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BACTERIOLOGY IN GENERAL EDUCATION¹

IN casting about for a topic around which might be gathered a few thoughts suitable for this occasion, I was impressed with the lack of appreciation of the value of bacteriology in general education and the comparatively small amount of systematic effort that has been put forth to establish efficient methods for teaching this important new science. I became so deeply interested in these phases of the subject that perhaps with more zeal than wisdom I chose for my topic "Bacteriology in General Education."

The practical value of any branch of science keeps pace with the general knowledge of it and an understanding of the methods by which it can be applied. This in turn depends largely upon the teaching of those who are versed in its details of fact and law. The earlier recognition of bacteria did not suggest the important rôle they play in nature's economy. While their existence had been known for more than two centuries, it was not until their causal relation to infectious diseases was recorded that they made an impression upon society in general, and the medical profession in particular. It was the discovery of this great power which they possess to destroy man and beast that afforded a point of contact between humanity and this vast, invisible, organic world about us. If I correctly understand the meaning of our declaration in the constitution of this society, that its object is the promotion of the science of bacteriology, it would seem

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that our first and most sacred duty is to ascertain the facts in the life history of microorganisms, to describe the laws governing them and to bring this knowledge into bold relief, in order that so far as possible it may be utilized for the benefit of humanity.

It is often the tendency of men who spend their lives in the seclusion of scientific research to become less mindful of the possible practical application of their work than they are of the technical details and of the truth which it reveals. This is of necessity a natural tendency, for application can not go in advance of the discovery of the facts to be applied. History is replete with illustrations of unsuccessful efforts to benefit humanity by applying theory or dogma in the place of knowledge which perhaps at the time did not exist. On the other hand, the results of investigations of the men of pure science have often led to the formulation of exceedingly practical procedures. In the development of the theory and of the application of a science, therefore, we have to deal with two factors, namely, the intellectual longing for truth regardless of its immediate significance, and the desire to apply specific knowledge for the benefit of society. Occasionally these two elements are equally marked in the same individual. As an example of a mind dominated by the experimental method, as well as the desire to alleviate the suffering and to improve the life conditions of mankind, there is no name that can be mentioned with greater fitness than that of Louis Pasteur, the founder of bacteriology as a practical science.

Almost from its inception, bacteriology has been a technical subject with important practical applications. It has been the agent that has revolutionized the medical professions, vegetable pathology, dairying and soil economics. The bacteriological

work that is being done at the present time is for the most part aimed directly at some one or other of the problems in these practical fields. There are few sciences in which the newly discovered facts or laws have been so quickly utilized for some real or hoped-for benefit to man or beast, as in microbiology. The result of this haste to apply new theories has tended to confuse the public relative to the possibilities of a knowledge of microorganisms. It is difficult to have the truth crystallized that bacteriology is a technical subject which can be understood by the specialist only. The tendency to immediately apply newly cited facts, before they are properly demonstrated, has not infrequently permitted errors to be proclaimed as truth, with ultimate disappointment for both those looking for beneficial results and those attempting to attain them by the use of methods based on somewhat hypothetical data.

This is illustrated by the present confusion relative to the various groups of bacteria. The discovery of the tubercle bacillus was followed by the declaration that it was the same in all mammalian tuberculosis. This assumption was applied in the prophylactics of tuberculosis before the important fact was ascertained that there are varieties or races of tubercle bacilli, and also that there exists a large group of bacteria morphologically and micro-chemically at least related to them. Laymen and even medical men are having difficulty to reconcile more recent findings with the original teaching relative to the identity of mammalian tubercle bacteria. I do not refer to this disparagingly, for progress is sometimes made by retreats as well as by advances, but could the truth concerning the tubercle group of bacteria have been determined before the application of the hypothesis that the etiological

factors of human and bovine tuberculosis were identical, much controversy would have been avoided and numerous sacrifices and hardships would have been saved. I have called attention to but one of the important subjects in which the earlier positive statements have been greatly modified by later discoveries, for the purpose of emphasizing both the difficulties and the responsibilities of the bacteriologist in developing a pure science and in applying it in a practical manner.

From the earliest times, life has been given the highest price in the rôle of earthly possessions. How to prolong life has been the theme of many. In more recent years, economists have considered at length the cost to the state resulting from immature death and for maintenance of its sick and diseased citizens. The country is spending millions of dollars annually to support hospitals and asylums for the incurables. As Messenger has stated it, such a work is greatly to the credit of our hearts but not so much to the credit of our heads. Society has been temporizing with these great vital and economic questions, for the aim of the future is to restrict the need for hospitals by preventing disease. The nation-wide conservation movement has a large task to prevent the damages wrought in nature's economy by microorganisms. Again the state and society are calling upon the bacteriologists to bring to the pressing needs of to-day a knowledge of the vital forces that will tend to purify polluted streams and make the soil more fertile. The prevention of infectious diseases and the conservation of the soil are two great tasks that confront practical bacteriologists. The question is: How, in the present demand for applied bacteriology, can this science attain to its highest development and at the same time render the greatest service? The declaration in

our constitution limits our field to the promotion of the science of bacteriology, while other organizations have largely for their duty its utilization. It is practically impossible to make this differentiation complete, for as yet there are no societies that seem to deal with the application of important recent bacteriological findings. It is clear, however, that the essential purpose of this organization is to safeguard the purity of the science and to point out the way for its advancement.

