone, such as potatoes, is of sufficient importance to transform farming from an unprofitable into a profitable industry, and if we were able to add the control of the insect pests and diseases affecting all other farm crops this industry would become much more profitable that it is at the present time. Stating it another way, the crop diseases of plant, insect and animal nature bid fair to become the chief limiting factors in crop production—in fact, they can be shown to be such already in the case of the potato crop, and what is true of this crop is probably true of other crops.

It would be interesting to know to what extent the losses to farm crops from disease are attributable to seed-borne parasites. We can gain some notion of this by scanning the detailed estimates in "The plant disease bulletin," from which the figures quoted above were taken. Averaging the losses for the four years over which the data have been collated it appears that seed-borne bacterial and fungous parasites have been responsible for reducing the wheat crop of the United States 2.3 per cent., the barley crop 3.1 per cent., the oat crop 3.2 per cent. and the bean crop 6.1 per cent. annually. It is apparent that seed contamination by parasites plays an important rôle in reducing the production of many of our most important food crops. Statistics on textile, forage and vegetable crops (other than beans) are not at present available. If we admitted to the argument the vegetative parts of plants commonly used in reproduction, such as the potato tuber, etc., the figures would be startling.

HISTORY OF SEED-BORNE PARASITES

While references to the transmission of plant diseases by the seed can be traced as far back as 1730, in the writings of Jethro Tull, it appears that Gleichen, in 1781, was the first to demonstrate that bunt of wheat is carried on the seed, and Tessier, in 1789, was the first to show that the treatment of the seed with copper sulphate was effective in controlling this disease. It was not, however, until about the middle of the 19th century and later, through the researches of the Tulasnes, deBary, Kuehn, Fischer, Von Waldheim, Wolff and Brefeld, on the smuts that the phenomena of seed infestation and infection were fully demonstrated. Frank, in 1883, proved that bean anthracnose was seed-borne by means of the mycelium which grows through the pod into the seed during its early maturing period. Since this date

[2] All figures in bushels except for cotton, which are in bales; 000 omitted in all cases.

many fungous and bacterial diseases of plants have been shown to be seed-borne until at the present time the number which the joint committee of the American Phytopathological Society and the Crop Protection Institute has recorded exceeds 160, with much of the foreign literature still to be reviewed.

PLANT DISEASES INTRODUCED TO AMERICA FROM FOREIGN COUNTRIES

Without doubt most of the more serious diseases of cultivated crops in North America and some of those affecting forest trees have been introduced from foreign countries within comparatively recent years. Asparagus rust; the smuts, rusts, downy mildew, stripe diseases, and ergot of cereals; club root and black-leg of cabbage; several of our most serious potato diseases, such as late blight, leaf roll, powdery scab, wart, and others; chestnut blight; poplar canker; white pine blister rust; grape anthracnose; citrus canker; nectria canker and scab of apple; brown rot, leaf curl, and scab of peach; bean anthracnose; early and late blight of celery; anthracnose and downy mildew of cucumber; downy mildew of onion; pea blight; carnation and chrysanthemum rusts; stem nematode, rust, and crown wart of alfalfa; probably the root knot nematode and many others have been introduced from foreign lands.

I would not wish my hearers to gather the impression that other countries have not been inflicted with plant parasites introduced from North America. European literature is well filled with the facts pertaining to such diseases as grape black rot and downy mildew, gooseberry powdery mildew, stripe of tomatoes, and others, but there has been no such general exportation of host plants from the United States, and consequently there has been no such wholesale invasion of their borders by parasites from North America as has taken place in the other direction. The child has "inherited" the ills of its parents.

