

## ORIGINAL CONTRIBUTION

# Evolution of Microbiology as Seen in the Textbooks of Edwin O. Jordan and William H. Park

James Strick

*Program in Biology and Society, Department of Biology, Arizona State University, Tempe, Arizona*

*Historians of science account the appearance of textbooks as an important step in the formation and consolidation of a new discipline. The texts of Park and Jordan were both very important in this light; however, they also can be used as a gauge of changing concepts within microbiology in the first four decades after its consolidation as a discipline, 1900-1940. This paper tracks these important texts and through them changing attitudes toward several important concepts: bacterial variation, human/bovine tuberculosis, and the existence of a non-symptomatic carrier state in infectious disease. The two texts are also compared regarding their view of microbes as pathogens vs. microbes as important and ubiquitous ecological agents.*

William Hallock Park (1863-1939) and Edwin Oakes Jordan (1866-1936): both were presidents of the Society of American Bacteriologists (1912 and 1905, respectively), both authors of important microbiology textbooks that ran through many editions, both powerful forces, then, in twentieth century microbiology. Both men began as members of that first wave of enthusiastic young scientists to take up the new science of bacteriology in the wake of its creation by Koch and other pioneers.

Park (Figure 1) initially trained as a doctor and intended to specialize in otolaryngology. But after a unique research opportunity under Dr. T. Mitchell Prudden at Columbia College of Physicians and

Surgeons, establishing that the Loeffler bacillus really was the cause of diphtheria, he was "bitten by the bug" of bacteriology and never turned back. Herman Biggs, pathologist of the New York City Health Department soon spotted his promise, and Park was hired in 1893 as bacteriological inspector and diphtheria diagnostician. The position offered the opportunity for research and put Park in charge of the Health Department laboratory of one of the world's great cities, with the services of a chemist and two bacteriology assistants. During a career of forty-three years until retiring in 1936, Park built the New York City Health Department laboratory into one of the world's leading centers of bacteriology, rapidly applying new laboratory

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<sup>a</sup> *To whom all correspondence should be addressed:* James Strick, Program in Biology and Society, Biology Department, , Arizona State University, Tempe, AZ 85287-1501.  
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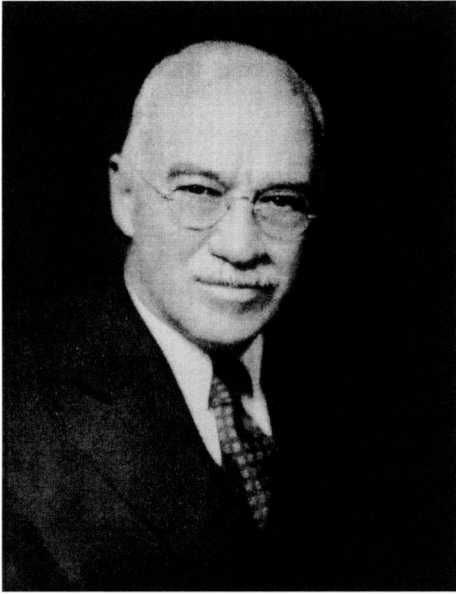
knowledge to the practical management of epidemic disease in the streets and slums of a metropolis [1].

Jordan (Figure 2) trained as a general biologist under William T. Sedgwick at MIT, and he quickly became interested in the implications of bacteriological knowledge for sanitation and hygiene. In 1888, immediately after graduation from college, he spent two months studying with Prudden in New York, just a year before Park began working under that same distinguished man. From him, Jordan learned the latest discoveries from Koch and other cutting-edge European labs, where Prudden had studied as recently as 1885. Jordan made his name initially studying the bacteriology of sewage and of drinking water treatment, first at the Lawrence Experiment Station outside Boston. It is to his early work that we owe the discovery that *E. coli* and related intestinal bacteria are constantly present in sewage but almost never to be found in water known not to be contaminated with sewage. This, of course, quickly became, and still is today, what Jordan had hoped for: one of our most reliable indicators of sewage contamination of a drinking water supply. And Jordan's work pioneered the practical application of such knowledge to the sanitation problems of many cities, even involving lawsuits and court cases over alleged disease from sewage contamination [2].

