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THE FIRST FORTY YEARS OF THE SOCIETY OF AMERICAN BACTERIOLOGISTS[1]

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THE last ten years of the nineteenth century are perhaps best known by the term "the gay nineties." A more important taxonomic characteristic is perhaps expressed in the description of this decade, and the one preceding it, as "the golden age of bacteriology." Between 1880 and 1900, a new science was born, a science fraught with rich gifts of health and happiness for the human race and one which—unlike many other sciences—has been used by man only for beneficent purposes. It was natural, therefore, that toward the close of this century the devotees of this new science should organize for the better performance of their challenging task.

[1] Address delivered at the Fortieth Anniversary Meeting of the Society of American Bacteriologists, New Haven, Conn., December 29, 1939.

This tendency took shape in the establishment of the Laboratory Section of the American Public Health Association at the Minneapolis meeting in 1899. Our own society was, however, the first independent organization devoted specifically to the service of bacteriology in the United States—perhaps in the world.

The idea was first evolved by A. C. Abbott, H. W. Conn and E. O. Jordan at the 1898 meeting of the American Society of Naturalists, and the new organization was conceived as an affiliate of that society. On October 17, 1899, a circular letter was sent out by the three pioneers to some forty bacteriologists, and on December 28, 1899, the organization meeting of the Society of American Bacteriologists was held at the Yale Medical School, in response to this call. W. T.

Sedgwick was chosen as the first president of the new organization, A. C. Abbott as vice-president and H. W. Conn as secretary-treasurer.

It is of interest to note that December 29 is Professor Sedgwick's birthday. If he were with us on this occasion to accept our tributes of affection, he would be eighty-four years old.

Of the 57 charter members of the society then formed, 18 are known to be still living and 7 of the 18 are present at this fortieth anniversary. The survival powers of the staunch 18 will be duly recognized before the close of this meeting; but a word of tribute is in order to the members of our fellowship who have passed on the torch of progress to our hands. Rarely, I think, has a new organization enjoyed the leadership of so distinguished a band of sponsors. In this group were A. C. Abbott, bon-vivant and leader of medicine in Philadelphia; J. Adami, distinguished Canadian pathologist; H. W. Conn, typical New Englander, decorous, keen-witted and sure; E. K. Dunham, of New York City's élite, wise counselor to many; F. P. Gorham, genial founder of a vigorous department at Brown and faithful public servant of Rhode Island; George W. Fuller, dominant figure in the development of sanitary engineering, a mind of razor keenness in some 250 pounds of flesh; Wyatt Johnston, pioneer water bacteriologist, of Montreal; E. O. Jordan, frail and gentle, but full of rich accomplishment as teacher, as investigator and as author of a great text-book, tireless in service and wise in counsel; L. P. Kinnicutt, gracious and aristocratic teacher of sanitary chemistry at Worcester; Veranus Moore, of Cornell, pioneer veterinary bacteriologist and able administrator; William H. Park, genial and kindly, founder and for forty years head of New York City's Health Department Laboratory, co-author (with Robert Koch) of the theory of the well carrier, whose brilliant contributions to science, in connection with the bacteriology and immunology of diphtheria, place him among the world's great bacteriologists; T. M. Prudden, thoughtful, ascetic and precise, a power behind the throne in the reorganization by Hermann Biggs of the New York City and State Health Departments; W. T. Sedgwick, beloved teacher and unselfish public servant, founder at the Massachusetts Institute of Technology of our first widely influential school of public health; Erwin F. Smith, father of plant pathology in the United States; Theobald Smith, incomparable scientist, sparse and dry and black-bearded, so imaginative that he anticipated in the nineties many of the "discoveries" made by others for a quarter of a century, so uncannily clear-headed a thinker and so meticulous an investigator that he left no errors for his successors to correct; G. M. Sternberg, of the Army Medical Corps, author of one of our first text-books of bacteriology; Victor C. Vaughan, rugged and salty, a fiery driving force in American medicine; William H. Welch, pioneer pathologist, statesman of medical education and of public health, expert in medical history, as genial a bon-vivant as Abbott, as wise a counselor as Jordan, tireless in energy as Fuller, kindly and helpful as Sedgwick. We knew them all. We loved and admired them all. We honor their memory and pledge our best efforts to carry on the tradition they have left for us.

During these forty years, the society which these men established has grown beyond their fondest dreams. Founded in 1899, we passed through a lag period of about five years, membership increasing only to about 100 by 1905. A phase of late lag or slowly accelerating growth brought us to 300 members in 1915. Between 1915 and 1923 occurred the phase of logarithmic increase, bringing the membership up to over 1,200 in the latter year. The generation time in this phase was therefore about four years. During the depression, the nutritive value of our national culture medium was so reduced that the membership curve dropped to less than 800 in 1932. The amino-acids introduced by the New Deal stimulated a second rise, however, and to-day we are nearly 1,400 strong. No toxic waste products of dissension have been manifest; and the services of Hitchens and Sherman and Baldwin as our beloved secretaries have at all times provided valuable regulative factors.