SPREAD OF PLANT PARASITES IN NORTH AMERICA

The interstate migration of plant diseases in the United States has been presented graphically by Stevens for asparagus rust, fire blight and peach yellows. That many of these diseases have been more or less rapidly widening their distribution within our borders is evident. The apple blotch disease first studied in the lower Mississippi Valley has traveled eastward and northward until it is pretty generally distributed east of the Mississippi River except in the New England states. Its spread westward has not been so marked. Many other examples might be cited, but two or three diseases spread by seed might be mentioned. I have already described elsewhere the spread of an important tomato disease variously known as "winter blight," "stripe" or "streak." This disease was first reported in the greenhouses at Cornell University in 1892. It was reported in Ohio in 1897, Pennsylvania 1907, Indiana 1916, Ontario 1916, California 1919, etc. It has also spread to Australia, New South Wales and Great Britain in recent years. This disease has been shown, by studies conducted in my laboratory, to be seed-borne and it will undoubtedly spread to many other regions within the next few years. The black leg of cabbage, another seed-borne disease, which came to America presumably from Europe, was first reported in Ohio in 1909. Since that date it has been reported widely in the United States and during certain years is a very destructive disease. Bean anthracnose, another destructive disease caused by a seed-borne fungus, was apparently first recorded in the United States from Cambridge, Massachusetts, where it has been known since 1882. Since then, according to Barrus, this disease has been reported from every state in the Union except South Dakota, Wyoming and Nevada and doubtless it occurs also in these states.

From these few examples, which might be multiplied almost indefinitely, it is seen that seed-borne parasites have played a very important rôle in the dissemination of plant diseases, and that unless this condition is recognized more generally and preventive measures taken it will be but a few years before such diseases are distributed wherever their hosts are grown and environmental conditions permit their development.

IMPORTANCE OF PATHOGEN FREE SEED IN CROP PRODUCTION

There are, of course, many factors entering into successful crop production, but from the standpoints of yield and quality, the health of the seed must be admitted to be a factor of first importance. When all the other factors, such as nutritive relations, moisture and temperature, are favorable for successful production the crop may be a failure because of parasites which are seed-borne. Bean anthracnose and bacterial blight are excellent examples of the many almost exclusively seed-borne diseases which destroy our crops annually. If bean seed is planted when infected with either of the parasites causing these diseases, the results are almost invariably disastrous. At the present time we have no satisfactory way of checking these two bean diseases once they have appeared on the growing host. Disease free seed is the one satisfactory method of dealing with these problems, except by the use of resistant varieties which are now being developed.

The problem does not stop with those diseases which are more exclusively seed-borne. In the cases of tomato and cotton wilt, caused by two specific fungous parasites usually considered as soil-inhabiting organisms, it has recently been shown by Edgerton and Elliott that contaminated seed may serve to initiate these diseases in the field. The problem has no end or at least there is no end in sight.

Nature of Seed-borne Parasites and their Method of Dissemination

It is well known that animal and insect life may be seed disseminated, but I shall discuss under this phase of the paper only those parasites which are of a plant nature. These parasites are either bacterial or fungous in nature but of varied form and development. So far as known the bacterial plant parasites are all of the usual simple cell types which do not form "spores." The fungous parasites are much more varied in their form. Polysporous forms are common and other complexities exist. In general, the fungi are seed disseminated by means of spores or spore receptacles adhering to the surface of the seed integuments (*external transmission*), or they may be carried within the seed or integuments (*internal transmission*), in the form of their vegetative or resting mycelium. Certain fungi also may be carried with the seed in the form of sclerotia, stromata and other resting stages such as occur with ergot, *Sclerotium* spp., etc. All these methods of dissemination upon, with and within the seed may be utilized by fungous parasites with great effectiveness. In some cases the method whereby the parasite is carried is well known; in other cases it has not been fully worked out. Among the most highly developed and effective methods of seed transmission are those loose smuts of wheat and barley in which infection takes place through the floral parts, the mycelium entering the growing point of the embryo, where it remains dormant until the embryo resumes growth at the time of germination. The mycelium then develops along with the growing point but only produces spores in the spike at the time the latter approaches maturity within the sheath. The spores are again disseminated as soon as the infected spikes emerge from the sheath and at the time the normal healthy spikes are in bloom. Freeman has described what is perhaps a still more highly specialized type of seed parasitism in the case of the "seed fungus" of *Lolium tementulum*. This fungus is said to produce no spores and to overwinter by means of its mycelium outside the aleurone layer, in the scutellum and in the growing point of the plumule. By such methods the parasite insures its perpetuation from year to year without the risk attendant to the methods utilized by many parasites which are disseminated by spores adhering to the surface of the seed or fruit. In these latter cases the safety of the parasite may appear to lie with the enormous number of spores produced.