At the turn of the century, very few textbooks of bacteriology existed in English. Both men saw this need and responded, Park's first edition appearing in 1899 and Jordan's in 1908. Both were up to date, as well as being good, readable writing, and both quickly enjoyed wide use. Demand was so great that by 1918 both had entered their sixth edition. Park's book was at first titled *Bacteriology in Medicine and Surgery*, but by the second edition of 1905 had changed to *Pathogenic Microorganisms, Including Bacteria and Proto-*

*zoa*. Park was joined by a new co-author on this second edition, his brilliant and fiery assistant Dr. Anna Williams, and their collaboration, like the title, continued through the 1939 11th edition that appeared shortly after Park's death. The book's emphasis was clearly on the medical applications of bacteriology. It was such a standard text that in America and abroad it "became known to medical officers, students and laboratory workers as 'Park and Williams'" [3]. Indeed, by Park's retirement in 1936 the book was even widely used among health officials in Japan and the Far East [4].

Jordan's text *A Textbook of General Bacteriology*, by contrast, from the beginning emphasized the multiple functions of bacteria in nature, including their positive roles as decomposers, in the nitrogen cycle, etc. Thus, though he devoted many chapters to what was known about the bacterial and protozoal agents of disease, Jordan approached bacteria more as a biologist than a medical man. He himself was interested in the bacterial diseases of plants, nitrogen fixation, and the self-purification of rivers downstream from a sewage outfall as much as in human pathogens. It was he, in fact, who first discovered, soon after becoming a professor at the University of Chicago at age 26, that the Illinois River had completely purified itself of Chicago sewage colon bacilli in less than 150 miles of flow. He had been intimately associated with Chicago's decision to stop emptying its sewage into Lake Michigan, because of major typhoid outbreaks. However, after the change, with the new disposal outlet eventually flowing into the Mississippi, the City of St. Louis sued Chicago for endangering the health of its own citizens. This suit eventually reached the Supreme Court. Jordan's testimony before the Court about the self-purification of the Illinois River well above its confluence with the Mississippi "was the decisive factor in its decision in



**Figure 1. William Hallock Park.**



**Figure 2. Edwin Oakes Jordan.**

favor of the city of Chicago,” according to one author [5].

Jordan’s view of bacteriology included the ecological perspective that Rene Dubos has attributed to Pasteur (and certainly shared himself) [6]. In his 1939 obituary of Jordan for the National Academy of Sciences, William Burrows said of the text that Jordan’s

facility for writing beautiful English stood him in good stead, and the immediate and continued success of his text is no doubt attributable to its well-written, orderly and accurate presentation, as well as to the need it filled. For many years [it] was, by all odds, the most widely used text in this country and had gone through eleven editions at the time of his death. Through the agency of this volume, Jordan may be said to have exerted a strong and wide influence on the development of American bacteriology and it was one of his important contributions to the field [7].

Given this, we might expect to use these two most prominent early American textbooks as differential gauges on which to measure the progress of different ideas and broad concepts in bacteriology.

The decade from 1900 to 1910 marks the first real breakthrough of the concept of the non-symptomatic carrier state. This makes a good example for our study, as it requires a more complex view than that simple “germ = disease” notion that so dominated early views of the germ theory of disease [8]. In the 1899 first edition of Park, this concept is only weakly represented, though Park was shortly to become one of the earliest and most vocal American advocates of the idea of the asymptomatic carrier. This was brought about by the New York Health Department following up on a lead that a cook employed by a Park Avenue family in 1907, though healthy herself, might be the source of twenty-six typhoid fever cases in homes she had been employed in since 1901.

