Gail Dack: Food Microbiology Pioneer

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SUMMARY

Gail Monroe Dack, PhD, MD, was a microbiologist who profoundly affected our understanding and management of foodborne disease. Yet we suspect many modern food microbiologists know little about him or his work. His career spanned the 1920s to 1970s, an era in which the insights, accomplishments, and tools available to microbiologists underwent amazing transitions. One can only imagine the wonder Dack would have today at our ability to analyze the molecular sequence of microbes, sometimes isolated from distant geographic locations, and link them to a single source in an ongoing outbreak.

1. EARLY YEARS

Born in Belvidere, IL, on March 4, 1901, Gail Dack attended Elgin High School. Following graduation in 1918, Dack attended the University of Illinois at Urbana–Champaign, receiving his scientiae baccalaureus (equivalent to a modern bachelor of science degree) in 1922. Dack demonstrated an interest in biomedical research even as an undergraduate and was coauthor on a paper published in 1922 *(54)* that described the isolation of toxin-producing strains of *Clostridium botulinum* type B from the feces of two healthy people.

2. UNIVERSITY OF CHICAGO, 1922–1929

Dack then moved to the University of Chicago as a graduate research assistant in the Department of Hygiene and Bacteriology, where he was mentored by Professor E. O. Jordan *(Fig. 1)*, chairman of the department and one of the microbiology pioneers in the United States. Jordan's book *Food Poisoning* (later edited by Dack) was the seminal text on food microbiology and foodborne disease at that time, and Jordan was the editor of and later coeditor with W. Burrows of *Microbiology*, a widely used text for decades.

Dack quickly exhibited exceptional productivity and intellectual flexibility that allowed him to address an array of microbiological research studies. He used the relatively new discipline of immunology to produce and use antibodies as tools to delineate the contributions of *C. botulinum* toxins to disease. His thesis research demonstrated that outgrowth of vegetative cells was required for toxin production *(46)* and that *C. botulinum* spores could remain viable but dormant for long periods in vivo *(47)*. Identifying botulinum toxin then, as now, relied on the mouse bioassay. Dack explored some limitations of the bioassay and the rudimentary equipment used to produce the anaerobic environment needed for growth of *C. botulinum (6)*.

Dack was awarded a PhD on June 14, 1927, and named an instructor in hygiene and bacteriology at the University of Chicago in 1926 and subsequently an assistant professor in 1929. His research publications during his early years at the University of Chicago focused largely on *C. botulinum* and other *Clostridium* species and their exotoxins. This topic was central throughout Dack's career and became an important focus of the Food Research Institute (FRI) that he later founded. Research on *C. botulinum* and its toxins remains a core strength of the institute to this day. Dack's research described the relationships of *C. botulinum* growth, proteolysis, and toxin production *(19, 27)* and defined the role of oxygen in inhibiting the growth of *C. botulinum (13)*.

Dack was involved in studies of other pathogenic bacteria. These included verifying that salmonellosis was an infection, not a toxicosis, after the experimental inoculation of live, but not heat-killed, cells of *Salmonella* species in rhesus monkeys *(16, 25)*. In the 1920s, experimental inoculation of human volunteers with viable pathogens was not uncommon. Dack was involved in several such studies, including experimental inoculation of human volunteers with culture filtrates of *Salmonella* Paratyphi *(16)* or a cocktail of *Salmonella* strains *(17)*. The latter failed to cause significant clinical symptoms, which might have been met with disappointment by the scientists conducting the study but undoubtedly was welcomed by the volunteers. Concern about human subject research was limited in that era, and oversight by institutional review boards, with which contemporary biomedical scientists are familiar, did not exist.

3. UNIVERSITY OF CHICAGO, 1930–1939

In 1933, Dack completed the clinical and other requirements for a doctor of medicine degree from the University of Chicago while fulfilling his research and teaching responsibilities as an assistant professor. Four years later, he earned a promotion to associate professor in what was then called the Department of Microbiology and Parasitology. During this decade, he conducted seminal work on the role of *Staphylococcus aureus* enterotoxin in foodborne disease and a series of investigations into the putative role of the anaerobe *Bacterium necrophorum* in ulcerative colitis.

