A History of

Avian Medicine at Cornell University

1898-2008

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Cover Photo: An early picture of the Poultry Disease Research Laboratory on Hungerford Hill Road, completed in 1932

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Dedicated to
Dr. P. Philip Levine
1909-1972

Acknowledgments

Dr. Julius Fabricant, a fellow emeritus professor whose connection with the avian medicine program spans the last 60+ years, was especially helpful in recalling specific relevant information, and he also contributed portions of this review related to his own work. Three current or former faculty members kindly reviewed the manuscript and helped with portions relevant to their special areas of research interest: Dr. Karel A.(Ton) Schat, who came to Cornell as a graduate student and subsequently joined the faculty of the Department; Dr. Benjamin Lucio, another graduate student who later became a faculty member; and Dr. Syed Naqi, a faculty member who retired in 2002.

I am particularly indebted to Dr. William Dean who, assisted by Dr. Tirath Sandhu, provided much of the detailed information and wrote a large portion of the history of the Cornell University Duck Research Laboratory at Eastport, Long Island. They had served consecutive periods as Director at that laboratory.

The assistance and suggestions of Susanne Whitaker in the College's library, is also gratefully acknowledged. She kindly supplied photographs of some of the early participants in the avian medicine program at Cornell.

Preface

Cornell University is one of many institutions that contributed greatly to the description, understanding and control of avian diseases, particularly those of domestic fowl. Only a few can boast of major discoveries and investigations into both fundamental and practical aspects of poultry diseases. Cornell has most certainly been among that group; many studies conducted here have had a significant impact on the enormous industries associated with poultry production and thus have benefitted consumers.

It is important to record and document the many objectives and accomplishments of programs that were carried out under the auspices of the College of Veterinary Medicine. This is particularly true now that this area of focus has largely disappeared from College activities.

The author of this review began his association with the avian disease program in September, 1948 as a 16-year-old high school student hired to work for Dr. Earl N. Moore, a turkey pathologist at the poultry disease research laboratory on Snyder Hill. He continued his involvement as a student assistant in that laboratory throughout his college years (preveterinary student 1949-51, DVM in 1955, MS in 1956). After a year as an Acting Assistant Professor in the Department of Pathology and Bacteriology, filling in during Dr. Julius Fabricant's sabbatic leave, he spent the next four years (1957-61) at the University of Massachusetts, again working on avian diseases. Since 1961, he has been a part of the avian diseases program at Cornell's College of Veterinary Medicine, first as an Associate Professor in the newly formed Department of Avian Diseases, then as Professor (1968), and finally Chair of the Department of Avian and Aquatic Animal Medicine (1976-95). He has been an active Emeritus Professor since his retirement in 1995.

A major source of historical information was the College's Annual Report, a highly detailed document which the Dean was obliged to provide to the Governor of New York State each year. These reports contained information on staffing, departmental structure and activities, teaching programs, individual research programs, facilities, physical plant, new or modified objectives, publications by faculty and staff, diagnostic laboratory data, *etc.* The earliest report with an entry related to poultry diseases was for the year 1898, and references to work in this field continued until the 1972-73 Report. Subsequent annual reports took on a varied but non-detailed approach representing a more glamorous view of selected highlights of the College's activities. College Announcements also were a source of information, particularly because they contained lists of course offerings, students, graduate students, and faculty. With the help of colleagues and some written documents, it has been possible to recall and record most of the relevant information from the period subsequent to 1973 when the detailed Annual Reports were no longer produced.

This account is divided into four parts. Part I deals with the history associated with the Ithaca campus, with sections based mostly on periods of leadership. Part II covers programs carried out at locations other than Ithaca (Farmingdale, Regional Poultry Laboratories, Duck Research Laboratory). Part III consists of a summation. Part IV has lists of faculty and professional staff, graduate students, visiting scientists and post doctoral associates, and a list of publications.

Part I

Programs at Ithaca

The Early Years (1898-1923)

The earliest period in the history of avian medicine at Cornell was characterized by the recognition that diseases afflicting poultry were economically important and very worthy of attention by the veterinary profession. The first recorded publication dealing with poultry was in the 1898 Annual Report of the College. It was a description of the air sac mite in the fowl by Walter L. Williams. The first notation of a significant disease appeared in the 1900 Report. Infectious entero-hepatitis in turkeys was reported to be a problem at that time. The disease had been seen for years in turkey breeders in Rhode Island but it had just recently appeared in flocks along the Hudson river and elsewhere in New York State, including the University flock at Cornell. It was suggested that restricting the exhibition of poultry from infected areas and also stopping shipment of poultry from those areas to others would help prevent future losses. At this time, the value of poultry in New York State was estimated to be nearly 15 million dollars, about 15% of the animal products of the State.

