

of veterinary medicine in Africa and the Middle East. Consequently, the college had a large number of international students. My accepted class of 100 students in 1952 had 10% international students and 12 females. At graduation six years later, the class had shrunk to 35 graduates. I aspired to be a large animal veterinarian, which I enjoyed very much, working in a government farm that had approximately 1,000 imported pregnant heifers which gave this new graduate a tough course in obstetrics and gynecology. An opening for a beginning academic position in infectious diseases at my university was so attractive that I accepted that position. At that point, poultry production was growing fast in Egypt, and it was becoming clear that poultry would be the major source of animal protein in Egypt. That changed my mind and I decided to pursue further graduate education in poultry health.

Traveling to the USA to get further graduate academic training was a goal to be achieved and I had friends at The Ohio State University (OSU). Although two of my mentors in Egypt (Dr. Amin Zaher and Dr. Solimar Zaki) were alumni of Michigan State University (MSU). All told me how great their universities were in the USA, and I went with OSU simply because I was impressed that they responded promptly to my inquiries. That was a major decision that influenced my life and career forever. I started school in September 1962, received an MS degree in 1964 and PhD degree in 1967. A most fortunate opportunity at OSU was having Dr. Edward H. Bohl as a mentor for my graduate program. Dr. Bohl was a highly distinguished veterinary microbiologist (both bacteriology and virology). His vast knowledge in both fields was an example to follow for the rest of my career. His energy, enthusiasm, meticulous pursuit of science and encouragement were traits that left their marks on all his graduate students.

By the time I was finishing my PhD studies Dr. Lloyd Ferguson became the chair of the Department of Veterinary Science at The Ohio Agricultural Experiment Station (former name of the Ohio Agricultural Research and Development Center). Dr. Ferguson was a highly respected veterinary scientist and administrator. Drs. Ferguson and Bohl (Dr. Ferguson was Dr. Bohl's mentor for his PhD studies) offered me an assistant professor position and I had to make a major decision at the time. My plan up to that point was to go back to Egypt after receiving the PhD degree where a faculty position was guaranteed for me at the College of Veterinary Medicine, Cairo University. I loved my native country but during the 5 years in the USA, my outlook on life had changed considerably, and several factors converged to shape the rest of my life. Most important of these factors was getting to know, date and love my future wife, Linda [we have been married now (2022) for 52 years]. In addition, it was obvious that going back to Egypt would negatively impact my future scientific career. That tipped the scales, and I accepted the position which proved to be the right decision.

In 1972, 2 years after we were married, we bought 70 acres that had a historic brick house estimated to be 170 years old at the time. We renovated the interior and later made two additions. We continue to live in this house, and we enjoy this quiet rural setting in Wayne County, Ohio. There are trees, pastures and two streams that run through it.

Our only son, Justin, was born in 1976, went to our local school rural district and graduated as valedictorian of his high school class in 1995. He was accepted at Harvard and graduated in 1999. He later went to law school at the University of Chicago and graduated in 2004. While at Harvard he met his future wife, Erin, who was attending Wellesley College and as luck would have it, she was an Ohio girl raised in our county and went to our school district, but she was at a different elementary school than Justin's. Then her parents moved out of our district. Justin and Erin married in 2014 and they both loved Boston and the New England, so they accepted jobs in Boston. Justin is an attorney in securities law and Erin works for Microsoft as a project manager. They gave us the gift of two granddaughters, Lilly and Violet, whom we adore.

My work at the Department of Veterinary Science (later to become Food Animal Health Research Program and most recently the Center for Food Animal Health) progressed well and I moved up the ranks to associate and full professor. There were several opportunities (offers) for employment at other institutions, but our (by then Linda had become a faculty colleague in the department) positions at OSU

continued to compare favorably with that of other institutions and both myself and Linda thrived at OSU and remained there for the rest of our careers. One opportunity for dual career couples in particular was very attractive. It came from Dr. Harley Moon (a gentleman, that Linda and I greatly respected as a scientist and as a person), Head of the National Animal Disease Center. Dr. Moon offered positions to Linda and me to lead the swine and poultry research efforts, respectively.

One interesting story related to my career advancement is when Dr. Ferguson (our department chair) came to tell me that I will be considered for promotion and tenure at rank of associate professor and my response was fine since I did not know what that was all about. I remember at that point I did not have what is now a formal dossier. A month later Dr. Ferguson came back to congratulate me for being promoted and tenured. I cannot help but compare that to what our young colleagues now go through for the promotion and tenure process.

