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GLENN WADE SALISBURY  
1910–1994

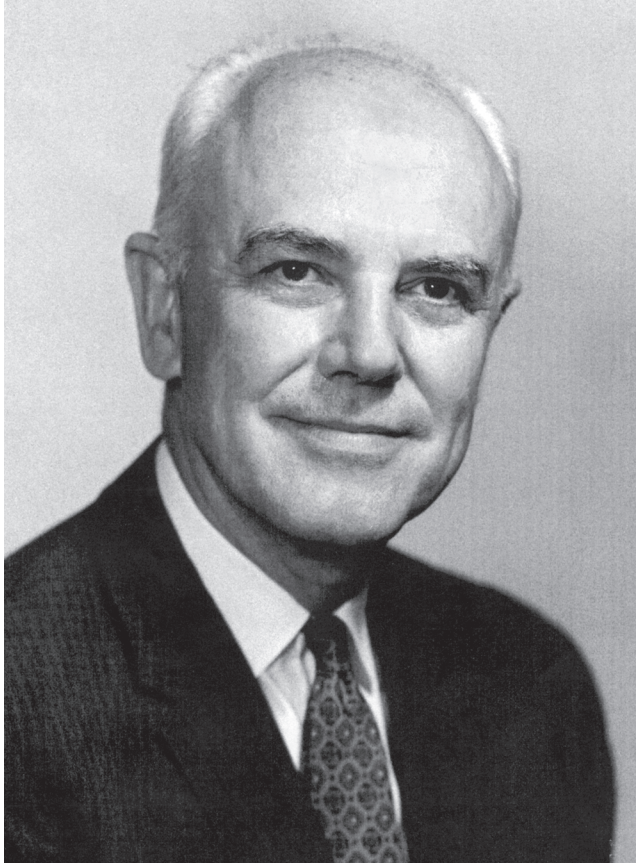
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*A Biographical Memoir by*  
ROBERT H. FOOTE

*Any opinions expressed in this memoir are those of the author  
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## GLENN WADE SALISBURY

*June 2, 1910–February 3, 1994*

BY ROBERT H. FOOTE

EARLY IN HIS CAREER Glenn Salisbury became the foremost researcher in the world in testing ideas and applying results that revolutionized the breeding of dairy cattle through the development of sound principles and procedures for artificial insemination with semen from genetically superior sires. This has become the most powerful biotechnology used worldwide for the improvement of cattle. The guiding principles exemplified by Salisbury were good basic research, integrity, and superior accomplishment. He expounded on these in a superb mimeograph, *An Approach to the Scientific Solution of Problems in Biology*, in 1948. These principles were passed on to students and others through example and active mentoring by Salisbury. Only the best in any endeavor was acceptable for his own efforts as well as those of his colleagues.

His exemplary leadership, as head of the Dairy Department at the University of Illinois, resulted in a department that rose in 20 years from near the bottom of the list of published research by agricultural experiment stations to near the top. He instilled in his associates the importance of reflecting on the moral aspects of their research, and the social and economic consequences nationally and inter-

nationally. He fought fiercely for what he believed was important and right, regardless of administrative inertia and any political backlash that might occur. He believed strongly that the higher the position one held, the greater was the responsibility for service to others. Consequently he did not pull punches when the obstacles were self-serving individuals. As a consequence, Salisbury made a major contribution in training outstanding young leaders, as well as in the improvement of animal agriculture, with the objective of feeding a hungry world better.

#### PERSONAL

Glenn Wade Salisbury was born on June 2, 1910, on his maternal grandfather's farm in Sheffield Township, Ashtabula County, Ohio. His dad's ancestors also were farmers. Thus he was surrounded in his early life with a family that had a zest for life, a great appreciation of the land, of working hard, and of caring for one another—all characteristics of Salisbury in his adult life. His father's academic career took him to many places and schools during his precollege days. Summers were spent on his grandfather's farm, enjoying the Jersey cows, trotting horses, and pigs.