The fact has already been conceded that bacteriology is the science that has much to do, and in certain instances practically all to do, in finding the solution and in settling the details of many of the common every-day problems in the conservation of life and health of the higher forms of life. Yet this science, with such possibilities, possesses scarcely any interpreters of its actual value to society at large, and it finds little or no place in the curriculums of our schools and colleges for general education.

The true significance of a knowledge of bacteriology should require no explanation. Because it has grown up through technical laboratory research and routine, educators seem to feel that its true service is restricted to such laboratories. For the highly specialized or professional work we agree, but should not the knowledge of basic facts and natural laws that have transformed so many practises in medicine, sanitary science and agriculture become common property? Is there not a place in our common schools and liberal arts colleges for courses in bacteriology for the purpose of imparting fundamental knowledge that will enable society to come into possession of an understanding of this science? It can not be successfully gainsaid that information concerning the cause of fermentations, the storing of nitrogen in the soil, the causes for the changes in food stuffs

and the etiology of the common infectious diseases is as important, or the acquisition of such knowledge of as much disciplinary value, as the study of the life history of the denizens of the deep as now required in many if not most biological courses. The world looked with wonderment at the hitherto unparalleled success in avoiding preventable diseases by the Japanese army at the time of the Russo-Japanese war. Up to this conflict it is affirmed that for every man killed with a bullet in war four died from infection, while in the Japanese army for every man who died from infection four were killed with bullets. The explanation of this victory over all the experience of the past was found to be the training of the Japanese soldiers in the principles of bacteriology. It should be clearly understood that this marvelous success was due simply to the application of knowledge which Europe and America had brought forth and which the Japanese had applied. Would it not be quite as valuable in civil life to have the people versed in the simple facts and principles of a science that would enable them intelligently and designedly to avoid infection, strengthen the efforts of the sanitarian, and enable the agriculturist to restore fertility to the soil, as to have them possessed of a knowledge of things far remote from their immediate environment? It is not my desire to belittle any course of instruction, for all knowledge is valuable, but I do wish to record the opinion that a science like bacteriology, which plays such an important part in the immediate physical well-being of every individual, should have a place in the curriculum of the schools for the masses.

Because bacteriology is a technical subject with numerous avenues of usefulness there is the greater need, in order to prevent errors in its adaptation, for efficient

instruction concerning it in both popular and technical schools. The prevention of its false application will attain its maximum success after the diffusion of knowledge concerning microorganisms. Knowledge is power, and when the people are versed in the fundamental principles of this science they will avail themselves of such information to improve their condition economically and to avoid the dangers of infection.

The position occupied by bacteriology in general education will depend largely upon its teachers. At the present time it has not been granted, with few exceptions, a place in the curriculums of popular educational institutions. Sanitarians and others have endeavored to educate the people in its principles by imparting isolated facts. This is having a certain beneficial effect, but unfortunately the recipients are unable to adapt this fragmentary knowledge to new conditions. At present the masses depend for their guidance in this subject upon the results obtained in professional laboratories and the teaching in technical schools. As bacteriology had its origin in the findings of those seeking the cause of important phenomena, it is to be expected that, for a time at least, its fountain head will continue to be in the results forthcoming from such researches. As these investigators are largely its teachers, we are brought to a discussion of methods for teaching it in professional schools.

I am led to touch upon this subject from the point of view of students, as I have known them, who have received their elementary training in bacteriology in different places. Every one who has to deal with post-graduates in this subject appreciates fully the difficulties encountered in properly orienting the subject-matter taught to beginners in order to produce the desired

result. It is the presence of these difficulties that prompted the opening of this subject, which can not be closed until after the results of many trials and careful discussions are recorded. On my shelf are numerous text-books and laboratory manuals for teaching this science. If they are carefully analyzed, they will give a variety of impressions as to the purpose of the course prescribed. Here then is found the logical reason for the discussion of the fundamental principle in its teaching. The crux of the question is: Shall bacteriology be taught as a science in our professional schools or shall simply the essential facts to be applied be imparted?