Mary Mallon, or “Typhoid Mary” as she came to be known, was arrested by police under an order from the Health Department on March 19, 1907, and brought immediately, kicking and screaming, to Park’s Bleeker Street laboratory in Manhattan to have her urine and feces examined for presence of the typhoid bacillus. Once Park’s examinations proved that she carried an almost pure culture of *Salmonella typhosa* in her bowels (and this continued for the entire period he sampled, over three years), researchers concluded that the carrier state was much more common than had been ever recognized, and was not even confined solely to those who had recovered from the disease. With a large potentially unidentifiable pool of asymptomatic carriers at large in the population, Park urged, from the 1908 edition of his textbook onward, that attempting to find and isolate carriers could perhaps intervene in a few more egregious cases like Typhoid Mary’s but was futile as an overall strategy to prevent spread of the disease. Efforts, he said, should be mostly concentrated on sanitary measures such as milk pasteurization [9]. (Would that the leading scientists of the eugenics movement at this time, faced with the discovery of Hardy-Weinberg equilibrium and heterozygous carriers, could have had the objectivity to come to the same conclusions [10]!)

Jordan’s first edition, appearing in 1908, already carried the news of asymptomatic carriers. His general “ecological” perspective may have predisposed him to expect such a thing. From the first, his text said

The conception of a pathogenic microorganism is a relative, not an absolute one; that is to say, no microbe is known that is capable under all conditions of producing disease in all animals . . . The power of a microbe to produce morbid effects or changes depends, therefore, primarily, upon the nature of the host . . . : the

typhoid bacillus, when swallowed by a man, can produce a serious, often mortal, illness; when fed to cattle, it produces no effect. As a consequence, no sharp line can be drawn between pathogenic and non-pathogenic micro-organisms. [In addition, t]he ability of a micro-organism to produce disease in individuals of a particular race or species may be modified by a number of general factors that predispose individuals to infection or endow them with resistance [11].

Jordan’s ecological approach seems, furthermore, to have predisposed him to be one of the earliest major figures in the field to recognize the significance of bacterial variation. In the mid- to late-19th century the degree to which bacteria could vary in morphology and physiological capabilities under different environmental conditions was a hotly contested topic. The advocates of pleomorphism, or almost limitless variability and interconvertibility of different microbial forms, were led by the respected German Karl Nägeli of Munich. They insisted that there were almost no stable bacterial species. Thus, they said trying to establish Linnaean taxonomies of the bacteria, yeasts, and water molds was a misguided and deceptive project that ignored the most basic fact of microbial life: its ultimate morphological and physiological mutability. One of Nägeli’s students even claimed to show the transformation of the hay bacillus *B. subtilis* into the deadly *Bacillus anthracis* and back again, by varying the environmental conditions.

Ferdinand Cohn of Breslau was the first to establish a clear-cut taxonomy of bacterial species as we know them today. His influence was great, but perhaps greater on nobody than on Robert Koch, the young country doctor who in 1876 published the first careful description of the life cycle of the anthrax bacillus. Koch and Cohn both asserted a dogmatic monomorphism and bitterly opposed Nägeli and other pleomorphist advocates. Koch, in particular, argued from well

before he had much clear evidence to support the claim, that each separate human bacterial disease must be caused by a separate stable species of bacterium. His whole scheme for isolating and identifying the causative pathogens of human diseases depended upon this assumption being correct [12]. Depended on it so heavily, as Thomas Brock first pointed out forty years ago, that Koch believed this must be true and did not see that he was begging the question in a logical sense [13]. Fortunately, Koch's assumption proved true to a first approximation, sufficient to launch his successful hunt for the pathogens of tuberculosis, wound infections, cholera, and many other major human killers.