Salisbury entered Ohio State University in 1927. He was a leader in student affairs and a member of the Student Senate and several honorary societies. He was an articulate member of the dairy cattle judging team. Upon graduation in 1931 he was selected as the outstanding senior in the College of Agriculture, based on his leadership and academic achievement. Following graduation in June 1931 he visited the famous Mt. Hope Farm in Massachusetts, where progressive genetic studies were in progress with cattle and poultry. These experiments stimulated Salisbury's interest in the genetic potential for improving animal agriculture.

Few jobs were available at the height of the Depression,

so Salisbury accepted a half-time assistantship at Cornell University. This financial support of \$700 per year enabled him to take a major step in his life. In August 1932 he married Dorothy Jane Cross, who became his lifelong, supportive companion and devoted mother to children Laird Wade Salisbury and Susan Lynne Salisbury. Glenn and Dorothy had dated regularly four years earlier, until her family moved. The romance was continued by correspondence. After the wedding it was immediately back to work for Salisbury in the middle of his Ph.D. studies. The honeymoon was a bicycle trip through Europe in 1937.

At Cornell University Salisbury studied nutrition, physiology, and genetics (1931-1934), receiving the Ph.D. degree in three years. The chairman of his committee was Professor F. B. Morrison, world famous in agriculture for his book *Feeds and Feeding*. Professor S. A. Asdell, one of the world's great animal biologists, trained by Professor F. H. A. Marshall at Cambridge University, was his mentor in physiology. His genetic exposure was to a superb teacher, Professor A. F. Fraser, in a department that had recently trained Barbara McClintock and George Beadle, both Nobel laureates.

#### PROFESSIONAL CAREER AT CORNELL UNIVERSITY

Salisbury was hired in 1934 as an instructor in the Department of Animal Husbandry upon completion of his doctoral program. This was the beginning of a long and illustrious career. In only 10 years he rose through the ranks to become a full professor. The year he became a full professor he was the youngest scientist to receive the Borden Award, a prestigious national award for outstanding contributions to reproductive physiology and production of dairy cattle. This was especially remarkable, considering that his appoint-

ment was for 45 percent of his effort in research and 55 percent for teaching and extension.

Initially he assumed responsibility for teaching an introductory course in nutrition of farm animals to animal husbandry students. Noting that veterinary students received little training in nutrition, he developed a course designed to meet their needs. He developed an introductory course in animal breeding, comprising both comparative reproductive physiology and genetics. Soon he was recognized as a master teacher. This course became one of the more popular undergraduate courses at Cornell.

He was a popular speaker among dairymen, bringing news of college programs to them and soliciting their ideas. He was equally comfortable and conversant with dairymen in the barnyard and scientists at national meetings.

Salisbury developed the program in animal breeding at Cornell University, which he administered until he left for the University of Illinois in 1947. This program required graduate students to obtain basic training in biochemistry, physiology, mathematics, and genetics. Salisbury also was a lifelong student, hungering after knowledge, which he consumed in great quantities.

How did he accomplish all this? Partly he sought out and developed associations with the best minds in each field at Cornell and elsewhere. He continued to collaborate with S. A. Asdell, author of the gold standard book *Patterns of Mammalian Reproduction*. He took a summer off to study at Iowa State University with Jay L. Lush and with George W. Snedecor, respectively, a foremost animal breeder and a biological statistician. Salisbury considered both Lush and Snedecor as among the best teachers in the world.

In 1937 he bicycled 4,000 miles with his wife, Dorothy, through the British Isles, the Channel Islands, and France, visiting research laboratories, experiment stations, and farms.

An appendectomy in the middle of the trip slowed him down only temporarily. In 1936 and 1938 the Salisbury couple drove to many agricultural experiment stations in the Midwest to become better acquainted with leading scientists, their research, and their approach to solving major problems. They did not stop at Illinois, because he felt that little of interest to him was being published there.

At the same time he was in contact with famous colleagues in the department at Cornell, including Nobel laureate J. B. Sumner. Sumner was the first person to crystallize an enzyme, which was catalase. He gave a sample of catalase to Salisbury. Salisbury added this catalase to bull spermatozoa and found that it prevented the damaging effect of oxygen by stopping the accumulation of hydrogen peroxide (1949).