I retired in 2013, but Linda continues to work in 2022. At FAHRP, we work with cohesive distinguished and hardworking teams of faculty, staff, graduate students and like I was initially, foreign visiting scholars who contribute greatly to the research program and culture within the unit.

My years at FAHRP were productive and joyous and I had the honor of mentoring many graduate students from the USA and globally. Dr. Erwin M. Kohler followed Dr. Ferguson as head of our group and the department continued to prosper under his wise leadership. I followed Dr. Kohler as Head of FAHRP in 1992 and these were busy and rewarding years of active research, mentoring graduate students, and leading the FAHRP as one of the most productive units at the OARDC. Again, I was fortunate to serve under the leadership of Dr. Bobby Moser, OSU Vice President of the Agriculture and Dean of the College of Agriculture. Serving with Bobby was indeed a pleasant experience. Drs. Tom Payne and Steve Slack led the OARDC during my term and I enjoyed working with them as well.

Research Activities

I began my research career while doing graduate work in the early sixties working on avian *Mycoplasma* which was an important topic at the time. Dr. Richard Yamamoto isolated and characterized *Mycoplasma meleagridis* (MM) of turkeys and I followed his work and discovered the venereal and egg routes of transmission and developed serologic methods to detect antibodies and improved media for isolation. In addition, we developed a method for control of egg transmission by dipping the eggs in antibiotic solutions using a heat or pressure differential methods. One of the issues we faced at the time was the widespread prevalence of the infection and that made it impossible to do experimental studies using university or commercial flocks. That led to the idea of developing a specific pathogen free (SPF) flock of turkeys. That was accomplished through a long series of isolations and serologic tests to select birds free of the infection, which was done successfully in 1964. That flock became the source of birds and eggs for all our experimental studies and over the years was selected for freedom from all the known pathogens of turkeys and zoonotic infections such as Salmonella and Campylobacter. To this day (2022) that flock continues to be used for experimental studies and as far as we know, it is the only SPF turkey flock in the world.

The availability of the SPF turkey flock made it possible at the time to experimentally reproduce the severe respiratory field condition of MM infection complicated by a secondary infection of *Escherichia coli*.

Immunology was becoming to mature into a discipline at that point and I was fascinated with the discoveries impacting infectious diseases. John Dohms, studying in my laboratory and Dr. Wayne Bacon from the Poultry Science Department and myself cooperated on studies of the turkey immunoglobulins (Ig). We characterized IgM, IgA, and IgG, studied their ontogeny and transfer from hens to poults. We demonstrated that IgG was only transferred from the hen to the embryonic egg. Later, Samia Metwally did interesting work on distribution and traffic of IgG in the body compartments.

Over the years my studies were closely tied to field conditions and intriguing complex diagnostic cases. Examples were interactions of *Hemophilus gallinarum* (currently called *Avibacterium paragallinarum*) and infectious laryngotracheitis virus leading to mortalities up to 65% which neither infection alone could induce. Another intriguing case was unusual high mortality associated with *Aspergillus fumigatus* infection. Experimental infections revealed the role of relative humidity (RH). RH acted in two ways. It affected the mucociliary apparatus of the respiratory tract and it maintained the spores of the fungus in the air for a long time (they are hydrophobic) leading to increased chances of exposure. When the RH was above 50%, none of that occurred. That led to the practical recommendation that once you see dust hanging in the air (sign of low RH) in a poultry house (which might include spores) the RH should be raised.

On some turkey farms, Erysipelas is a recurring problem in some flocks. The organism survives in the soil and when turkey toms (males) reach sexual maturity and start fighting, the organisms can enter through the broken skin resulting in disease. Commercial vaccines were made of killed bacteria (bacterin) and had to be administered to individual birds. Joe Bricker, a PhD graduate student in my laboratory, developed an oral vaccine that worked under experimental and field conditions.

A most productive research cooperative effort started in the early eighties with Dr. Karl Nestor, a geneticist, in the Poultry Science Department. It started with investigation of two disease outbreaks in intermingled turkeys from different genetic lines. Examining the mortality data from these outbreaks, Karl noticed a remarkable, statistically significant high mortality in a line selected for increased body growth. That started a long series of experimental studies that confirmed the genetic basis of resistance to a bacterial disease, fowl cholera, and a viral disease, Newcastle disease. Again, genetic lines selected for increased growth rate were most susceptible to disease.

Further studies demonstrated the cellular and molecular basis of the increased susceptibility. Several graduate students were involved in these studies.

