

PRESIDENTIAL ADDRESS

The Responsibilities of a Mycologist

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Every science has three objectives; (a) self improvement, which can be accomplished only by investigation and research, (b) a better and more closely integrated relationship with other, and more particularly, closely allied sciences, (c) a recognized responsibility to the public, and to society generally. Mycology must, along with other sciences, recognize these three objectives.

Voltaire once said "If you wish to converse with me, define your terms". When I am asked concerning my profession, I reply that I am a mycologist. The second question follows usually, "What is a mycologist"? I then give the brief dictionary definition—"Mycology is the science of fungi". For some reason the obvious third question does not follow. Either my inquirer is too polite to quiz me further, or he thinks he knows what is meant by the word "fungus". It is fortunate for me that the inquisition stops where it does for a definition of this term is most awkward. The definition for fungus given to my classes is this—"A fungus is a plant without roots, stems, leaves, or chlorophyll, and whose vegetative body is a thallus". Students accept this definition usually without question, as is the nature of students everywhere; but there are many grave doubts in the mind of the professor who gave it. Dr. G. W. Martin, one of our most able mycologists, throws doubt on the initial premise, that a fungus is a plant. Also, the definition as stated does not differentiate between slime molds, bacteria, and the kinds of plants such as molds, mushrooms, etc., that ordinarily come to mind when the word "fungus" is spoken. To overcome this difficulty we must differentiate further between Myxomycetes, Schizomycetes, and Eumycetes. The latter division, Eumycetes, includes the fungi with walled-thalli producing exospores as well as endospores, with some type of mycelial development the most common form of thallus. There is so much diversification and so many exceptions that the Eumycetes can not be too sharply delimited. The mycologist is concerned principally with the Eumycetes. Mycology, in the present discussion includes the Eumycetes only. When fungi are mentioned, reference is made only to Eumycete species.

Fungi were objects of interest to men of the most remote antiquity. There are a number of references in the Bible concerning fungi and their effects. The ancient Greeks and Romans used mushrooms as food. Mushrooms also played an important rôle in ancient and mediaeval toxicology. While ancient records indicate that the knowledge of fungi

was coincident with the history of man the earlier ideas concerning the nature and origin of fungi were extremely naïve and crude. In the herbal of Hieronymus Bock published in 1560 I find these words, "Mushrooms are neither herbs nor roots, neither flowers nor seeds, but merely superfluous moisture of the earth and trees, of rotten wood and other rotten things." "From such moisture grows all fungi." "This is plain from the fact that all the above mentioned mushrooms, those especially which are used for eating, grow most when it will thunder or rain." "Porphyrius speaks also in this manner and says that fungi are called children of the gods, because they are born without seed and not as other kinds."

The detailed structures of fungi, their life-histories, and their true relationships among themselves and other members of the plant kingdom could not be ascertained until after the development of the compound microscope and the complete overthrow of the doctrine of spontaneous generation.

Modern mycology was brought into being by the advent of a world-shaking catastrophe,—the Irish famine of 1845. The potato disease responsible for the famine was of fungus causation. The control of this disease was a matter of terrible urgency and all of the best botanical brains of the period were concentrated on such a study. It was evident that if the fungus, *Phytophthora infestans* were to be halted in its devastation of the potato crop that more would have to be learned concerning the life history of this causal agent. Anton DeBary made in connection with his study of *Phytophthora infestans* the most notable contribution. He was probably the first investigator to apply the scientific method to the study of a pathogenic fungus. So fundamental was this study of *Phytophthora*; and others, equally important concerning heterocism of rusts, and the morphology of various other fungi that DeBary is credited with being the father of two lusty offspring—mycology and plant pathology.

Modern mycology had its beginning with the pioneering work of DeBary. American mycology was stimulated by the organization of the Mycological Society of America, in 1931 and the adoption of *Mycologia* as the official mouthpiece. It was however, the announcement of the discovery of penicillin by Alexander Fleming in 1929 that gave an entirely new direction to mycological endeavor.