Several years later, in the 1908-09 Report, losses from disease were judged to be from 5 to 10 percent, with the most destructive afflictions being "white scours" (later referred to as bacillary white diarrhea, and finally, pullorum disease), roup or diphtheria (fowl pox), and entero-hepatitis (also known as blackhead). Tuberculosis, cholera, fowl typhoid and an unidentified "destructive septicemia" were mentioned as problems in some localities. Parasites, coccidiosis, tumor diseases (sarcomas, leukemia), and aspergillosis also were cited as predominant conditions in poultry during the second decade of the 1900s. The College was becoming aware of the need for more attention to the problem of poultry diseases. The1910 Report noted that "there is a constantly increasing demand for information concerning the nature, treatment and prevention of diseases of poultry ..... definite knowledge of the infectious diseases of the feathered tribes is somewhat meager, and the pathology of the more common disorders is far from complete." Further, "The millions of dollars invested in poultry in this State warrant a careful investigation into the diseases which are causing losses aggregating tens of thousands of dollars annually. This college is endeavoring to give all possible assistance in the acquisition of knowledge that will enable the formulation of methods to prevent these losses and bring into existence a better knowledge of poultry diseases."

Faculty during the early period

Frederick S. Jones (1909-11). Significantly, the 1908-09 Report stated that work had begun on several of the most important of the poultry diseases with particular attention being given to investigations on "white scours." It did not identify the individual who was responsible for attending to these problems, but almost certainly it was Dr. Frederick S. Jones, a new member of the Department of Comparative Pathology and Bacteriology. He was the source of several subsequent reports on poultry diseases. His title was a long one: Instructor in Research Work in the Study of Poultry Diseases, later slightly shortened to Instructor in the Study of Poultry Diseases. Jones investigated bacillary white diarrhea (pullorum disease), the most important of four infectious diseases lumped together under the heading of "white scours" or "white diarrhea." Pullorum disease was one of the most serious problems in the poultry industry at the time.

Jones determined a number of very important facts regarding this disease, including the manner in which infection occurred, the age of susceptibility, and methods for preventing the spread of infection. He reported the results of experimentation carried out in the summer months of 1910 and 1911 in a paper entitled

"Further studies on bacillary white diarrhea in young chickens," which was published in the 1910-11 Report of the College. He had confirmed an association of the organism *Bacterium pullorum* with the infections he was studying. Also, he learned that infection was introduced through the egg, by contact of chicks with egg-infected hatch mates, or by housing in contaminated quarters. He found that the cycle of infection included transmission through the egg, producing infected chicks. Survival from the early disease by some individuals who grew to maturity harboring the organism in the their ovaries continued the cycle. Prevention required the removal of infected adults, segregation of chicks until at least 4 days of age to reduce the incidence of clinical disease, and disinfection procedures for premises and equipment. The next year he published four papers, two dealing with pullorum disease (acute infection in adult fowls, and a macroscopic agglutination test for detecting infected adults) and two on avian tuberculosis (a case report of pigeon infection and a general paper on the disease).

Much of this early work was done with help from the Poultry Department in the College of Agriculture. They supplied incubators, eggs, chickens and also helped care for the experimental chickens.

Dr. Earl M. Pickens (1914-17). After Jones left in 1913, no one was listed with an appointment specifically related to the field of poultry diseases until 1922. However, poultry were not forgotten during this intervening period. Dr. Earl M. Pickens reported on the effect of atmospheres of hydrogen, carbon-dioxide, and oxygen, respectively, and of mixtures of these gases on the growth of *Bacillus subtilis*. Also, in the 1915-16 College Report, he described what he considered to be two varieties of leukemia: 1) the lymphatic form consisting of lymphoid leukemia and "lymphemia," and 2) the mixed-cell type which included myeloid and myelogenous forms. He provided an excellent historical account of research by others, and presented gross and microscopic pathology findings from 22 cases of leukemia or "pseudo leukemia" in chickens. He noted that the study of these conditions was more significant to human medicine than to avian medicine.....