Among such a varied group as the fungi, comprising as they do several orders with innumerable intergradations of nutritive relations from obligative saprophytism to obligative parasitism, it might be expected that some instances would occur of a relation between the stage of parasitism attained and the methods of seed dissemination. Possibly such relations will eventually be shown through a more thorough investigation of the life histories of such a group as the smuts. The instances of mycoplasmic transmission described by Eriksson for the rusts have not yet been generally accepted, but further researches in this field are highly desirable. If we accept the symplastic condition for the bacteria, as described by Lohnis and Smith and others, there is less ground for doubting that such a condition may be proven eventually for the fungi.

Rôle of Commerce in the Dissemination of Parasites

The period of very active dissemination of plant parasites was ushered in with the development of our vast interstate and transcontinental systems of transportation. This period began about 1885 and may be said to be concluded only within the past decade. During that period a majority of our plant parasites were introduced and widely disseminated, though of course the dissemination is still continuing and possibly with even greater frequency. Other factors, such as the mail, parcel post and congressional distribution of seed have undoubtedly furthered such disease dissemination. The only real brake which assisted in checking this widespread distribution of plant diseases in the United States was the passage of the Simmons bill, which became the Plant Quarantine Act, August 20, 1912. Since that date there appears to have been a slowing down of the rapid distribution of plant parasites, especially among those species which are generally carried on propagative stocks, plants with roots and soil, etc. The forms which are more specifically seed-borne have not been checked so effectively by this quarantine which did not, during its early inception, take into close consideration these particular forms. However, since 1919, with the passage of the nursery stock, plant and seed quarantine No. 37, the question of seed transmission has been given more careful consideration.

Parasites not yet introduced to North America

While we have already more plant parasites than we can hope to combat successfully in the next half century, there are many more in other countries which are only awaiting a favorable opportunity for emigration. Of such we know comparatively little except from the published lists and, for the most part, brief accounts in the literature of foreign countries. We do have, however, sufficient experience with those diseases which have already found their way to our domain, to warn us of the grave danger of each and every one of these potentially serious foreign plant diseases. This experience has almost invariably taught that newly imported parasites are more destructive than any parasites native to this continent, and that furthermore once they are introduced to our shores they become permanent boarders. We have yet to prove that a single disease once established can be completely eradicated. We can not be over careful in dealing with such enemies. As Spaulding has stated, "we are in constant and increasing danger from serious foreign plant diseases, and this danger is much greater than the public believes can be possible." The United States and Canada could well afford to spend large sums gaining more complete knowledge regarding these as yet unintroduced parasites, many of which undoubtedly are capable of being transmitted with seed.

REGIONS IN NORTH AMERICA WHERE PLANT PARASITES HAVE NOT YET BECOME ESTABLISHED

While it is evident that many of those plant diseases which have been in our midst for a comparatively long time are already widely distributed, there are still many of the more recent acquisitions which have not as yet become generally distributed within our borders. Two examples of parasites attacking alfalfa may be cited as illustrating this point; the crownwart disease caused by *Urophlyctis alfalfae,* and the stem nematode caused by *Tylenchus Dipsaci.* Both of these parasites have been introduced from foreign countries, quite probably on alfalfa seed. At the present time their distribution is more or less local in the western United States, but they are spreading and this past year *Tylenchus Dipsaci* was recorded in New Jersey. We shall have to move quickly to head off these parasites from further invasion of new territory. The movement of alfalfa seed from infested areas should not be permitted. There are many other examples of the same sort, such as the Physoderma disease of maize introduced into the southern United States, and it would appear probable that a number of such diseases could be restricted from further spread if strict measures were taken promptly. A good example of what may be accomplished in this direction is afforded by the apparently successful attempts in preventing the further spread of the potato wart disease in the United States and Canada. Thorough surveys should be made at once, particularly with respect to these more recently discovered diseases and pests. Only by such data at hand can we intelligently direct efforts against the further distribution of such parasites.

METHODS OF ATTACKING THE PROBLEM OF SEED-BORNE PARASITES

Much of what I have already stated applies to plant diseases in general. I shall now try to confine further remarks to the problem of seed-borne parasites. However, it would appear that the problem, so far as the seed is concerned, is only a part of the more general one of disease prevention and as such can not be restricted too closely since the fundamentals remain the same.