Much of the early work relative to fungi in the United States was exploratory and descriptive. New species were being discovered, described, and classified. It was recognized generally during this period that fungi constituted an important part of the flora of any region; that they contributed an important phase of that never ending cycle of nature in which organic life is born, dies, and returns to the elemental forms from which it was derived. If a fungus were found to cause a plant disease it was turned over promptly to the Plant Pathologist. If a fungus were found to contribute to human ailments it was donated to the medical doctor. A fungus that had no apparent economic importance became the property of the mycologist; an object upon which to gaze, to be written about, and then stored away in dusty boxes,

perhaps with moth-balls. If you should peruse the pages of *Mycologia* you will become impressed with the fact that you have become closely akin to the man in *Thanatopsis* who "in the love of nature holds communion with her visible form" and who has few ambitions beyond communion. You must read through many pages before you will find mention of a fungus that is being discussed because of some economic value which it may possess. The meetings of the Mycological Society has many resemblances to a social meeting of war veterans. The members of the society meet to reminisce concerning collections, and forays, to swap collection experiences and to quibble over moot points of taxonomy and nomenclature.

The discovery that fungi were capable of producing antibiotics and the exploitation of that discovery has altered the mycological outlook very considerably. This new development demonstrated not only that fungi are able to produce products of the greatest economic significance; but it indicated also, that fungus fermentation products of various sorts produced previously only on an experimental scale, could be quantity-produced. Thus, such products could compete effectively with synthetic types of manufacture. As a result of these amazing discoveries an entirely new field of fungus exploration was revealed.

According to Ainsworth and Bisby there are approximately forty thousand valid species of fungi. Most of these species include numerous strains whose physiological potentialities may vary within wide limits. Furthermore, it has been demonstrated in antibiotic production that the substrate may alter markedly the nature of the substances produced by the fungus strain. Thus, if we attempt to make a conservative estimate there are probably four hundred thousand strains or varieties of fungi that must be investigated in order to determine their economic possibilities. These investigations must be made on various types of media, at various pH levels, at different temperatures, under different light conditions, etc. Also, it is not necessarily true that these fungus strains will perform best in pure cultures, but in combination with others.

Perhaps the mathematician can compute for us the possible combinations and permutations that could be made with four hundred thousand fungus strains. There is no field in either physical or biological science that holds so much of promise. It is possible that fungi and their products could revolutionize our present national economy. With the proper sort of cooperative work, results of fungus exploitation will be more spectacular in the future than in the past. The mycologist will be unable to accomplish these things by himself. He must have the assistance of the bacteriologist and the biochemist. I have no quarrel with the contributions that have been made to mycology by these sister sciences, but I do have serious doubts whether the mycologist is aware of his opportunities or his responsibilities.

Mycology, because of the developments of the past decade has ceased to be a hobby-science and is now as utilitarian in its outlook as are the sciences of chemistry, physics, or medicine. The mycologist does have certain responsibilities in connection with the new concepts

of his science and some of these responsibilities constitute the material for discussion in this paper.

The chemist in his omnipotence believes that he can solve all mycological problems involving industrial operations. Perhaps the chemist may be efficient with the limited number of fungi with which he works, but in order for any one to learn the limits of the industrial possibilities of any fungus, the origin, natural habitats, morphology, cytology, variability, and relationships must be understood. Such information is available only to persons trained in mycological techniques.

All the fungus species have not been discovered and the geographic distribution of known forms has not been well ascertained. The fungus collectors and explorers laid the foundation of the science of mycology. The services of such men are needed now and in the future. But, the mycology that goes no further than the discovery and naming of species is an impotent science. The enormous number of fungus species that have been described, made classification a necessity and laid the foundation for taxonomy. The perishable nature of the soft-bodied thalli has banned the possibility of an extensive paleontological mycology. Without a comprehensive knowledge of fossil forms a purely natural classification of fungi will never be possible. The present taxonomy is chaotic, and confusing and must in its present condition retard the progress of the science. An example of the sort of condition to which I refer is the confusing state of the taxonomy and nomenclature in medical mycology. The physician and the botanist speak an entirely different language.