Some years ago I accepted a position carrying with it the responsibility of teaching bacteriology in a professional course. I went from a research laboratory where I had grown up with the technique and knowledge of a certain phase of the subject. I labored under the delusion that the essential elements could be easily taught. There was no difficulty in securing the interest of the students, but the pangs of disappointment were mine when these same interested men attempted to apply the knowledge I supposed they possessed, in the actual practise of their profession. Their errors were not more grievous than those of other men, but the things they did and the kind of assistance they sought pointed clearly to a lack of knowledge or understanding of the subject which I believed I had taught with great clearness. This combined experience has caused me to question the efficiency of many pedagogical methods employed in teaching bacteriology, and to test as best I could different methods of instruction. The conclusion that seems to me inevitable is that the course in bacteriology must be dominated by a scientific system of presentation and that the technique, facts and

laws of bacteriology must be clearly developed before too much stress can be placed upon the value of fragmentary facts such as staining tubercle bacilli, or the examination of water for the colon bacillus. The difficulty does not rest alone in a lack of the knowledge of technique in making the examinations, but quite as much in the inability to interpret the findings. Conclusions drawn from isolated facts by partially informed individuals are responsible for many of the charges of error against our laboratories. There is, therefore, no way to more effectively promote this science than to have its conclusions based on accurate and verified data.

I have considered the difficulties encountered by way of lack of time granted to bacteriology in curriculums, the eagerness of many inexperienced men to assume charge of bacteriological work and the pittance of salaries often paid for this service. These are recognized hindrances, but they are far more easily overcome than the results of hurried application, snap diagnosis, indifference and commercialism that dominate this work wherever the spirit of science and regard for scientific verification are not enthroned. If the public is to be benefited, as it should be, by the existence of this science, it is important that those responsible for the training of men to occupy positions in public laboratories take fully into account the nature of their teaching. Wherever the true scientific spirit dominates, the final results prove to be more helpful. It is not my purpose, nor do I believe it possible, to outline a schedule to be followed by all. It is, however, within our power to give to bacteriology the dignity commensurate with its vital relations to our environment and to teach it as a science and not as an aggregation of biological facts.

I can not leave this subject without

pointing to the possibility of misguided application of this science because of a lack of understanding of it. The mere knowledge of the presence of microorganisms in milk, in water and in dust is responsible for many unprofitable propaganda. In following these, the real dangers may be overlooked. This is illustrated in certain practises. There are, for example, those who, because of a low bacterial count of milk, consider it of excellent quality, without taking into account the condition of the udders or the general health of the cows from which it was obtained. In certain lines of domestic science much stress is placed on the bacterial content of dust and the unsanitary condition their presence creates, when the actual problem is simply one of cleanliness, as the organisms present are of less significance than the dust itself. Regulations based on certain microbial findings and the importance thereof are frequently appealed from because of the seemingly unwarranted expenditures they impose. Many of these interpretations prove later to be without justification, and the annoyance and perhaps hardships they occasioned would have been avoided if the science of bacteriology rather than a few isolated facts had been applied.

There is at present a great demand for men who are capable and qualified to bring to the aid of those struggling with great sanitary and economic problems the relief that is possible, or that seems to be attainable by the utilization of the laws of microbiology. The question we have to consider is how this demand can be satisfactorily met. How under the present restrictions of bacteriology in technical schools and the willingness—because of the lack of knowledge of it—to keep it out of curriculums of schools of liberal arts and sciences, are we going to secure the men and train them to efficiently occupy

these positions? The answer may come that our problem does not differ from that existing in other biological and physical sciences. This may be true, but the fact remains that we are a body organized to promote this science and consequently clothed with responsibility that we can not throw off relative to the ways and means to be employed in bringing into existence more efficient bacteriology. The lesson taught by the older branches of knowledge, such as chemistry and physics, points to but one solution, namely, the upbuilding of the purity of the science.

Thus far, bacteriology has operated as an aid to many branches of applied learning, like medicine and agriculture, and for that reason it has not reached its full development as an independent science. Because of this its greatest value has not been secured by those activities which it has served. Its application has been so immediate that most of those who have come in possession of any knowledge of it have been attracted to some field for its application. Some of these places require more breadth of knowledge than others, but there are indeed few of them where bacteriology is dignified as a pure science and its truths and laws studied, tested and cherished as such. The difficulties met in nomenclature, bacterial floras and technique speak for themselves concerning the fragmentary status of the knowledge of this subject. With its diversion to practical lines there is too much specialization before there is a foundation of basic knowledge sufficient to support the superstructure. The desire for application rather than the scientific spirit is manifested too early and often too conspicuously in the devotees of this subject.