While the pleomorphists were wrong that bacterial species are illusory, unfortunately, Koch was also wrong in believing that stable species were incompatible with very extensive genetic mutability. But Koch's towering influence over the field imposed monomorphist blinders on researchers in a way that delayed for several decades any investigation of just how great the limits of variation in bacteria are [14]. This includes such phenomena as the smooth and rough variant forms of pneumococci, and the resultant path to the double helix. By Koch's death in 1910, a few prominent bacteriologists had begun to publish observations of significant bacterial variability, but for many reasons the phenomenon was not recognized by the mainstream to be significant until after a major review article by Philip Hadley appeared in the *Journal of Infectious Diseases* in 1927. Then research on variability enjoyed extraordinary prominence through the 1930s and much of the 1940s before receding into relative obscurity again [15].

At any rate, in 1914, well before most American workers were more than vaguely aware that evidence was beginning to crop up that weakened Koch's monomorphist dogma, Edwin O. Jordan read a

major paper to the National Academy of Sciences on the importance of bacterial variation [16]. Jordan's first edition of 1908 was already highly critical of the relative arbitrariness of existing taxonomic schemes, especially of "the unwieldy size that certain 'genera' ha[d] been allowed to assume" [17]. Following DeVries and Beijerinck, he defined "variations" as genetic, i.e., pretty similar to what we would call mutants. He noted, however, that many such variations, especially loss or re-gaining of some key taxonomic characteristic such as pigmentation or virulence seemed to develop gradually with repeated transfers in laboratory growth conditions, not in a single spontaneous all-in-one event like true mutations.

Park's first text of 1899 described a fair amount of morphological variability and postulated the gradual evolution of animal pathogens from bacteria that were originally, e.g., saprophytic soil organisms; however, Park insisted on a fairly sharp uncrossable divide (on a time scale of decades or perhaps even centuries) between species of pathogens and saprophytes today [18]. Despite discussing the ability of environmental factors to influence bacterial growth, Park took a more mainstream line in emphasizing the limits on such influence and the relative permanence of existing types. He accepted relatively uncritically that epistemological wastebasket category, "involution forms," to which most observations of bacterial variation were banished while the field was still dominated by Koch's monomorphist paradigm.

By his 1917 sixth edition, Park had become less assertive about how limited the range of variation might be, saying whether or not

the changed characteristics may be considered species characteristics cannot at present be decided. Our lack of more definite knowledge in relation to the significance of these changes, as we have said, is the

chief cause of other many unsatisfactory results from attempts at classification [19].

By the eighth edition of 1924, Park had added a new section discussing “mutations,” some years after Jordan first gave that term prominent use. And by 1939, again, following the mainstream rather than leading it, Park and Williams finally included a whole chapter on bacterial variation. Both were retired by this time, and they asked Philip Hadley, chief of the Bacteriological Service of Western Pennsylvania Hospital in Pittsburgh and a leader in research on variability, to write the chapter. He gladly complied [20]. While variation did not turn out to vindicate the pleomorphist vision of Hadley or Arthur I. Kendall, it was a phenomenon that provoked a significant amount of research in bacterial genetics, in order to finally make it intelligible [21].

Let us consider one more specific case of how the text tracked or anticipated conceptual changes in the field: that of the relationship between human and bovine tuberculosis. As mentioned above, the New York Health Department lab under Park became a premier center for disseminating the practical results of bacteriological science to health departments all over the country. In the preface to his first edition of 1899, Park already remarked that as early as 1898 the methods developed in his laboratory for isolation and identification of typhoid, tubercle and diphtheria bacilli were generally in use throughout the United States [22]. And the success of the text obviously further enhanced this situation. Koch himself personally expressed his admiration to Park for the leadership New York City had shown in the control of tuberculosis when he visited the lab in September 1908, just before the Sixth International Tuberculosis Congress in Washington that autumn [23]. Park, like many other American bacteriologists, must have been somewhat surprised, then, when at the

Congress Koch took a position on bovine TB that led to his almost total isolation.