In order to revise taxonomy along rational lines it will be necessary to have extensive monographs of the various fungus groups. Monographing is a labor of love. There are no monuments erected to monographers, unless the inconspicuous marker in the pauper's cemetery may be considered a monument. A man who is able to monograph does not have the type of mind, or the time which will permit him to engage in more pecuniary labors. Furthermore, monographs require many pages of printed matter and most botanical journals are not prepared to allot the proper amount of space for comprehensive and exhaustive monographs. Most men engaged in monographic work do not have the means to publish privately. Educational institutions will add new seats to the stadium, or pay for an oil painting of the prize bull, but there is too little advertising value in a fungus monograph to justify an outlay of cash in order to permit its publication. Monographs are essential to the continued development of this science and they must be published before the fullest exploitation of fungus production can be realized. It should be the concern of all botanists as well as those directing the fermentation industries to see to it that monographic publications are made possible.

Monographs may contribute little to our knowledge of fungi if they depend solely on musty herbarium specimens and the inadequate descriptions so often given by the original investigators. There is scarcely a genus of the fungi that would not benefit by a searching, painstaking,

and detailed study of all the species that we consider at the present time to be its component parts. Such investigations would reveal that some species have no reason for existence, and that others may belong in entirely different categories. I realize that I am giving aid and comfort to the "lumpers" and "splitters"; but revision of a genus should have a more solid basis in fact than that offered by a cheap publicity. Mycology has suffered enormously from the antics of taxonomic exhibitionists. Thom and Raper in their recent revision of the genera *Aspergillus* and *Penicillium* have given to the mycological world examples of the type of studies that need to be made in nearly all genera. At Purdue we are attempting studies of a similar sort with the genera *Trichoderma* and *Verticillium*. Too much of the older type of taxonomic research has been based almost solely on comparative morphology studies. New studies in this field must include physiology and cytology, utilizing every technique available to the microbiologist.

The type of research which I am discussing is essential in establishing the industrial potentialities of any fungus species or race. My thesis is that only the mycologist with a background training in chemistry and bacteriology is capable of handling industrial problems involving fungi. The bacteriologist has his hands full if he comprehends the 1500 pages of Bergey's manual. He has neither the time nor the energy remaining to attempt an understanding of the great world of the Eumycetes. The chemist is absolutely incompetent to engage in fungus investigations unless he is willing to devote as much time to the study of mycology as he has to the study of chemistry. There remains then the properly trained mycologist as the only scientist capable of handling in an intelligent manner the multi-faceted problems of industrial mycology.

This then is the responsibility that has been thrust upon the mycologist during the past decade. Living up to this responsibility is not only a matter of adequate preparation but includes also a change in the mental attitude which he has toward his profession. The mycologist may lose his opportunity and evade his responsibilities because of two very unfortunate fixations. First, many mycologists object to the fun being taken out of fungi. They dislike leaving the peaceful contemplation of beautiful and interesting fungi and knuckling down to the difficult task of learning just what a fungus can do; and finding that, to learn how to make it still more productive. We are told that a number of the eminent mycologists refused to attend a recent annual meeting of the American Mycological Society because there were too many papers dealing with purely practical aspects of fungus research.

The other complex which may limit our opportunities has to do with what Dr. Neil Stevens termed "The excessive meekness of American botanists." The chemist, the physicist, and more lately, the bacteriologist have demonstrated the utility of their sciences. Their discoveries have been associated closely with those technological developments that have contributed so much to our modern mechanical civilization. The publicity from these discoveries has made the public believe that their finely