It is difficult to overstate the impact of the work by Dack and his colleagues on foodborne disease caused by *S. aureus*. In a groundbreaking report, he demonstrated

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FIGURE 1. Photograph of Professor E. O. Jordan (http://ihm.nlm.nih.gov/images/B15878).

toxin production by *S. aureus* recovered from a cream-filled sponge cake associated with an outbreak of food poisoning that sickened 11 people *(18)*. Dack and two other human volunteers who ingested a culture filtrate of the *S. aureus* isolate developed vomiting, bloody diarrhea, cramping, and prostration within hours of ingestion. Rabbits injected intravenously with the culture filtrate died within several hours, even after first heating the filtrate at 100°C for 30 min. The preceding observations established that staphylococcal foodborne disease is a food intoxication rather than an infection and that once formed, the toxin is not inactivated by cooking. Woolpert and Dack *(64)* showed that some strains of *S. aureus* elaborated an enterotoxin that was distinct from other known exotoxins of *S. aureus* (e.g., hemolysin and dermonecrotic toxin) and not produced by other bacterial species *(36)*.

Dack investigated other foodborne disease outbreaks caused by *S. aureus (14)* and established the importance of maintaining proper temperatures during food production to prevent enterotoxin formation *(15, 39, 48)*. These efforts are prescient of the later efforts by Dack to establish the FRI and conduct food challenge studies to assist the food industry and protect consumer health.

Those who are familiar with inflammatory bowel disease (IBD) know that its etiology remains uncertain and controversial to this day. Several potential pathogens, as well as the more general process of microbial dysbiosis in the gut, have been proposed as contributing to IBD in humans *(41)*. Dack developed an interest in a potential pathogenic role for *B. necrophorum* (likely *Fusobacterium necrophorum*) in ulcerative colitis. Proctology specimens from three colitis patients yielded *B. necrophorum* as the predominant organism *(23)*. Instillation of oxygen for 90 min into the isolated colon of a dog eliminated *B. necrophorum (28)*, whereas instillation of oxygen into the colon of a human colitis patient failed to reduce disease severity or eliminate *B. necrophorum (20)*. The revolutionary development of sulfanilamide by future Nobel laureate Gerhard Domagk in 1935 gave physicians a potent new weapon in the fight against infectious diseases. Hemmens and Dack *(35)* showed that treatment with sulfanilamide extended the survival of rabbits inoculated subcutaneously with *B. necrophorum* but had little effect on disease severity and did not result in the elimination of *B. necrophorum* in human IBD patients *(22)*.

4. UNIVERSITY OF CHICAGO, 1940–1949

During the 1940s, Dack and Hoskins *(24)* showed that macaques were generally resistant to intracolonic injection of botulinum toxin at doses that were lethal when fed to them, suggesting the colon is relatively impermeable to botulinum toxin. More recent work has shown that toxin absorption in adult humans occurs largely in the small intestine *(3)*.

Dack's research focused on staphylococcal enterotoxin during this period. Segalove and Dack showed that growth of *S. aureus* in canned foods was inversely correlated with pH in canned foods *(42, 45)*. Concern about bacterial growth in also led Dack to conduct a *Salmonella enterica* challenge study in various food products. Growth was greater at 22°C than at 37°C and occurred at one of those two temperatures in all canned foods except peaches *(43)*.

One unique investigation by Dack concerned a winter episode of diarrhea, vomiting, nausea, and cramping among 48 students and staff members in four university dormitories. Although knowledge of foodborne viruses was rudimentary at the time, one might reasonably conclude that this outbreak was caused by norovirus or some other gastrointestinal virus *(7)*. Symptoms had an acute onset and were of short duration, and those sickened were located within a shared environment. No food or water was epidemiologically incriminated, and testing of clinical specimens from patients did not yield known bacterial pathogens. In addition, injection of macaques with serum or respiratory secretions from patients failed to trigger similar symptoms.

4.1. MILITARY SERVICE

World War II had an effect on academia that we cannot readily appreciate in the current era. Many faculty members and students were involved in active military duty. Beginning in September 1943, Dack served as chief of the Safety

Division at Fort Detrick, which was to become the world's largest biological warfare research facility focused on the potential military use of several highly pathogenic microbes (*Bacillus anthracis* and *C. botulinum*). Fortunately, these were not then, nor have they since been, used in global warfare. Contributions by Dack and his colleagues resulted in the development of biological safety cabinets whose design remains similar to this day *(Fig. 2)* *(5)*. Dack was highly successful in protecting workers at Fort Detrick and received an Exceptional Service Award (the highest civilian award) from the U.S. Army for his wartime efforts. Upon decorating Dack with this award *(Fig. 3)*, General Waitt commented, "Outside the Manhattan Project I know of no other place where the dangers … were equal to those at Ft. Detrick, MD. Thanks to Dr. Dack's skill, dedication to duty, and untiring efforts our personnel were spared any serious outbreak of infection and suffered fewer accidents than any of our instillations" *(57)*. The work of microbiologists and other scientists at Fort Detrick during World War II, and afterward, is a fascinating topic with which many in the current era are likely unfamiliar. For a captivating and detailed analysis of Fort Detrick, and the involvement of prominent scientists from the University of Wisconsin and elsewhere, refer to the scholarly work of William Vogel *(60)*.