> "These two conditions with the allied forms make a very important group of maladies in the lower animals, especially in the common fowl. This importance is due, not so much to the economic loss caused by them, as to their relation to these affections in the human subject, in which they generally prove fatal. It necessarily follows here, as in most other diseases, that where the mortality is high, the condition is but little understood, and treatment in a scientific manner cannot be applied. Happily, the chicken with its apparent susceptibility, and the readiness with which it may be obtained, lends itself most admirably to experimental work."

This conclusion is of great significance when one considers that a great deal of the research on poultry diseases that has been carried out over the many subsequent years has been of enormous value from the standpoint of comparative medicine as well as being of fundamental value in solving the problems of a wide variety of diseases in poultry. The support for studies on Marek's disease (a herpesvirus-induced lymphoma), and atherosclerosis (caused by the same herpesvirus) that was provided by the National Institutes of Health over several decades attests to this conclusion.

Pickens also published a paper in 1915-16 on chicken pox (now called fowl pox) and roup (probably the "wet" form of fowl pox). He covered the clinical disease, its etiology ("an ultra-microscopic virus"), gross lesions, treatment, prognosis, and prevention. The reports by Dr. Pickens were comprehensive and were undoubtedly useful to those in the profession who had occasion to deal with poultry diseases, although unlike those attributed to Dr. Fuller, they did not appear to have been based on any experimental work that he had carried out.

Presumably he was involved in poultry diagnostic work as part of his duties in pathology.

Earl M. Pickens 1911

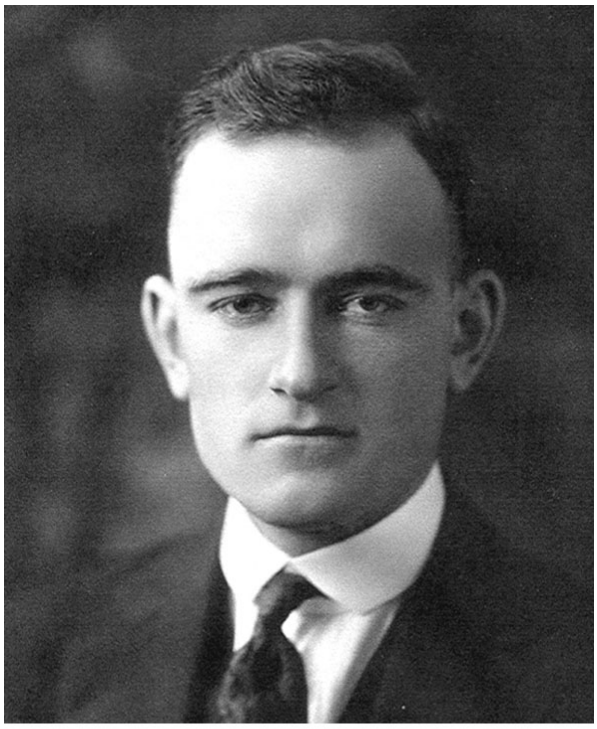
Earl M. Pickens

S. A. Goldberg and J. P. Benson. The only other mention of a poultry disease prior to the 1920s was in a paper included in the 1919-20 Report entitled "A study of cloacitis in the domestic fowl (so-called vent gleet)" by S. A. Goldberg and J. P. Benson from the Department of Pathology. They provided a description of the condition in which the mucous membrane of the cloaca becomes inflamed and subsequently develops a purulent discharge. It was thought to be a contagious condition which has some resemblance to gonorrhea in man. Several case reports were detailed, and experimental transmission attempts were made with little success.

James W. Fuller (1922-23). In 1922, the College again recognized the need for a poultry disease specialist, appointing a 1921 graduate from the College, Dr. James W. Fuller, as Instructor in Poultry Diseases in the Department of Materia Medica and Small Animal Clinic. His charge apparently did not include a research component since he reported that the only work on poultry diseases at that time was restricted to 1) the examination of diseased poultry sent to the college for diagnosis and advice to the owners, and 2) a survey of the diseases of poultry in the State. The demand for diagnosis of diseases among poultry had increased rapidly. For example, only 37 cases were examined in 1910 but this doubled the next year and by 1922 the number of specimens submitted for diagnosis was nearly 500 (it was to reach over three thousand accessions in the Ithaca and Farmingdale laboratories by 1930). Thus, Fuller's charge was primarily for diagnosis and extension, the latter reflected in 24 visits to poultry farms in 1921-22.