Perhaps the greatest difficulty in finding men desirous of taking up bacteriology for a life work is the fact that it is an un-

known topic to them until they reach it in some technical or professional course. By this time their mind is usually centered on the line of attainment desired, and the hurried instruction they receive in bacteriology does not illuminate the science sufficiently to attract them. To overcome this, two alternatives present themselves, namely, to have a preliminary course in bacteriology in the preparatory school or to have the course in the professional schools extended and taught more efficiently. It seems to me that it is a mistake to assume that persons who have received instruction in some narrow field of the subject, and who may decide to follow this work, are qualified to take at once positions of responsibility. There is no other science where accuracy, correct interpretation and application are of more vital importance than they are in this, yet there is no other science where men are elevated to positions of responsibility with so little real preparation. We seem to have forgotten that in the acquisition of knowledge and the coming into an understanding of bacteriology the element of time and the discipline of routine work and research are as essential as they are in chemistry or in physics. Again, in the preparation we must not be unmindful of the necessity of a thorough preliminary training in the fundamental sciences and modern languages.

The question is a perplexing one. The errors of insufficiently trained workers call forth trying criticisms that those who are responsible for laboratory work must bear. Yet when more thoroughly qualified men are sought for they can not be found. What then are we to do? We each and all who are in professional schools must feel that the regular course or courses we give in bacteriology can not fully or adequately prepare one for teaching the subject or taking a responsible position in it. Yet the student

has ability, is earnest and a hard worker. He is financially so situated at the time of his graduation that he can not continue his studies. In this condition the acceptance of the proffered position, with the mental resolution that he will study hard and later do graduate work, is apparently the thing for him to do. The outcome of such a course is well known. The numerous and unexpected difficulties attending the new position together with the increased amount of routine exhaust the energies and the hoped-for special training is rarely secured and the desired efficiency is not attained. Until we have a better system for preparing young men the present practise will continue and our science, our laboratories and the public must suffer the consequences.

I have dwelt somewhat at length on the difficulties which exist in the promotion of the science of bacteriology. If they are analyzed it will be found that they are temporary, and incident to the way by which man found his dependence upon his microbial environment. After the numerous demands for men to do work, which the recognition of the importance of microbes has created, bacteriology will undoubtedly develop into a pure science that will be as eagerly pursued as any branch of learning in the acquisition of an efficient education.

In conclusion, I desire to make a few suggestions as to the possible means for both promoting this science as such and increasing its value as an asset in practical knowledge.

The first is to introduce in the courses of biology in our common schools, instruction on the existence and varieties of bacteria, and something of the action of a few of the more important economic species. This would afford a little fundamental knowledge to help the masses to better understand the cause of many natural phenomena.

The second is that there should be established in our normal schools, colleges and universities thoroughly scientific courses in bacteriology. Such a course would lay the foundation of the science and place it on a par with other branches of biology, such as botany and zoology. Such departments should be prepared to do research, thereby fitting men for the special phases of the subject in technical and professional schools, and qualifying others to do research of a purely scientific nature, without reference to any particular trade, occupation or profession. The problems here are as numerous and their solutions are as taxing upon the mental forces of the investigator as they are in any branch of scientific endeavor.

The third suggestion is a plea for more scientific methods of teaching bacteriology in our professional schools. The course should, as a rule, be lengthened and the theoretical teaching supplemented by as much practical work as possible.

We should in view of all conditions rejoice in the achievements of the first half century of practical bacteriology. There is every reason to believe that with a better understanding of the vital relation of the microbial environment to higher forms of life bacteriology will be productive of still greater benefits, because of the education of the public concerning it and because of its more intelligent application by all.

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THE PALEONTOLOGICAL SOCIETY¹
ADDRESS OF THE PRESIDENT

THERE is a respectable virtue in the observance of well-tried usages. In the societies out of which we have emerged it

¹ Delivered by request at a joint meeting of this society and the Geological Society of America, Pittsburgh meeting, 1910.

has been the established procedure to penalize a retiring president with a somewhat formal address. It is a practise which is at once a solace and an opportunity; the former, inasmuch as successors to this honor of office must share these heart-searching efforts of its closing hours; an opportunity, for here is an outlet to unspoken cogitations which seldom take on the formal expression of the printed page, a chance to weave together the threads of evidence or suggestion we may have followed many years and left dangling; perhaps even, to perfect into some well-finished form the summation of our larger problems. It seems to have been tacitly assumed by our council and membership that I should inaugurate for this society the accustomed procedure anew. I frankly face this situation, but with no promise of the adequacy of the outcome.

I. At the outset I propose to take brief advantage of my own somewhat peculiar position and experience as a public official in paleontological science as a point of view from which but few of you, my audience, may have had opportunity to contemplate the subject. You will, I pray, be indulgent with this exploitation of a personal attitude, for it does seem to have certain complementary attributes which may in a way illuminate and supplement your own experience. If you find it a rather frank expression it will be couched in terms of fraternal regard, and I hope entirely devoid of unfair or invidious comment which might expose the writer to the charge of being a profane railer at the sanctities. My contact with the public of an intelligent and progressive government is now of rather long standing and this experience has been illuminating in any estimate of public sympathy with pure science.