Meanwhile, gonidial budding has added to the vitality of the parent stock. Beginning with Washington in 1917, local branches have been established (under the leadership of Conn and Koser) to the number of 17, extending from the Connecticut Valley to Southern California.

Our annual meetings have been notably successful, particularly since the establishment in 1925 of the program committee, which through its successive chairmen, Bayne-Jones, Cohen, Frazier and Berry, has functioned to perfection. Our sponsorship of the International Microbiological Congress of 1939, under the presidency of Rivers, is another feather in the cap of the society.

We have operated the *Journal of Bacteriology* since 1916, the *Abstracts of Bacteriology* from 1917 to 1925, *Bacteriological Reviews* since 1937 and *Microbiological Abstracts* since 1938. Our share in the management of the American Type Culture Collection since 1925, the development of the Descriptive Chart by Chester in 1905 and by H. J. Conn since 1917, and the admirable work of the Archives Committee under Cohen since 1934 have made notable contributions to research and teaching and to the cultural and historical backgrounds of our science.

Such a society as ours is not an end in itself but a means for the promotion of the field of knowledge which it represents. What has happened to the science of bacteriology in these four decades which we review to-night?

It will be of interest to turn back to the program of the first New Haven meeting to see what the bacteriologists of 1899 were really doing and thus give us a datum line for measuring the progress made since then. There were 25 papers on this first program which may be subdivided roughly as follows.

There were four papers on this program dealing primarily with descriptions or demonstrations of specific organisms; on *Bacillus enteritidis* by Gehrmann, on the plague bacillus by Park, on a new sporothrix by Hektoen and on Actinomyces by Ernst. The earlier phase of discovery of new organisms had already passed its zenith.

Two papers by Conn and Theobald Smith dealt with variation in bacteria, and two, by Chester and Erwin F. Smith, with taxonomic problems, an early indication of the society's later interest in such problems.

Four papers only dealt with researches bearing on the physiological reactions of bacteria, and these on a very elementary plane. Harding presented two of these, on steam sterilization, Sedgwick and the speaker discussed the influence of cold on the typhoid bacillus, and Erwin Smith the antiseptic properties of thymol and chloroform.

One paper by Ernst dealt with the teaching of bacteriology and one only touched on serology, a study by Park on the effect of blood serum from tubercular animals and men upon the tubercle bacillus.

The rest of the papers presented were in three different fields of applied bacteriology. Five of them dealing with water and sewage bacteriology were contributed by Clark and Gage, Jordan, Moore and Wright, and Kinnicutt; four, on milk bacteriology by Conn, Leighton, Keith and Ward; two on industrial bacteriology by Leow (tobacco fermentation) and Prescott and Underwood (canned foods).

The bacteriologist of 1899 was not, however, so helpless as one might imagine. To check my memory of what I thought I was taught as a student at this time, I have referred to the fifth edition of A. C. Abbott's "Principles of Bacteriology," published in the year that this society was founded. Here we find the general nature and morphology of bacteria and of their chemical activity well described, but with no attempt at classification and no consideration of variation. The influence of oxygen and temperature upon their growth was recognized and the action of disinfectants (including even the factor of ionic dissociation) intelligently discussed. Methods of sterilization were well developed, incubators available and plating on solid media (including the new Petri dish, as well as the ice-cooled mechanically leveled plane glass plate) described. Broth and serum media and the Smith fermentation tube were in use for colonial and biochemical studies, with staining fluids (fuchsin, gentian-violet and methylene blue) as well as the gram stain, flagella stain and stain for the tubercle bacillus. Animal inoculation procedures were of course described. In the chapters dealing with specific organisms, we find the major characteristics of the common staphylococci and streptococci, of the gonococcus, the Pfeiffer bacillus, the causative agents of plague, tuberculosis, typhoid, cholera, diphtheria, anthrax and tetanus, the colon bacillus, the nitrifiers, the spirilla and vibrios. A chapter on "Infection and Immunity" emphasizes the evidence for active humoral immunity in such diseases as diphtheria and tetanus and describes the phenomena of phagocytosis. Concluding chapters deal with very primitive procedures for the study of the bacteriology of water and air and for the testing of disinfectants. We learned a good deal as students in the laboratories of the nineties.