Salisbury was not shy in emphasizing that the new paths he wanted to explore in reproductive physiology required basic research to underpin applied studies in artificial insemination. He found ways to do it despite the lack of administrative support. One of his friends, I. C. Gunsalus, had laboratories in another department where the bacteriology of bull semen could be studied (1941), as infectious disease transmitted through semen was one of the probable major causes of low fertility in dairy cattle.

Simultaneously Salisbury teamed up with Professor Stanley Brownell, one of the most able, articulate, and forceful extension professors in the United States, to generate support from leading dairymen and key members of the Cornell Board of Trustees to develop a major artificial insemination program in dairy cattle. Governor Dewey had a dairy farm, and he supported the idea. Timing was right to develop this program. Some members of the veterinary profession were opposed to the development of artificial insemination; however, a strong advocate was William A. Hagan,

dean of the New York State Veterinary College. In 1945 the artificial insemination program moved to Ithaca, New York, where Cornell University made land available. Dairymen in the New York Artificial Breeders Cooperative, Inc., and New York State each contributed \$25,000 to build facilities close to the Cornell campus. An enormously successful cooperative program of research and application followed. Salisbury now had his laboratories where the biochemistry of bull sperm could be studied without interference.

Salisbury also was a member of several important committees, including the Graduate School. He was a faculty member on the Cornell Board of Trustees. He had made substantial progress in all aspects of his career. However, he was rankled by the lack of support by the dean of the college and the criticism that his group was conducting biochemical research outside of the Department of Biochemistry. He voiced his objections to this criticism. Furthermore, in 1945 he was not chosen to become head of the Department of Animal Husbandry, a position that he had been interested in exploring. Consequently, as inquiries came to Salisbury from several universities, inviting him to consider heading various departments, he began to think, "What if the right situation came along?"

In 1947 he was invited to come to the University of Illinois, as a new head was being sought for the Department of Dairy Husbandry. During his first visit Salisbury pointed out many deficiencies that existed. Subsequently, after several changes were made at Illinois, Salisbury was invited to visit a second time. This time he visualized that he could have a dairy husbandry group that would contain highly qualified individuals to form sections of dairy chemistry, dairy bacteriology, and dairy cattle genetics, in addition to the more traditional physiology, nutrition, and management sections. All they needed was stimulation to move



ahead with their research more aggressively. Events moved swiftly. Glenn W. Salisbury resigned his position at Cornell University, effective October 31, 1947.

#### PROFESSIONAL CAREER AT THE UNIVERSITY OF ILLINOIS

The new job at the University of Illinois was not without problems. There had been considerable disarray in the Dairy Husbandry Department during the war. Many faculty members were pleased to see a new head arrive who could resolve problems by appropriate reorganization. Others were concerned that Salisbury would promote the development of the basic sciences and weaken the animal production component. Fortunately, Salisbury had several factors going for him, which he skillfully managed.

As a new department head he had been given the charge of revitalizing the department. This he did initially by convincing the administration to change the name of the department from Dairy Husbandry to Dairy Science. Then he obtained additional prestige for the professors in the department by receiving permission to appoint them with the specific titles of professors of biochemistry, physiology, genetics, microbiology, or nutrition. Salisbury was able to add seven new faculty members to his staff during the first four years of administration. He attracted superb individuals trained at several excellent universities and with a mixture of special talents. The result was a department ready to lead into the future, facing agriculture changing rapidly after World War II.

He, and others, fought for new facilities, campaigning within the university and by personally contacting influential farm leaders throughout the state. This resulted in a new Animal Sciences building that housed the entire faculty and provided all with excellent laboratory facilities. The

extension group was included, as Salisbury recognized the importance of the Land Grant mission.

Stimulated by these new resources and by Salisbury's dynamic leadership, the department attracted more outstanding graduate students. Research flourished. When Salisbury left as head of the Department of Dairy Science in 1969, his department was one of the leaders among dairy and animal science departments in number of research publications per year.