In the first place, some organization is necessary. We can not hope to accomplish what needs to be done single handed or by unguided efforts. We need the keenest minds and the most persistent workers on this problem, which is an exceedingly complex one. It is complex because of its varied aspects and because so little has been done to guide us in the best methods of technique. It involves as possibly no other closely related problem, a detailed study not only of the life history of the parasite but also that of its host from seed to seed. Coupled with these studies should be those which will inform us accurately as to just how any specific parasite on or within the seed is transmitted to the seedling or to the growing plant. Very few tracings of this sort have been made. It is complex because it involves on the one hand a specialized industry in seed production and on the other hand a generalized and unorganized industry of crop production—the agriculture of our country. These two agencies, between which the investigator must take his stand, must be brought to see the importance of this problem, and induced to bring support for its solution. I believe this can be done, but only by the concerted efforts of a considerable number of persons who will use their influence to bring the matter to an issue. There can be no doubt of its importance. The problem strikes deep at the fundamentals of disease control. The problem is complex further because it is international as well as interstate in scope. These parasites recognize no boundaries except those which we can artificially erect with more or less success and for this reason alone the problem involves many legal principles which are intricate. There are other complications attached, but I do not wish to discourage any one from attacking this problem by enumerating further these difficulties which beset the way. I only wish to point out the most obvious difficulties with the hope that once seen the more easily may they be avoided.

THE RESEARCH PHASES OF THE PROBLEM

One of the reasons why we have not progressed further in the investigations on seed-borne parasites is because we have been relying too much upon empirical methods. After we have demonstrated that a specific parasite is seed-borne we are prone to turn at once to the various methods of treatment with the hope that a short cut can be found to the solution of the seed-borne phases of the problem. Sometimes this works out and doubtless much time is saved in such cases, but we have any number of other cases where much time has been wasted in empirical tests. In all these cases we need research methods applied to the solution of these problems. As stated above, we need to know just how each of these specific seed-borne organisms infect or infest the seed as well as their further development to infect the seedling or the growing host. With this information fully worked out, it should simplify greatly the methods of treatment to be employed in each specific case. There are many other research phases of these problems, some of which will be discussed in the following paragraphs.

Cumulative Effects of Parasites

Nature is considered to be the great adjustress of biological phenomena. Natural agencies bring about adjustments and adaptations of living organisms to their environment. This is accomplished in a more or less uniform way so long as nature is not interfered with by artificial methods created by man. It is perhaps by creating such artificial conditions that many of our epiphytotics are brought about. Systems of cultivation, fertilization, rotation and other general practices undoubtedly affect both the parasite and the host and not infrequently create conditions especially favorable to the parasite. If such conditions are created over two or three successive seasons epiphytotics are almost certain to result. Here again lies a fertile field for cultivation by the investigator. The work of L. R. Jones and his associates on the effects of soil temperatures upon parasitism has paved the way for an extension of these lines of research. We very much need accurate information on the effects of temperature, moisture and other factors upon the development of parasites which are seed-borne. Presumably, these environmental factors are of major importance in determining the success or failure of any specific seed-borne organism to infect its growing host plant.

Comes has discussed the influence of climate upon the susceptibility of plants to disease and believes in general that the introduction of parasites into warmer and more humid climates is apt to increase their destructiveness. He also believes that nitrogenous manures, in general, tend to reduce the resistance of the host. I am convinced that one of the most important reasons for rotation of crops is because of the tendency of this practice to retard the accumulation of specific parasites.

W. A. Orton has summed up the general conditions with respect to newly introduced parasites as follows: "Parasitic fungi thus transferred to a new environment have found species of plants closely related to their original host, but lacking the resistance or endurance possessed by that host. The newly introduced parasite spreads under such conditions with a rapidity and destructiveness never observed in its original habitat." This of course applies with equal force to both inter and intra-continental introductions.

Another related phase of this problem which appears to be deserving of attention, but upon which we have very little exact information, is that of readjustment of crop distribution. While it is probably true that our present crop distribution is in general based upon adaptation to environments, there is still to be considered the possibility of reducing the losses from parasites by centralization of certain crops and particularly so in the production of seed and other reproductive parts. As instances indicating such possibilities, that of black-leg of cabbage, a destructive fungous disease, may be cited. It has been shown that this disease fails to develop, for some unknown reason, in the cabbage-growing regions of Puget Sound, Washington. We may find it advantageous to develop there a cabbage seed producing industry. Likewise, five years' experience in Pennsylvania with seed potatoes from many sources has shown conclusively, for some unaccountable reason, that seed tubers grown in certain areas in Michigan are more free from disease than from any other known source. Other instances of a similar nature are known, but so far little advantage has been taken of these pointers which are much in need of further study.