The knowledge then available even to such a genius as Theobald Smith was, however, but a tiny fraction of what the graduate from an elementary course in bacteriology has at his disposal to-day. To refresh my memory, I have read through the 277 pages of Dr. Bayne-Jones' invaluable index to the first 30 volumes of our journal published between 1916 and 1935. I hasten to admit that an occasional valuable contribution may have seen the light in some other publication; but I believe that the *Journal of Bacteriology* presents an excellent mirror of the progress of our science. Let us use its columns as at least a fair random sample of what bacteriology has come to mean to-day and note how its scope has broadened and its penetration deepened since the days of the founders.

First of all, we may note some of the most important of the species and groups of bacteria which were unknown or almost unknown in 1898 and yet have come to be subjects of major interest to-day. Here we may list the dysentery group and the Salmonellas, *Treponema pallidum*, the undulant fever and tularemia organisms, the diverse serological and cultural types of pneumococci, meningococci and streptococci, the fusiforms and new anaerobic spore-formers, the azotobacter group and the rhizobia, the actinomycetes, the propionic bacteria, the cellulose-destroyers, the thermophiles and the sulfur bacteria. All these and many more are discussed in detail in the pages of the journal; and even more startling to the fathers of bacteriology would have been the papers (beginning in 1927) on the viruses of plant diseases, of herpes, of vaccinia, of poliomyelitis and encephalitis, of influenza and the common cold.

Our society has not, however, been content to study these varied types of new organisms which the science of bacteriology has revealed as isolated and accidental phenomena. In our very first volume, we find papers on the classification of the aerobic spore-formers and of the colon-typhoid group and on the grouping of strains of meningococci. In the next year, 1917, Buchanan began his epoch-making contributions to systematic bacteriology, and the Committee on Characterization and Classification of Bacterial Types made its first report. In the next year, 1918, Conn's Committee on Methods of Pure Culture Study began its fruitful labors. It may fairly be claimed that the United States has led the world in the field of bacterial taxonomy.

The notable achievements of the taxonomists are secure; but their significance is modified, though not in any sense discredited, by the somewhat malicious efforts of the students of variation. The tremendously important phenomenon of dissociation does not appear in the index of our journal till 1920 and becomes important there only with the work of Hadley and Soule in 1927. In the very first volume, however, there appears a pioneer contribution on "life cycles" from Löhnis and Smith, and in 1917 Mellon enters the picture with an even bolder challenge. To-day, our conception of a bacterial type must include not one but all of the characteristics which it and its dissociants may assume under varying environmental conditions.

Allied to this problem of variation, but quite distinct from it, are the phenomena of the culture cycle, reproducing in each individual medium-habitat a series of changes analogous to those which occur in the body of a multicellular organism. From the work of Clark and Ruehl in 1919, that of Sherman and Albus in 1923, Bayne-Jones in 1929 and a group of Yale workers in the thirties, this field of research has been developed in our journal, though Henrici unfortunately sought other channels of publication and, in the present discussion, must be sternly ignored.

Even more fundamental are the complex researches which have been made in the field of bacterial metabolism. The exhaustive study of nutritive requirements, the amino-acids, the salts, the vitamins and other accessory substances and the ingenious analysis of the organic materials which are synthesized or formed by decomposition which we owe to such laboratories as those of Rettger and Fred are exhaustive and profound.

Along with metabolism, the second major problem of bacterial physiology is that of the chemical and physical conditions limiting growth and viability. The columns of the journal contain numerous valuable practical contributions on limiting values for heat treatment and chemical disinfection. The most important contribution in this area, and one of the most significant of all American contributions to bacteriology, is the classic paper of Clark and Lubs on the colorimetric determination of hydrogen-ion concentration, published in 1917. If you will try to imagine bacteriological and serological technique without modern methods of measuring pH you will realize the magnitude of this achievement.

In 1928 Cohen and Thornton and Hastings presented to the readers of the journal another highly significant conception—that of oxidation-reduction potentials. In 1921, Holm and Sherman and, in 1923, Falk and the speaker opened up the quantitative study of the stimulating and inhibiting effects of cations. In 1926 Rettger and Valley demonstrated the essential need for carbon dioxide in stimulating bacterial growth. The influence of surface tension, the effect of radiation, the destructive power of bacteriophagy, have been the subject of other significant series of contributions.

The bacteria have been followed from the laboratory out into their natural habitats, up in the clouds by Proctor, down into the depths of the sea by ZoBell. Henrici has revealed to us a whole new world of lake bacteria, sessile forms which the traditional techniques of bacteriology passed by unseen.

Of equal practical and theoretical importance is the vast field of serology, now almost as extensive as bacteriology itself, but existent only as a bare initial outline when this society was founded. Toxins and antitoxins, complements and antigens, precipitation, neutralization and skin reactions, hemolysins and carbohydrate fractions fill many of the pages of our journal, and their utilization saves tens of thousands of lives each year in the United States.