Another of Fuller's duties was the testing of a pox vaccine. This was prepared with virus obtained from the Veterinary Division of the University of California. In the 1921-22 Report, he presented a paper entitled "Vaccination in the control of chicken-pox." He discussed the history of vaccination for the disease, vaccine preparation and administration, and the results of the application of the vaccine to several flocks of chickens. Apparently, he was in charge of making the pox vaccine and also a bacterin against "roup" (in this case, "roup" may have referred to coryza or chronic fowl cholera), both of which were sent to veterinarians and poultry owners. In 1922-23, his laboratory distributed nearly 35,000 doses of the pox vaccine and nearly 14,000 doses of "roup" bacterin. He reported that the most serious losses during that year were from chicken pox, roup, bacillary white diarrhea and coccidiosis, in that order.

Finally, it bears noting that Dr. Fuller was the



James W. Fuller 1921

first faculty member at Cornell to offer a formal course on poultry diseases to veterinary students. In the 1922-23 academic year, he presented a 1-credit-hour course (Catalog No. 26) to 4th year students in the 2nd term. It would appear that the subject of avian medicine was truly becoming a credible entity at Cornell. Dr. Fuller moved to Springville, NY in 1924 where he established a veterinary practice but continued working with poultry as well.

Summary

Thus, the beginnings of avian medicine at Cornell included an awareness of the importance of poultry in New York State, identification of the most significant disease problems, recognition of the need for veterinary attention to these diseases, and a modest but important effort in both research and service for this special area of veterinary medicine.

The Brunett Period (1923-1943)

Earl Louis Brunett 1923

The period between the early 1920s and the early to mid 1940s was one of evolution for the field of avian medicine at Cornell. The College was obviously aware of the need for work in this subject area, but its commitment of resources had been somewhat limited for the first two decades of the century. Dr. Fuller's appointment in 1922 can be seen as the beginning of a renewed appreciation of the importance of poultry diseases when one considers the fact that, after Jones had left in 1914, no one person had an appointment with specific responsibility for this subject area. Fuller remained for only a year. It was his immediate replacement by Dr. Earl Louis Brunett that really signaled a new era. The period from Brunett's appointment in 1923 to his retirement in 1943 was one of growth in the size, scope, and staffing of the program on poultry diseases, along with a concomitant maturing of objectives and the development of means for carrying out those objectives. Certainly, Dr. Brunett was not the only player during this time, but his tenure epitomizes the commitment that the College of Veterinary Medicine at Cornell made to addressing the needs of the poultry industry in New York.

Contributions by Dr. Brunett

Earl Louis Brunett had been a student assistant for two years prior to his graduation from the Veterinary College at Cornell in 1923. He immediately joined the faculty as an Instructor in Poultry Diseases in the Department of Pathology and Bacteriology He undertook studies toward a graduate degree at the same time but he apparently did not complete this program. As had been the case with Dr. Fuller, Dr. Brunett had diagnostic work as a major responsibility. In his first contribution to the Annual Report of the College (1923-24) he wrote that there had been a 62% increase in the number of birds examined at the laboratory, to a total of 778 accessions. These included chickens, turkeys ducks, geese, grouse, pheasants and bobwhites. The major cause of disease in New York State poultry that year was pullorum disease (bacillary white diarrhea), but tuberculosis was found to be prevalent in certain sections of the state, and coccidiosis was a serious problem in rearing chicks. Bacterins and hygienic measures were used to control acute infections with some of the bacterial diseases.

The importance of pullorum disease dictated the attention of Dr. Brunett from the beginning of his tenure. He prepared a paper entitled "Bacillary White Diarrhea" (1925-26 Report) which discussed the etiology, forms of the disease, signs, pathology, treatment, and diagnostic tests. It was illustrated to show the cycle of infection and some of the gross lesions of the disease. A couple of years later, he described a test project for the eradication of this disease, pointing out that there was a lack of experimental data on which to evaluate the usefulness of testing regimens. Together with the Farmingdale laboratory, which began to look after the

poultry disease concerns on Long Island beginning in the mid 1920s (see later), the Ithaca laboratory oversaw a major serological testing program that was in place between the 1920s and the1940s. The program was aimed at the removal of infected reactors with total eradication of this egg-borne disease as the goal. Breeding flocks were the major targets of the program. Testing for carriers done by the two laboratories, or supervised by them, totaled nearly 29,000 birds in 1926 and nearly 36,000 birds in 1927. The consistent and concerted effort aimed at eradication of the disease relied on serological testing almost exclusively, and Cornell's participation through the production and distribution of antigens extended for several decades. Some testing was done at Ithaca but a majority was done at other laboratories in New York State, particularly in the later stages of the eradication program. In addition to the tube-agglutination tests done at laboratories, practicing veterinarians were employed to conduct rapid plate-agglutination tests of breeding stock to identify reactors. An intradermal (wattle) test for detecting infected fowl was described in the 1922-23 Report. It was not clear if it was ever used to any extent in the eradication programs in New York State.