Methods of testing Seed for the Detection of Parasites

At the present time there are no standards nor reliable methods known for detecting the presence of parasites on or within seed unless it be in the case of corn. More than twenty years ago Bolley pointed out a method of centrifuging various sorts of seed for the purpose of detecting and identifying the spores of fungi carried upon the seed. This method has been utilized in other laboratories with considerable success, but unfortunately it is only a help and not a solution of the problem. In the case of internal parasites surface disinfection has been very helpful, but the methods of developing and culturing the internal parasities are extremely faulty and much study is needed on this point. Here, again, the factors of temperatures and moisture add to the complexities of the problem. In some cases the presence of such parasites have only been detected upon the germination of the seed and the development of the plant, and we are often thwarted at the beginning through our failure to induce the seed to germinate. We are also frequently baffled by our failure to induce growth of the parasite from spores, sclerotia and mycelium.

SEED PRODUCTION METHODS

The fact is that seed production is so largely in the hands of the seed trade that plant pathologists have not especially concerned themselves with the methods employed. No doubt a great deal of very valuable information might be gained through a careful survey and analysis of seed production methods. The factors of protection, sanitation, harvesting, curing, storing and general handling of the crop and the seed need detailed study. It seems certain that in this field the expert plant pathologist might readily point out weak points or practices, the correction of which would fully repay the expense of such studies. The seed producers need our assistance, and we in turn need theirs in solving these problems.

SEED DISINFECTION

Space prevents any extended discussion of seed disinfection regarding which much has been published—particularly from the empirical standpoint. There has been much progress in seed disinfection since Arthur and Bolley introduced the formaldehyde method. Recently, the dust treatments have been renewed with considerable success and still more recently have come the organic mercury compounds, the phenolic acids and the chlor-phenol compounds. The list of these newer compounds is increasing rapidly and a number of them have given promise of worth. Certain of these apparently stimulate the germination of seeds as well as acting as fungicides. The so-called electrical treatment of seeds has not given, under experimental tests, the results claimed by its originators, but a more careful study of the effect of electricity upon seed germination and its possible fungicidal action is needed. The heat treatments, both dry and wet, need further study and probably many materials not yet tested have possibilities of use for such purposes. The work of Braun on the physiology of seed treatment needs to be extended. However, these phases of the problem are advancing more rapidly than the more fundamental phases and we may be assured that, once the underlying principles are worked out, the remedy will be forthcoming.

LEGAL CONSIDERATIONS

The matters of exclusion of plant diseases under quarantine have been discussed by W. A. Orton in several papers. While the grounds for excluding many plants and plant products are fully justified the work of the various quarantine agencies of the different nations has been hampered in the case of seeds because of the general lack of specific information regarding seed-borne parasites. Action has been taken in a number of cases by Great Britain and in a very few cases by the United States, but if specific information was available undoubtedly we would be protected much further by adequate restrictions. At the present time we have six quarantines against foreign countries which are aimed in part or whole against seed-borne parasites. There are practically no interstate restrictions on seed-borne parasites except in California. Galloway has very clearly stated the problem from the standpoint of the office of Foreign Seed and Plant Introduction of the U. S. Deparment of Agriculture.

COOPERATION AND COORDINATION IS NEEDED

We can not hope to attack this problem in any general way without the cooperation of the seed producers. We need this cooperation to carry out the preliminary surveys which should be made, as well as in securing the funds which would be required to finance the work. We need the cooperation of the seed analysts, particularly those who have been trained in the technique of culture methods and seed germination. Without their assistance it would require more time and funds to work out what they already know and to duplicate the special equipment of the seed laboratory. Plant physiologists and chemists are needed in the problem, and in fact it would be necessary to organize the project on such a basis that scientists in any line could be called in to aid in solving the various phases of this problem.