Teaching also flourished. Salisbury was a great disciple of the principle that knowledge is power. All undergraduates should be exposed to the basic sciences within the dairy field as well as the more traditional courses of feeding, breeding, and management. The new faculty added courses for advanced undergraduates and graduate students in physiology of reproduction, rumen microbiology, biochemistry of nutritional processes, endocrinology, biometry, and quantitative genetics. The emphasis on basic training equipped undergraduate students to fill technical positions in agriculture and the pharmaceutical industry, and to pursue advanced studies, as the number of dairy farms was decreasing rapidly. The graduate students were competing successfully for excellent postdoctoral positions, university faculty positions, and technical positions in industry.

Salisbury was criticized by those who resisted change from the traditional department dealing primarily with management problems of producers. This aspect was reduced but not neglected. Furthermore, he could point to a large increase in funding and research productivity through competitive extramural grants awarded to faculty in the department. This enabled the faculty to provide excellent research exposure for undergraduates and graduate students. The department became nationally recognized, resulting in increased opportunities for faculty to assume leadership roles

nationally as well as within the university. With this recognition, the faculty received an increasing number of prestigious awards for teaching and research. Salisbury accomplished this by acquiring a complement of competent interactive faculty. Then he sought ways to assist staff members to develop their full potential, and was intolerant of those who didn't.

#### CAREER RESEARCH ACCOMPLISHMENTS AND AWARDS

Salisbury followed the logical concept that an inquiring mind was necessary for development. Furthermore, any procedures applied broadly in agriculture should be based upon as much understanding as possible of the principles, mechanisms, advantages, and weaknesses of the system. Thus, careful research was always an essential component of any program in his department. He personally continued to be involved directly in research as well as teaching during his two decades of leadership in the Department of Dairy Science.

Salisbury is best and rightfully remembered for his foresight and research contributions in reproductive physiology that provided the framework for the successful development of artificial insemination of cattle worldwide. He recognized that in addition to trained people, a successful artificial insemination program required (1) superior healthy, fertile bulls, (2) methods of semen collection that protected the sperm, (3) techniques for evaluating semen quality, (4) preservation of the viability of sperm until used for insemination, and (5) a system to evaluate the fertility of sperm inseminated. His 265 publications addressed all these components and more, but only a few examples can be highlighted here.

Extensive research had been conducted on feeding dairy cows, but little was known about the nutrition of bulls. With his graduate students he was the first to study the energy

and protein requirements of mature bulls. Feeding standards were established for maintaining healthy bulls that produced high-quality semen. Objective measurements of semen quality were needed as indicators of sperm fertilizing ability. Salisbury and his students published many papers on the morphology, motility, and metabolism of sperm. Basic studies on sperm metabolism elucidated mechanisms by which sperm gained energy to remain fertile. Suppression of the more efficient oxidative biochemical pathway, and forcing sperm to use the glycolytic pathway, increased sperm motility during storage and subsequent fertility. Studies on mineral components of fluids from the excurrent ducts of the male reproductive system revealed that the sodium-potassium ratio markedly affected sperm metabolism. Later studies showed the importance of phosphate and  $p\text{CO}_2$  in depressing sperm respiration. A variety of tests of sperm function were established and standards set to assure that semen used for insemination would be highly fertile.

Salisbury's discovery of the importance of the citrate ion combined with egg yolk led to egg yolk-citrate becoming the standard medium worldwide for preserving bull sperm. His studies with Gunsalus, and later with Foote, on the bacteriology of bull semen and control of pathogens through the inclusion of antibiotics in the egg yolk-citrate medium led to a major improvement in fertility in dairy herds. This greatly accelerated the adoption of artificial insemination.

Salisbury and Thompson, in 1947, developed an ingenious, simple method of accurately estimating fertility to evaluate results of all semen processing and insemination procedures. The "non-return" rate method developed is still in use worldwide to assess fertility.