Dr. Brunett contributed two other papers on pullorum disease in the 1929-30 Annual Report. One, entitled "Transmission of *Bacterium pullorum* infection among mature chickens" detailed experimental studies in which mature non-reacting chickens were held with reacting female or male chickens to determine rates of spread. Transmission was found to be inconsistent. The second paper, by C. E. Hayden (Department of Physiology) and Brunett, was entitled "A study of the influence of *Bact. pullorum* infection upon some organic and inorganic constituents of the blood of S. C. White Leghorns." Only a few minor differences were detected.

The problem of pullorum disease was so important that in 1928 many states and provinces in the northeastern US and Canada formed an organization called "Workers in Pullorum Disease Control," which met annually (at Cornell in 1932) to share information and work together to standardize antigens and testing methods. The 1931-32 Report commented on the Cornell meeting thusly: "Inasmuch as the members of this group devote practically all of their time to the study of poultry diseases, meetings of this type have never been duplicated by any organization." This group later embraced other disease problems and eventually evolved into the present organization known as the Northeastern Conference on Avian Diseases (NECAD). The name change was made after the success of the eradication program resulted in a meeting one year (1956) in which no papers on pullorum disease were presented. Eventually, all poultry breeding flocks in New York and most other states were declared pullorum-clean.

In addition to his considerable involvement in pullorum disease control, and his commitment to diagnostic and extension work, Dr. Brunett oversaw the production of fowl pox vaccine for distribution to veterinarians in New York State (over 500,000 doses in 1938), and also carried out a limited amount of research on pox and a few other conditions. A publication in the 1930-31 Annual Report, entitled "*Bacterium abortus* infection in the fowl II," which he coauthored with Dr. H. L. Gilman from the Veterinary Experiment Station, showed that there was some evidence of natural infection in chickens in New York State, but it was considered to be neither widespread nor serious. Transmission to pigeons and from chickens to cattle was effected.

Some of Dr. Brunett's research on fowl pox is presented in 3 publications. In the 1930-31 Report, he was a coauthor with Robert Matheson and A. L. Brody (from the Department of Entomology in the College of Agriculture) for a paper entitled "The transmission of fowl pox by mosquitoes, preliminary report." They showed that *Aedes* mosquitoes could transmit infection for at least 27 days after feeding on pox lesions on combs or on virus soaked raisins. In 1933, he published

a paper in the Journal of the American Veterinary Medical Association entitled "Studies on fowl pox vaccination" which concluded that cow pox virus did not immunize against fowl pox, that fowl pox virus did not propagate in pigeons or rabbits, and that pigeon pox virus was partially successful in protecting cockerels against natural exposure but unsuccessful against inoculation exposure to fowl pox virus. A second paper published in the 1932-33 Annual Report ("Some observations on pox virus obtained from a turkey") concluded that a pox virus from a flock of White Holland turkeys was essentially the same as the type commonly found in chickens. Also, he noted that whereas turkeys were very susceptible to feather follicle inoculation with pigeon pox virus, it produced no immunity against chicken or turkey pox viruses.

A paper by Brunett and S. Kondo, from the Department of Pathology and Bacteriology, was published in the 1924-25 Report and pointed out that the first diagnosis of fowl plague (now referred to as highly virulent avian influenza) in the United States came from the Veterinary College at Cornell University in 1924. They reported that there were 22 outbreaks from October, 1924 to June, 1925. Losses in greater New York were estimated to be from 500,000 to 600,000. Their paper presented seven case histories and discussed the nature of the disease in terms of the pathology, etiology, species-susceptibility, characteristics of the causative virus, and transmission. Interestingly, Cornell can lay claim to making the first diagnosis in North America of another disease with a "plague" designation, *i.e.*, duck plague (a herpesvirus-induced disease of ducks now known as duck virus enteritis). Drs. Louis Leibovitz and Jen Hwang isolated the virus in 1968 from commercial ducks on Long Island (see the Duck Research Laboratory section).