From the first edition of his text, Park had presented the consensus of American experience that the tuberculosis strain from cattle could be passed to humans, especially children, via milk and produce tuberculosis in them [24]. Koch, however, had committed himself at the 1901 Tuberculosis Congress in London to the view that bovine tuberculosis could largely not infect humans and produce illness [25]. This was a change from his previous beliefs, but, again, such was Koch’s stature that his official public stance created a serious obstacle to those pressing for purging cattle herds of tuberculous animals and for pasteurization of milk on the grounds that it was a serious source of TB in children. In Britain, there was considerable skepticism over Koch’s view, but in Germany it was accepted as fact, much to the relief of the German beef and dairy industries. American bacteriologists usually followed the Germans closely, but in this instance there were a few important exceptions. One was Theobald Smith, and another was Park in his textbook. Thus, in his address to the Congress in 1908 Park was in the slightly uncomfortable position of contradicting one of the world’s great authorities on tuberculosis, though the vast majority of American bacteriologists by this time concurred with his position. Park was a mighty advocate of pasteurizing New York City’s milk supply and in this way he and his textbook showed even more leadership in this area than the admiring Koch had been able to see. This was one of the first significant areas in which the American bacteriological community established clear maturity and independence of thought from the Germans in whose shadow they had so long stood.

A word is in order about the unusual presence of a female co-author on Park’s

text as early as 1905. Anna Williams was one of Park's most able assistants at the New York City Health Department laboratory. But she was by no means the only woman to do important work there during Park's tenure as director. In fact, women outnumbered men among the most productive to such a degree that Park was often asked to comment upon how such a thing had occurred when men still so dominated the professions, especially the sciences. His biographer says Park replied

that if a man and a woman, both equally competent, applied at the same time for a laboratory position, he would choose the man every time. He gave several reasons for this stand. His chief one seemed to be that he thought the man needed the work more than the woman. And the times and customs being what they were, . . . he had public opinion on his side. Fortunately for Dr. Park, an opportunity for making such a momentous decision seldom arose, because women applied in such numbers that naturally there were some superior ones among them, and the result was women, and more women, were appointed. A superior man did manage to slip in now and then, . . . but . . . our laboratories have always had more women than men workers. And . . . they have done such good work under Dr. Park's inspiring direction . . . that it does not need to be described; it is too well known [26]!

"Park and Williams" seems to have ceased with the retirement of both authors and the death of Park soon afterward in 1939. It seems, like "Dr. Spock," to be a book so intimately identified with its author that it could not continue beyond his death. However Jordan chose a much younger co-author, William Burrows of the University of Chicago, for the last editions while he still lived. And Burrows so ably took over lead authorship upon Jordan's death that the book continued to be one of the most prominent texts in the country for another generation or more,

the 19th edition appearing in 1968 shortly before Burrows died. Indeed, the book had such stature 13 years after Jordan's death that, when a later Society of American Bacteriologists president Stuart Mudd, wanted to dispute a claim made in the Zinsser textbook, widely used in medical schools, he asked Burrows to run his counter-argument, complete with several new electron micrographs to back it up, in the upcoming edition of the "Jordan and Burrows" text [27].

Historians of science have long maintained that the appearance of specialized textbooks and journals is a key feature in a new field becoming recognized as an independent academic discipline. While there were bacteriology textbooks before those of Park and Jordan, even in English, on the American scene, bacteriology was still almost always taught in botany, zoology or biology departments up through the 1890s. Jordan was himself a staunch proponent of the establishment of bacteriology as a department-level discipline in its own right, and he succeeded in getting one of the first American departments of bacteriology and pathology established at the University of Chicago. And there can be no doubt that the role the textbooks of both men played in more rapidly disseminating bacteriological findings greatly catalyzed the consolidation of the science as a new discipline. Particularly because those findings were so rapidly put to use in dramatically decreasing disease, suffering, and pollution, the textbooks helped generate the prestige that so quickly made bacteriology the shining star among the new biological sciences in the early decades of the century. Thus, it would be no exaggeration to say that for both men their textbooks were one of their most important contributions; to saving lives and reducing suffering, but also to the establishment of American bacteriology on the worldwide scientific scene.

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