We also need more complete coordination of the restrictive measures existing between nations. Inspection laws should be more uniform, international plant disease surveys should be organized and a general effort made to restrict in all feasible ways the further distribution of plant diseases, whether by seed or in any other way. Some of these points already have been given preliminary consideration by the International Phytopathological Commission which met at Rome in 1913, but the various expressions of that commission have not yet been crystallized and brought into effect. Further efforts to bring about some such permanent organization to deal with the international aspects of these problems should be made. Whether it will be possible to accomplish such a goal in the near future may appear doubtful. There is a feeling that such movements must follow public sentiment and this elusive thing moves slowly in regard to scientific matters, especially when dealing with agricultural problems. This may be our own fault, and I am thus led to mention the educational features of our research problems. Many of us have been content to work out our problems in the laboratory and perhaps publish the results, and let the matter rest there. There is nothing startling to the public mind in the agricultural field, such as occurs in the engineering industries or in the sciences of physics and chemistry. Agriculture seems slow, inactive and dull compared with these other fields. We must, therefore, push forward more rapidly the educational campaign in order to more generally focus public opinion on our problems. Humanity needs to have these problems solved. They are more important than air transportation, wireless communication and the hundred other things which humanity discusses daily, but how long will it take us to convince the human race of this fact?

Clayton Roberts Orton
The Pennsylvania State College

THE AMERICAN PSYCHOLOGICAL ASSOCIATION[1]

When I asked the president of your society for suggestions on this toast, he said there were only two rules that would be strictly enforced. In the first place, he thought you would not stand for more than 10 or 15 minutes from each of us, and in the second place he was sure it would not be safe for us to inflict our presidential addresses upon you. I told him that, in view of the time limit, the second injunction was entirely unnecessary, as no one ever heard of a ten-minute presidential address. In view of the "blue laws" that your president has laid down, I can only say a few words about the American Psychological Association and the work of its members.

The association was founded in 1892 by G. Stanley Hall, who was made its first president. It is one of the smallest of the national scientific societies. Its membership of 500 looks very insignificant, indeed, in comparison with the 15,000 of the American Chemical Society or the 75,000 of the American Medical Association. There are several reasons for our scanty numbers.

In the first place, although psychology of a sort has a very ancient history, and, as the science of magic, was the parent of medicine, chemistry and astronomy, psychology as an experimental science is hardly more than a half century old.

In the second place, the ranks of psychologists have been seriously depleted by the fact that so many have been called to university presidencies, though why any one should be willing to give up the delights of psychology for the worries of a university president is a little hard to understand. Among those who have seen it otherwise are the presidents of Yale, Cornell, Northwestern, Indiana, Kansas and a half dozen other universities and colleges. These men have at least proved that the psychologist is not afraid of a dangerous occupation!

We used to lose a good many of our members to philosophy. To-day we are more likely to lose them to biology, medicine, education, social science or business administration. As an illustration of the catholicity of the psychologist's interests and contacts, I may mention the fact that this year one of our members (Cattell) heads the American Association for the Advancement of Science, and another (Troland) the American Optical Society. The psychologist's work is leading him into such a variety of fields that his science is becoming ever harder to delimit. As Cattell recently expressed it, you can only define psychology as that which the psychologist works at.

But to resume my apology for our small numbers. I want to make it clear that the trouble is not due to any dearth of psychologists. I am sure there are more psychologists on Main Street, in Los Angeles, than there are chemists in the whole United States! Paradoxical as it may seem, it is precisely because there are so many psychologists that the American Psychological Association is so small. In order to reduce undesirable competition we have had to raise the bars higher than any other scientific body has found necessary. Not even the holder of a Ph.D. degree in psychology from the best university is assured of admission. He must also hold a respectable position in psychology and must prove by continued publication that he is genuinely interested in research. We do not dare to accept every bright graduate student of psychology, much as could be said about the inspiration this would bring to the young worker. If we did so, we might soon have a number of our members scattered over the country reading palms and practicing psychoanalysis at so much per palm and psyche. Hence the bars, which perhaps are even higher than necessary. Our membership committee is sometimes dubbed the "exclusion committee."

Now the psychologist must compete not only with the thousand and one kinds of professional fakirs, but also with everybody else, for all of us have practiced psychology from infancy up, including mind-reading, the psychology of suggestion, and the psychology of salesmanship. The boy runs away on Sunday to go swimming, slinks home, reads his father's mind from the look in his eye, and discreetly retires behind the barn. Even mental tests, which are often supposed to be a recent development,

[1] A toast at a dinner given by the Sigma Xi Society of Stanford University in honor of Stanford presidents of national scientific bodies.