4.2 ORIGIN OF THE FRI

Postwar society was changing, and Dack made several noteworthy contributions in this period. Perhaps most importantly from our perspective, he received encouragement from the food industry to establish the FRI at the University of Chicago in 1946, making it the first academic unit with a focus on food safety in the United States. A one-sentence note in the 1946 issue of the *University of Chicago Magazine* *(56)* announced formation of the FRI by Dack. During that time, there was also a Meat Institute within the Department of Bacteriology and Parasitology at the University of Chicago. We lack details regarding the arrangements between the institute and the department in regard to space, financial resources, and responsibilities. Several of Dack's early botulism studies in the 1920s were funded by the National Canners Association, presaging the later development of the FRI and its efforts to address the food industry's concerns about botulism and other food safety challenges.

5. UNIVERSITY OF CHICAGO, 1950–1959

Dack's work during the 1950s and 1960s had an increasing emphasis on practical food safety questions, consistent with the development of FRI *(Fig. 4)*. During this time, publications by Dack featured coauthors (e.g., Merlin Bergdoll, Hiroshi Sugiyama, and Dean Cliver) who were associated with and long an integral part of the institute.

Perhaps partly in response to his experiences during the war effort, Dack was involved in various challenge studies of canned food products. Challenge studies with canned

FIGURE 2. Research personnel working in a biosafety cabinet at Fort Detrick (p. 22, Cutting Edge, *A History of Fort Detrick 1943–1993*, N. M. Covert).

FIGURE 3. Dack receiving the Exceptional Service Award from General Waitt for his leadership of the Safety Division at Fort Detrick *(57)*.

bread (used by the military) indicated that bread was a poor medium for toxin production *(38)* and confirmed the importance of achieving pH 4.8 or lower and moisture content of less than 36% to prevent the production of toxins *(61)*. A separate challenge study that assessed the survival and potential growth of various foodborne bacterial pathogens in dehydrated meat showed that temperature and moisture levels were key factors in inhibiting bacterial growth *(44)*.

Nicholas Grecz found that *Brevibacterium linens*, predominant in the surface microflora of Limburger cheese, produced an inhibitory substance for *C. botulinum* when grown on cheese or certain media and was partly responsible

for the color of the surface smear of Limburger *(31–33)*. Ultimately, the possible commercialization of the antibiotic substance was turned over to Eli Lilly and Co. *(55, 58)*. Reports indicate that the work done by Grecz fulfilled his thesis requirements at the Illinois Institute of Technology, reflecting Dack's adjunct appointment as professorial lecturer at that institution.

During this decade, Dack continued to work on *S. aureus* and its enterotoxin. Some of these efforts involved Bergdoll and Sugiyama, new members of the FRI who would go on to become recognized leaders in the fields of enterotoxin and botulinum research, respectively. Several reports outlined efforts to purify enterotoxin, produce antibodies against it, and develop assays to assess it *(2, 51, 52)*. Sugiyama et al. *(49)* reported liver damage and liver enzyme release following ingestion of enterotoxin by macaques.

A symposium on *Salmonella* (55th Annual Meeting of the American Society for Microbiology, 1955), organized by Dack on behalf of the FRI, provided a detailed analysis of methods for isolating *Salmonella* from contaminated food. Current researchers in this field will not be surprised to learn that this study concluded that enrichment and several selective media were needed to ensure isolation of *Salmonella* when low cell numbers were present in the food *(11)*. That same article included data documenting the relatively common contamination of pork and raw sausage with *Salmonella (11)*.

The difficulties with and value of coliform detection from various food products versus the actual human risk were thoughtfully considered in a review article in the *American Journal of Public Health (10)*. In a separate concise review article, Dack discussed the possibility that postoperative use of antibiotics could favor the survival and growth of enterotoxin-producing *S. aureus* in the gut that would lead to diarrhea and *Pseudomembranous colitis (53)*. The potential adverse effects of enamel coating of food cans were investigated, and discounted, in a study by Ives and Dack *(37)*.