Finally, less dramatic but in the long run equally significant for human welfare, are the numerous contributions by our members in the practical fields of water analysis, of stream pollution and sewage disposal; of dairy bacteriology (with titles occupying five pages in the index to our journal, and beginning with Frost's description of his microscopic counting method in 1916); of soil bacteriology and of industrial bacteriology.

I think you will agree that the first forty years of American bacteriology has justified the wisdom of the founders. What are the prospects for the four decades to come?

Here inspiration fails me. I am neither a prophet nor the son of a prophet. But I do know this. The future of our science depends on the young men just beginning or completing their graduate work, the young men who sit in this audience as I sat at the meetings of 1899. It is to their hands that we commit the torch, and it is their vigilance that must keep the flame burning.

Science does not always go forward. Sometimes it halts and stumbles. During the past few months I have been studying a period when this occurred—a period when prolonged gestation delayed the birth of the science of bacteriology, and, in particular, of the germ theory of disease, for a century and a half.

The plague tracts of the fourteenth century recognized the importance of contagion in the spread of epidemic disease as clearly as we recognize it to-day; and in the sixteenth century, Fracastorius developed a complete and closely reasoned theory of contagion by direct contact, through the air and by fomites which can scarcely be improved upon in 1939. The contagious element was, however, conceived in chemical rather than biological terms. Although Fracastorius wrote of "germs" or "seminaria," it is clear from the context that the term was used only as we might speak of "the germ of an idea" and not as implying living organisms.

This gap in epidemiological thinking was, however, filled in the seventeenth century. Athanasius Kircher, in his "Scrutinium Pestis" in 1658, first clearly advanced in definite and challenging terms the theory that communicable disease was due to *"contagia animata"* to minute living "worms"; and he backed up his contention by actual observation of such worms in decomposing organic matter and, perhaps, in the tissues of plague patients themselves. With the microscopes at his disposal he did not, of course, see bacteria; but his championship of the conception of living germs as the cause of disease is a landmark in the history of epidemiology.

Kircher held that the germs he postulated were spontaneously generated in decomposing organic matter. Ten years later, in 1668, Francesco Redi, in his "Experiments on the Generation of Insects," corrected this error and demonstrated experimentally that—for the maggots of insects at least—spontaneous generation did not occur, but that, when living matter was apparently produced from dead matter, the seeds of life must be introduced from outside.

Within one more decade, in 1676, Antony van Leeuwenhoek of Delft actually discovered the bacteria with his powerful magnifying glasses and described them in his epoch-making letter to the Royal Society of London—the letter which Cohen has reproduced and published for our society in full. Thus, by 1700, there was available the *"contagium animatum"* concept of Kircher, the demonstration of biogenesis by Redi and the discovery of the bacteria by Leeuwenhoek. If an open-minded and imaginative observer had put the work of these three pioneers together, the germ theory of disease could have been developed in the seventeenth century instead of the nineteenth.

Unfortunately, there was no leader in seventeenth century medicine capable of accomplishing such a synthesis. On the contrary, Thomas Sydenham, its outstanding figure, ignored the factor of contagion almost completely and based his whole theory of epidemiology on the epidemic constitution of the atmosphere, an occult property beyond the power of observation, let alone measurement; hence, nearly two centuries of sterile philosophizing and controversy between miasmatists and contagionists—which was only terminated by the experimental methods of Louis Pasteur.

The bacteriologist of 1940 will not need warning against the errors of Sydenham's approach. We have learned the lesson that the assumption of a force beyond the scope of actual observation leads to metaphysics and not to science. There is another lesson from this seventeenth century situation which has, I believe, a fundamental message for us. That lesson is the importance of openmindedness and imagination in visualizing the importance of new observational and experimental data in fields allied to—but somewhat removed from—our own. There is a similar lesson in more recent experience. It is astounding to me to realize that I, with all the bacteriologists of my generation, had under my nose each day plates containing rough and smooth colonies, and for twenty years we ignored them. Even the scientist too often sees with his mind and not with his eyes. Custom and inertia blind him to the light that is ready to pour in. If you young men are to carry on the torch of bacteriology, keep your minds free from hampering pre-conceptions and open to new truth. I once had in my laboratory a text on the wall which read, "The experiment which succeeds teaches us nothing." If things come out as we have anticipated, we are only craftsmen perfecting an edifice already erected by others. The exception to the rule, the unexpected result, the novel observation in some other science which can be related to our own—these are the materials by which the new cathedrals of science are built. If you who are beginning your careers have courage and imagination, curbed always with the bit of experimental verification, the second forty years of American bacteriology will be more glorious than the first.

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I am grateful for this opportunity to join with The American Institute of the City of New York in honoring one of our country's great pioneers, Dr. Frank Conrad.

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