Semen from superior sires became available to inseminate thousands of cows per bull as a result of his pioneer-

ing studies that the billions of sperm per ejaculate of semen could be diluted to millions of sperm per insemination without reducing fertility. Critics scoffed when they heard of these planned experiments, saying it was like “watering the milk.” Instead, the high fertility led successors in the Salisbury laboratory (Foote and Bratton) to coin the term “extending semen,” which is used throughout the industry today.

Salisbury observed that extensive data from the artificial insemination industry indicated that aged sperm held at 5°C could fertilize the oocyte, but embryo death often appeared to follow. Laboratory studies of DNA and DNA-protein complexes also showed changes as bull sperm aged. Aged frog sperm also produced defective embryos. Furthermore, from analysis of large batches of cryopreserved sperm used in the field, he concluded that similar trends occurred with frozen sperm. However, storage temperature in the field was confounded with multiple manipulations by inseminators. Controlled laboratory studies by others have revealed that sperm cells are highly stable when stored continuously at -196°C.

Salisbury shared his information through scientific publications, presentations at national and international meetings, and in various classroom settings. Together with N. L. VanDemark he prepared a seminal reference book *Physiology of Reproduction and Artificial Insemination of Cattle*, which was published in 1961 and was revised in 1978. His wide range of interests are indicated by his membership in the following societies: American Association for the Advancement of Science (fellow), American Dairy Science Association, American Society of Animal Science, American Genetics Association, American Physiological Society, Society of Cell Biology, Society for the Study of Fertility, Society for Experimental Biology and Medicine, and Society for

the Study of Reproduction. He was also elected to five honorary societies, including Sigma Xi, becoming president of that society at the University of Illinois in 1966.

Salisbury was the recipient of many honors and awards. Previously mentioned was his receipt of the Borden Award at age 35 for outstanding contributions to physiology and production of dairy cattle. The American Society of Animal Science presented its highest award, the Morrison Award, in 1964 for research contributions to animal science. Several honors from foreign governments were received in 1964 and 1965. In 1971 the University of Illinois recognized his outstanding achievements in research and contributions to agriculture with the Funk Award, and national acclaim resulted upon his election to the National Academy of Sciences in 1974. This was followed by a Distinguished Service Award from the American Dairy Science Association in 1978 for his lifetime contributions to science and the dairy industry. The highest world prize in agriculture, the Wolf Prize, was awarded to Salisbury in 1981. This award was timely, as it occurred when he was closing his remarkable academic career.

#### PUBLIC SERVICE

Salisbury started his public service while at Cornell University. In 1944 Salisbury and others were asked by the Near East Foundation to propose a plan to restore Greece's livestock population, which had been decimated by the war. There was a great opportunity to rebuild the dairy cow population with superior animals by artificially inseminating cows with semen from selected bulls. This rekindled a dream that Salisbury had first visualized when he visited Mt. Hope Farm in 1931. This program really was democracy in action, making the best genetics available not only to wealthy bull

owners in the United States but also to all cattle farmers regardless of their economic status.

In 1946 Salisbury went to Greece for several months, working with Greek authorities to implement the plan he had helped to design. In 1963 he was commissioned, as part of a team, to develop plans for agricultural research and higher education in Greece. The influence that this experience had on his life is evidenced by his devoting a whole volume of his memoirs to the Greek experience. I can appreciate this impact, because I was a graduate student in Salisbury's laboratory at this time, and listened to some of the discussions afterwards.

At the University of Illinois, Salisbury served on his share of housekeeping committees, but more importantly his foresight and insight were shared on many university, national, and international committees and commissions. He was elected to the Executive Committee of the Graduate College, the Long-Range Planning Committee, the Council on Program Evaluation, the Faculty Senate, the Committee on Academic Freedom, the Committee to Determine Policy on Classified Research, and many others. These positions and committees and others benefited from his brilliant mind and the wisdom that came from experience.