6. UNIVERSITY OF CHICAGO, 1960–1969

By the 1960s, Dack was widely recognized as a leading authority on microbiological food safety *(Fig. 5)*. A reflection of Dack's visibility and stature in the field is found in his authorship of a review article on the therapy of foodborne disease in the *Journal of the American Medical Association (12)*. As he neared the end of his career at the University of Chicago, Dack's laboratory focused on staphylococcal enterotoxin and applied projects of concern to the food industry. Examples of the former included an agar gel immunodiffusion method to visualize enterotoxin production *(50)* and an ion exchange method to partially purify enterotoxin *(2)*. Examples of the latter included demonstration of the inability of several pathogens (*Salmonella*, *Escherichia coli*, and *S. aureus*) to grow in a slurry of meat pot pies *(26)* and formation of botulinum toxin in some cans of chocolate nut rolls *(62)* or canned cheese experimentally inoculated with spores of *C. botulinum (30, 34)*.

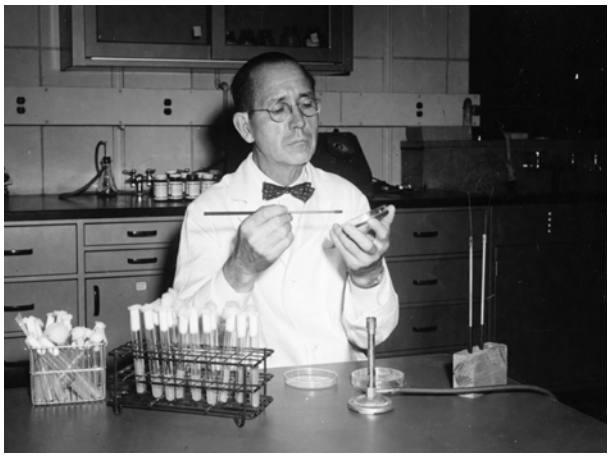

FIGURE 4. Dack working in his laboratory in 1958 (University of Chicago Library, Special Collections Research Center).

Earlier in his career, Dack described a foodborne disease outbreak that, based on its course, was likely caused by some viral agent *(7)*. In 1962, he had firsthand experience with what was likely a viral enteritis outbreak that, ironically, occurred at the 1962 International Conference on Microbiological Quality of Food. Because Dack was among those afflicted, he managed to acquire clinical samples; however, these failed to yield known bacterial or viral pathogens, perhaps because the methods available at the time could not identify norovirus *(4)*.

6.1. RETIREMENT AND TRANSFER OF THE FRI

As Dack neared retirement in 1966, it became apparent that the University of Chicago was not interested in maintaining support for FRI *(Fig. 6)*. This resulted in efforts by several key individuals in the food industry to find a new academic home for FRI. Ultimately, this led to the transfer of FRI to the UW, where it was led by Dr. Mike Foster. These efforts may have been facilitated by familiarity among Dack and Foster, as well as other prominent UW-Madison faculty members (Professors Ira Baldwin and E.B. Fred) from their time at Fort Detrick during the war *(60)*. The planning and efforts that culminated in the successful transfer, and the academic negotiations inherent in that process, could be the topic of a separate article. It is curious that the University of Chicago was not interested in continuing to provide a home for FRI, which had a strong team of food microbiologists and sustained evidence of interest in and financial support by the food industry. Some might suggest the decision was largely the result of lesser regard for applied versus basic science. That may be at least partly true, although the circumstances were likely more nuanced. A history of the department (then called the Department of Microbiology) at the University of Chicago *(40)* indicates that by the 1960s, its faculty felt

FIGURE 5. Dack as an invited dinner guest to the left of Albert Einstein (photo reproduced with permission of the Leo Baeck Institute, F 5322E).

a keen strategic need to develop robust research programs in molecular biology and genetics. One senses that the department regretted it had not moved decisively in that direction as these new fields emerged. Perhaps the long careers of some of the department's distinguished faculty members (including Dack) prevented them from doing so at an earlier date. In any event, the University of Chicago's loss proved to be the UW's gain, and FRI moved to the UW-Madison, where it is in its 78th year of addressing, and trying to prevent, food safety problems.

7. ACADEMIC AND PROFESSIONAL SERVICE

Besides being a highly productive research scientist, Dack gave back to society in several meaningful ways. Dack was a member of the American Public Health Association's Committee on Sanitary Practices in the Food Industry, which was charged with preparing a manual on the principles and practices of sanitation for the food industry *(29)*. In keeping with his wartime duties and experiences, Dack was named a member of the Finance Committee for the Quartermaster Food and Container Institute for the Armed Forces (1948) and met with the World Health Organization Expert Committee on Meat Hygiene (1955).