A newly recognized respiratory disease of turkeys was shown by Dr. Donald Simmons to be caused by a bacteria later designated *Bordetella avium*. We further characterized the disease under field and experimental conditions. Mark Jackwood was involved in this work while working on his PhD in my laboratory. Suspicion that infectious bursal disease virus (IBDV) might be involved in this disease led to work on that virus and the characterization of a new serotype 2 of the virus that was shown to be (along with serotype 1) prevalent in commercial turkey flocks. Daral Jackwood while doing PhD work in my laboratory at the time was involved in these studies. Further studies on IBDV were initiated because of concern about high morbidity and mortality associated with respiratory disease in broiler chicken flocks in the Delmarva Peninsula in Delaware. Our studies revealed that an antigenic variant of serotype 1 IBDV was prevalent in these flocks lowering the resistance of the chickens to respiratory infections. One of the viruses isolated in our laboratory was developed into an inactivated vaccine and used commercially. Further studies by Deborah Jackwood, who was doing graduate work in my laboratory, characterized the antigenic diversity of IBD viruses and Nader Ismail, Gomaa Abdel-Alim, Olcay Ture, Mohamed Hassan, and Mohamed Al-Natour extended this work to delineate the immunogenic diversity of the virus and to show the widespread occurrence of the virus antigenic variants in commercial chicken layer flocks. Our laboratory became the OIE (World Animal Health Organization) official expert laboratory on IBD, and we cooperate with OIE and USDA in resolving trade issues dealing with transmission of IBD in different continents.

We conducted studies on a newly discovered virus, metapneumovirus, that causes a respiratory disease in turkey. Mohamed Khalifa in our lab, studied the transmission of the virus, serologic test (and prevalence) for the infection.

We investigated a field case of a drop in egg production in a commercial turkey flock in Ohio and isolated an influenza virus we characterized as H1N1. We isolated the same virus from swine on the same farm that experienced a respiratory disease after the introduction of boars that apparently carried the

virus. We worked on that case with Dr. Ram Mohan of the Ohio State Clinical Disease Diagnostic Laboratory. Further studies in my laboratory provided the first evidence of the natural and experimental of interspecies transmission of an influenza virus between pigs and turkeys. It took several years before other influenza researchers accepted that influenza viruses could cross the species barrier.

The turkey breeding hen relatively produces few fertile eggs in a breeding season and drops in egg production are economically costly. We documented the role of influenza and parainfluenza viruses in egg production drops.

Reovirus was documented as a cause of viral arthritis in turkeys, but the condition was seen only once and years later we recognized the condition in an Ohio commercial flock. We thought the condition to be secondary to a hemorrhagic enteritis (HE) outbreak. That was before the development of HE vaccines for turkeys. It is interesting to speculate on whether some of the current outbreaks of reovirus arthritis in turkeys have possible primary inciting agent(s). That line of thinking recognizes that reoviruses are common in the turkey gut, but not always inducing arthritis, and the reoviruses isolated from cases of arthritis are the same ones that reside in the turkey guts.

My laboratory was involved in studies on enteric viruses of turkeys for a long time. Dr. Arun Bahl while working at the Cuddy Organization brought to our attention the seriousness of enteric problems in commercial turkey flocks. My wife, Linda, was heavily involved in studies on enteric viruses in baby pigs and calves. We solicited her help and she identified rotaviruses, astroviruses, reoviruses, adenoviruses and enteroviruses from affected flocks. These discoveries led to an extended period studying these viruses, their role in disease, singly and in combination, their distribution, persistence, and the immune response of turkeys to rotavirus. Collaborators in these studies included Drs. David Swayne, Charles Hofacre, Kenneth Theil, Donald Reynolds, Christopher Hayhow, Yuxin Tang, Samia Metwally and Maria Murgia. One of the significant findings at the time was the devastating role of coronavirus when present in combination with other enteric viruses.

Many institutions were involved in research on coronaviruses. A colleague in Canada reported on using an established cell line to replicate turkey coronavirus. That was a significant finding at the time because we and others were not able to find a cell line primary or established, that would support replication of turkey coronaviruses. The Canadian colleague was also working with bovine coronaviruses which are easily adapted to cell culture. Out of frustration, I decided to consider the possibility that the Canadian colleague was dealing with a bovine coronavirus. I had one of my graduate students (Mahmoud Ismail) use a well characterized bovine coronavirus we obtained from Linda to inoculate SPF turkey poults. That work established for the first time that coronavirus from a mammalian species could infect and cause disease in an avian species and vice versa. Up to that point, most coronaviruses were considered host specific with no crossing of species lines.