From 1961 to 1963 he served on President Kennedy's Science Advisory Committee. In 1965 Salisbury was a Fulbright scholar at the Agricultural University in Wageningen, Netherlands. The same year he was a consultant to the U.S. Agency for International Development, studying and recommending programs for improving agriculture in India, and in 1969 for Indonesia. From 1974 to 1977 he was a consultant to the Office of Technology Assessment of the Congress of the United States. He served on the Board on Agriculture and Renewable Resources of the Commission on Natural Resources of the National Research Council from

1975 to 1978. He participated in writing the report *World Food and Nutrition Study: Enhancement of Food Production for the United States*. From 1977 to 1978 he cochaired the Joint U.S. Department of Agriculture/State Agricultural Experiment Station Commission to recommend safety procedures to the USDA. These are only examples of many groups that sought his advice, which he willingly gave.

Simultaneously he was involved in many community organizations. He was active in the Methodist church, a board member of the University of Illinois YMCA, and served as president of the Urbana Rotary International organization. He was a Paul Harris fellow.

In 1969 Salisbury became associate dean and director of the Illinois Agricultural Experiment Station, a position he held until his retirement in 1978. During these nine years Salisbury continued to publish research. In addition, he became more interested in and deeply concerned about the efficiency of the U.S. agricultural experiment stations in the United States and the effectiveness of the Cooperative Extension Service in delivering timely information to the needy anywhere. He despised excessive bureaucracy, with its effect on decreasing the efficiency of research and distribution of the results. The important goal was to feed the hungry, wherever they were.

As he viewed advances in the technology capable of manipulating the reproductive process in animals, he became increasingly concerned with *Homo sapiens* having the moral wisdom and courage to control or withhold application of this technology to our own species.

#### FAMILY AND HOBBIES

Salisbury was intensely devoted to his job, his staff, and his students. The older graduate students at Cornell remember the young Professor Salisbury as a brother. All of



us graduate students and our families looked forward to the annual Thanksgiving invitation to share the day with Dorothy and Glenn Salisbury. We gave thanks for our wonderful academic family. At the same time he was a loving personal family man. He was devoted to his wife, Dorothy, and supportive of their children. He took great pride in their achievement. As time passed he joined the ranks of doting grandparents.

He loved the out-of-doors and the good earth. He was an avid gardener. His garden continued to grow larger during retirement. Salisbury loved to till the soil, plant the tiny seeds, and watch a variety of nourishing vegetables grow, especially if someone else would weed the garden and harvest the abundant supply.

Family camping trips to scientific meetings or to Wisconsin vacationlands were an adventure during rain or sunshine. He enjoyed the serenity—the time to relax away from it all. He enjoyed fishing, and the kids reported that the fish enjoyed their Dad, because many of them got away. He refinished furniture, painstakingly scraping off multiple layers of paint that obscured the beautiful wood underneath. He enjoyed cherry wood especially. One refinished cherry table served as the family dinner table for many years.

Salisbury had an insatiable appetite for reading novels as well as scientific publications. He was particularly fond of military history. When he was a young boy, his grandfather had spun tales about service in the Civil War. It is likely that Salisbury was as much interested in the study of soldiers and their leaders as he was in the bloody outcome of battles. He was an astute judge of human beings.

While he was excellent in repairing and building people, he had no hankering for repairing cantankerous equipment or assembling do-it-yourself items. This was a family joke, likely to the annoyance of Salisbury, who did everything in

his professional life as near perfection as possible. His kids reminisced that they had to remind their Dad to read the directions.

In retrospect, Glenn Wade Salisbury combined intellect, vision, and unlimited enthusiasm with integrity, qualities that inspired others. As a result his group was the dominant factor in developing artificial insemination, the most powerful biotechnology for genetic improvement of livestock. He was a builder of people, as he saw the potential of individuals, and nurtured each one to the fullest.

THIS BIOGRAPHY is based on personal reflections as I began graduate work with Glenn Wade Salisbury, on files obtained from the Department of Animal Science at Cornell University, and especially on voluminous files kindly sent to me by his wife, Dorothy Cross Salisbury. Drs. George and Sarah Seidel reviewed the text. Their helpful suggestions are appreciated.

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