Dack's postwar public service efforts were not limited to applied questions of food safety. In 1953, he served as president of the American Society of Bacteriologists, predecessor to the American Society for Microbiology, the premier professional society for that discipline. His presidential address, given at the annual banquet in San Francisco, CA (August 12, 1953), was prescient of the rapid changes and future demands on the discipline of microbiology. His comments included, "Microbiology is rapidly becoming a highly specialized field. Our Society has an obligation to take leadership and direct its efforts to improvement of the profession to benefit not only our

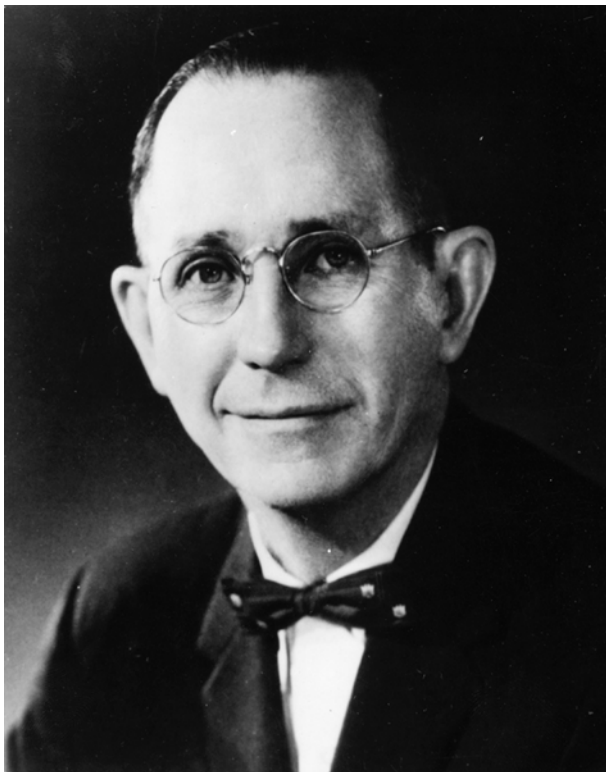

FIGURE 6. Dack with his characteristic bowtie in 1963 (University of Chicago Library, Special Collections Research Center).

membership but also the public which the profession serves" *(8)*. These efforts included development of standards for the certification of microbiologists. In keeping with this initiative, in 1962, Dack became one of the first microbiologists to receive certification as a diplomate of the American Board of Microbiology in Public Health and Medical Laboratory Microbiology. He was appointed a member of the first council of the new National Institute of Allergy and Infectious Diseases (1956), was named to the National Research Council Group of the Food and Drug Administration's Civil Defense Foods Advisory Committee (1955), and was appointed to the National Advisory Health Council by the U.S. Surgeon General (1956). Perhaps related to the visibility he received through his government service, we found a photo of Dack enjoying dinner with Albert Einstein and his friends *(Fig. 5)*. Dack testified before Congress *(9)* on the importance of microbiology in national defense and the need for government funding to support microbiological research. In his testimony, he commented on the emerging issue of antibiotic resistance and adverse responses by people to some antibiotics, problems that persist to this day. He also made a strong case for continued funding of mechanistic infectious disease research: "The central factor in all these studies of infectious agents is the need for fundamental knowledge. Until this is gained, little

progress can be made against the communicable diseases which still elude science. The answers are not easy."

For his many outstanding research and professional accomplishments, Dack received several awards, including the Babcock–Hart Award (1954) and the Appert Award (1962) from the Institute of Food Technologists and the Pasteur Award from the Society of Illinois Bacteriologists (1957).

8. FINAL YEARS, 1970–1976

After his retirement from the University of Chicago in 1966, Dack remained actively involved in food safety and microbiology. Dack enjoyed a part-time appointment at UW-Madison, where he remained actively engaged with the FRI until his second and final retirement in June 1971 *(59)*. Family members speak of Dack's struggle with Parkinson's disease during his final years and that his wife Martha also experienced ill health during this era. These struggles led the Dacks to leave their rural family home, with its gardens and orchards that they had enjoyed for decades, and move to Elgin, IL. It was there on June 21, 1976, that Dack passed away at the age of 75. He was survived by Martha, his beloved wife of 50 years; son John; daughter Carol; and four grandsons.

ABOUT THE AUTHORS

Chuck Czuprynski, PhD, is professor emeritus and former director of the FRI, and Wendy Bedale, PhD, is a science writer at the FRI at UW-Madison. Their involvement with the institute would not have occurred were it not for the efforts of Dack, who established the FRI at the University of Chicago in 1946. This synopsis of Dack's career is an effort to recognize the many contributions he made as a food safety pioneer and his establishment of the institute that flourishes to this day.

ACKNOWLEDGMENTS

This work could not have been completed without access to digital resources from the University of Chicago and the documents of Dr. E. Michael Foster held in the UW-Madison Archives. The personal insights provided by Gretchen Dack (daughter-in-law) and John Dack (grandson) are greatly appreciated.

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