Influenza became an important topic again with outbreaks in people and avian species. We revisited the studies on the interspecies transmission of avian and swine influenza. Hadi Yassine in my lab established the interspecies transmission of avian and swine influenza viruses in both animal species. Some of the virus strains moved both ways and others moved only in one direction. We spent considerable time attempting to define the molecular basis of intraspecies transmission of influenza viruses. We did reverse genetic studies concentrating on manipulating the HA gene of influenza virus considering that this gene is responsible for attachment to the host cells. Unfortunately, we were not able to prove that the HA by itself from strains of virus that transmitted or failed to transmit between species endowed the virus strains with the ability to cross the species barriers. Apparently other genes in combination with the HA gene facilitate the process which could make sense from an evaluation perspective.

Service in Professional Societies

Professional societies help shape our careers. I belonged to several and I do list below four of these societies that had the most impact.

The American Association of Avian Pathologists (AAAP)

The AAAP represents all the workers in the poultry health field. It is a welcome community that nurtures and inspires its young members. I was mentored by senior colleagues at the AAAP and encouraged to participate in the various activities offered and to serve on committees. I took this advice to heart and served on numerous AAAP committees and chaired several over the years. I also served on the Board of Directors and was elected as president of AAAP. I was appointed to represent the AAAP at the AVMA House of Delegates and served in that capacity for several years. That was an eye opening and instructive experience dealing with the veterinary profession and the importance of the AVMA to veterinarians in all the areas they serve.

I was honored to be asked by the AAAP Board of Directors to serve as Editor in Chief of two editions of our textbook, *Diseases of Poultry*. That was a major undertaking, but highly rewarding. The support and advice of the previous editor were indeed valuable. Another privilege, which I accepted at my retirement in 2013, was to serve as Editor in Chief of our peer reviewed scientific journal, *Avian Diseases*. Now that I have served for more than 9 years in that capacity, I can reflect with satisfaction on these major opportunities that I had in my career.

The American College of Poultry Veterinarians (ACPV)

The ACPV is the official certifying agency of the competency of veterinarian in the poultry health field. It is an AVMA specialty group and membership is by exam. The group sponsors continuing education workshops and partners with the AAAP in some activities.

I was a participant in the early discussions that led to the creation of the ACPV and served as the first president of the college. I was very active in the early years of the organization and now younger generations of poultry veterinarians keep the organization vibrant and effective.

The American College of Veterinary Microbiologists (ACVM)

It is another AVMA specialty group where veterinarians engaged in the microbiology (infectious diseases) can become diplomates by taking examinations in the fields of virology, bacteriology, and immunology. I learned early in my career that one can benefit tremendously from learning and interacting with colleagues working with other species of animals. I have been very active in that college since I became a diplomate in 1968 and served as president of the college in 1983. It has been a valuable experience.

The Conference of Research Workers in Animal Diseases (CRWAD)

As its name suggests, this is an organization that represents all those that do research on animal disease with the greatest emphasis on infectious diseases. Again, one can learn from colleagues working with other species. For graduate students, this organization fosters their work and helps further their careers.

Reflections

A life in research is an interesting experience. As frustrating research can be at times, the joys of the occasional discovery are highly rewarding experience. One can indeed recommend this career for young associates.

Despite official retirement in January 2013, my career has continued. Editing *Avian Diseases* keeps me informed of developments on our field and I thoroughly enjoy that experience.

After spending a lifetime doing research in poultry health, one can look back and reflect on some of the issues we currently face. The so-called normal mortality in the commercial flocks which is accepted as normal should be viewed as a challenge with the aim of discovering the cause(s) and reducing that mortality.

There are diseases considered as caused by one pathogen, but there are indications that they might have multiple etiologies. This puzzle has yet to be solved. Studies on pathogenesis have to be expanded and emphasized.

There are several rewarding benefits to life in research. Most significant, is mentoring young colleagues and watching their careers develop. Travel across the country and internationally has always been an interesting experience. These plus the joys of discovery are reasons to recommend this career to young colleagues.

Those who carry us on their shoulder

Our lives are shaped by the people around us and I am no exception. My parents, family, associates (faculty, staff and students) and friends helped me do what I did in my lifetime. I humbly thank you.

Two individuals that have helped me tremendously in my career are Hannah Gehman and the late Robert Dearth. Hannah is the department office associate. A most capable and pleasant person one wishes to work with. Robert ran my laboratory for 36 years and I had full confidence in his lab and animal work. Indeed, I was fortunate to have Bob's support and I continue to receive capable help from Hannah.

Finally, to Linda, my wife. Thank you for being a partner, friend, advisor and critic.

Acknowledgment

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Additional biographical materials may be available from the AAAP Historical Archives located at Iowa State University. Contact information is as follows:

*Special Collections Dept. & University Archives
403 Parks Library
Iowa State University
Ames, IA 50011-2140*