equipped laboratories and their high salaried personnel have been worth all the cost. Graduates from these sciences are easily placed as well paid technicians in industry. The botanists know that the animal world is absolutely dependent on the plant world, but they have a way of losing all the publicity advantages of plant improvement which more than any discovery of the chemist or the physicist has kept mankind from sinking into oblivion from famine and disease. Dr. William Trelease has said that "the chief difficulty with botany was that as soon as it became practical it was called something other than botany:— agronomy, horticulture, genetics, forestry, etc. The chemist and the physicist do not seem to have the same trouble; no matter what the practical angle may be, it is still chemistry or physics. Is the botanist meek because he is robbed of the utilitarian phases of his subject; or is he robbed because he is meek? Some one has said that you never have to inquire for the botany building when you go to a strange campus:— just search for the most run down and the poorest equipped building on the campus. Mycology suffers from this same type of robbery. Its practical phases become Plant Pathology or Medical Mycology. Now, there is a movement on foot to take the industrial mycology away from the parent science and place it under a new name,—“microbiology”. The inferiority complex so often felt by the botanist and the mycologist in his contacts with other scientists arises from the fact that he can offer only theoretical solutions to the problems of mankind. Today the properly trained mycologist is just as necessary to our society as is the chemist or the physicist. He must not only realize this, but he must be aggressive enough to claim his share of the rewards that are attached to services rendered. The mycologist has every right to feel as Marmion felt when he found himself surrounded by critical and supercilious Noblemen—“And if thou sayest I am not peer to any Lord in Scotland here; lowland or highland; far or near; Lord Angus, thou has lied.”

Given the desire to become practical, how do we sell our product to the public? It is my belief that those of us engaged in school work have the immediate task of impressing our students with the opportunities and the far reaching objectives of our science. Taxonomy should be taught as well as the comparative morphology which is so necessary for the proper comprehension of taxonomy. Taxonomy is the essential corner stone of any natural science whether it be zoology, entomology, bacteriology, botany, or mycology. The student should be made to realize that there is no substitute for taxonomy and there is no easy way to learn that subject. A proper understanding of taxonomy requires memory and a proper appreciation of the philosophy with which the subject is permeated. A man who is lacking in orderly mental processes can never become a taxonomist.

Fungus physiology is a science which is able to inform us concerning the possible productiveness of a fungus. Fungus physiology is a study that will be so much extended in the next fifty years that it will make present knowledge seem primitive. Much of what we know concerning

the functions of fungi is based on superficial and inadequate data; and these data are based on a few species only. Until we know as much about many of the forty thousand species of fungi as we know about *Aspergillus niger*, the essential science of fungus physiology is going to remain inadequate. No area of research offers so much promise, or so much of challenge as this one.

Following the advent of penicillin there was an urgent demand for the mycologist to improve industrially important strains of fungi. This had a very close similarity to the more conventional demand for the farmer to improve his milk cows. Whether a fungus strain is improved by a breeding program or by the production of induced mutations the ever increasing science of fungus genetics must be comprehended. The fungus genetics that is available today is pretty sketchy and involves relatively few species. Further progress in this direction is dependent on cytological research. An adequate fungus-cytology must await new techniques in staining and microscopic observation. These deficiencies will disappear in time, but they again call attention to research possibilities in mycology.

There is one phase that is too often ignored in the mycology teaching program. There are institutions where a student may get a degree in mycology having learned all of the ancient lore of the subject. He knows all the nomenclatorial rules and can argue them pro and con in the same way that a lawyer knows the criminal statutes of his state. He is able to recite the fungus classification from *Allomyces* to *Zythia*, and he is thoroughly familiar with all known variations in classification systems. He has a green thumb and is able to make the most difficult cultures to grow and fruit. He knows every fungus enzyme and can name every organic acid produced by fungi. He can write the most complicated chemical formulae that involves fungi. In spite of all this knowledge which is certainly well to know, this student may have trouble in the identification of even the most simple molds, nor will he know the techniques that will enable him to make necessary identifications. The principles and practices of identification are absolutely essential to the training of the modern mycologist; especially if he hopes to go into industrial employment. A department teaching identification must have a large pure-culture collection with the facilities necessary to maintain the cultures in typical form. Laboratory courses should be organized to give intensive and rigorous training in identification. The success of such a program may be judged by the ability of a student to identify a large number of "unknowns".

The productive mycologist will not fail to tell his story wherever and whenever the opportunity presents itself. Much information that would be helpful now lies buried in incompleting and unpublished manuscripts. If students are taught properly they will be informed as to the investigational possibilities of the subject, and guided into research channels resulting eventually in publication. Few major discoveries in any field of science have been made at one time or by one man. Most of our discoveries and inventions have been made possible

by the piecing and fitting together of a countless number of data. It is almost criminal to keep any known facts from co-workers in the field of science. The results of research become buried because of the inertia of the worker, a change of the field of interest, or deliberate suppression in order to prevent another investigator from "arriving first". Many times the investigator is too modest to realize that his few data may add up some day with others to something that will be tremendously important. The State Science Academies have been very useful in serving as publication media for young scientists to make public the results of important but preliminary research.

In the beginning of this discourse I state that every science had three objectives; one of these being a recognized responsibility to the public. The discoveries resulting from mycological research have fulfilled a part of this objective, but we have not been doing so well in another public relationship. We have not made our science known to and understood by that hypothetical, but very important man,—“the man on the street.” Mycology along with other sciences takes pride in speaking a language that is understood only by its initiates. Technical terms in any field are unavoidable whether it be fungi, baseball, needle-point, racetrack gambling or canasta. Many times however, descriptive terms in common usage will serve as well and be more easily understood. For instance, in describing the common umbrella-type mushroom we can use cap instead of pileus; gills instead of lamellae; stalk instead of stipe; ring instead of annulus, and cup instead of volva. Writing on technical subjects for the benefit of the public should not only utilize easily understood terms, but attention should be given also to sentence structure and length. In his recent book, “Art of Plain Talk” Rudolf Flesh speaking of the relationship of sentence length to ease of understanding classifies sentences as follows:

Very easy to understand.....	Eight words or less
Easy to understand.....	Eleven words
Fairly easy to understand.....	Fourteen words
Standard.....	Seventeen words
Fairly difficult.....	Twenty-one words
Difficult.....	Twenty-five words
Very difficult.....	Twenty-nine or more

Flesh states that scientific English averages thirty words a sentence.

It would seem that most scientists pride themselves in making their subject as difficult to understand as possible. Perhaps this is a remnant of the dear, dead days when the robber barons of industry were wont to exclaim “The public be damned.” Perhaps it partakes the mental complex that makes a man desire to join a fraternal organization so that he may have a few secrets from his wife and the other underprivileged members of mankind. Perhaps the basic reason is just snobbery—the desire to be exclusive. Whatever it is that makes a scientist write in a language that may be understood only by a few of his fellow scientists, it is a childish weakness and should be outgrown. The science that makes itself understood to the reading public will be the science that will receive public sympathy and support. More important than this; the science

that serves most will be the science that is understood and appreciated by the most people. It is a weak argument to claim that a man capable of doing technical writing is incapable of writing for the general public. If this is true it is a fault in our educational training for scientists. Do we mean that we are to insist that the scientific scholar should be able to read and write in two other languages in addition to his native language, but it is not necessary to teach him to write and speak in the vernacular of his own people? It is often claimed that a popular account of a scientific discovery is a distorted account. It is my contention that if you can write in technical language without distortion you should be able to write in common language. If you can relate your research in such a manner that it is interesting to a fellow mycologist you are lacking in ability if you can't write in a manner that will interest the nonprofessional man. In addition to our language requirements in the University, we should add a further requirement; that graduate students be able to describe the most difficult phases of their own research in a manner that would be acceptable to the science sections of a popular magazine such as Time magazine. Most of our scientists would benefit by a thorough course in journalism. However, it is not only an inability to write in simple language that does a disservice to the public, but also, some sort of an idea that prestige will be lost if one should write in interesting and understandable English. So long as this inane conception prevails so long will a scientist be regarded as a longhaired, impractical intellectual who has lost most of the attributes that make him human. As long as he is so regarded, the science which he represents will fail to meet the needs of the people who should be served.

Mycology has lived through the childhood when its devotees were happy and satisfied to pick mushrooms in the cool damp woods of early spring. It is growing toward a healthy maturity. It is our job as mycologists to see it does not loaf, procrastinate, or deviate from a path of service.