Teaching was also one of Dr. Brunett's responsibilities. Beginning in 1924, the year after it was first given by Dr. Fuller, and continuing until his retirement in 1943, he taught the course on poultry diseases to veterinary college students. Starting in 1933 and continuing for the first few years it was offered, he also presented a second course on poultry diseases designed for students in the College of Agriculture. Also, beginning in 1931, Brunett assisted Dr. Peter Olafson in a course entitled "Autopsies."

Under the heading of "Needs of the College", the 1930-31 Report gave considerable attention to the need for an assistant professor to provide extension work in the field of poultry pathology. This was noted to be a departure from college policy (which did not do extension work except through practitioners in the state), but justified because "Poultry diseases have become of great economic importance only during the last decade or a little more. Before that time, poultry pathology was not taught in this or the other veterinary colleges in the United States." The aim was to provide "advice of disease control directly to the poultrymen when there are no trained veterinarians available, and also the conducting of schools for veterinarians in poultry pathology." It is interesting that in spite of the acute awareness of the problem, *i.e.*, the lack of attention to poultry disease problems by practicing veterinarians, to this day the need for specialists to deal with the veterinary needs of the poultry industry persists. Thus, it was no surprise when, in 1934, a special appropriation from the State to expand work on diseases of poultry included funds to free up Dr. Brunett from other duties so that he could initiate the College's first formal program of extension teaching. During the 1934-35 year, he made more than 60 visits to various parts of the State to address groups of poultrymen and veterinarians and to make farm visits.

Dr. Brunett also participated in graduate training, although he himself did not have an advanced degree. Dr. Fred Douglas Patterson had received his DVM and an MS degree from Iowa State in 1923 and 1927, the latter while he was employed as a Veterinary Instructor in Bacteriology at Virginia State College. In 1928, he was a Veterinarian and Instructor in Bacteriology at Tuskegee Institute in Alabama.

Apparently, he took a leave from that position and came to Cornell to pursue a PhD. His thesis dealt with avian coccidiosis, with attention to the viability of *Eimeria tenella* in the soil and to cross-infection experiments with coccidia from various avian species. This work was done under the supervision of both William Hagan and Earl Brunett. Patterson also credited P. P. Levine for advice offered during his studies. Of interest is the fact that Dr. Patterson, an African-American, later became the Dean of the Veterinary College at Tuskegee. Dr. Carlton C. Ellis, another person for whom Brunett served as a mentor, carried out studies leading to a 1936 PhD thesis entitled "Avian coccidiosis, studies of the viability of coccidial oocysts (*E. tenella*)."

Dr. Brunett remained in his position at Cornell for over two decades. He was promoted to Assistant Professor in 1929 and to Associate Professor in 1941. By the time he retired in 1943, the number of accessions in the Ithaca laboratory had risen to 2,233. Diagnostic work and extension constituted a major activity for him, but his teaching and research, and undoubtedly the nurturing of many young persons entering the field of avian medicine at Cornell, were also important contributions.

Faculty during the "Brunett Period"

Who were Dr. Brunett's colleagues and what did they do? First it should be mentioned that some faculty and staff colleagues of Brunett's were assigned to a laboratory on Long Island and are covered in a later section entitled "The Farmingdale Laboratory."

Those who worked in Ithaca included some, with the title of "Instructor" who apparently were assigned to work with Brunett, particularly in helping with the diagnostic laboratory and probably with tasks such as antigen preparation, vaccine production, *etc*.

Drs. W. E. Brandner (1926), W. C. Caslick (1926-28), and Carlton C. Ellis (1931-36). Early Instructors hired to work with Dr. Brunett. included Drs. W. E. Brandner and W. C. Caslick. Brandner stayed only one year and Caslick for only 2 years. In addition to helping as noted above, they may also have assisted in Dr. Brunett's research efforts with pullorum disease and fowl pox, but records are not clear as to any specific assignments.

William Caslick 1927

Carlton C. ("Herk") Ellis remained in the position of Instructor for five years. As already noted, he received a PhD under Brunett's supervision. He had BS and MS degrees from Connecticut Agricultural College and had served as a bacteriologist for a commercial company in Philadelphia before entering the Veterinary College at Cornell in 1928. After he left Cornell in 1937, he continued with a lengthy career in the field of poultry diseases. He served for seven years with the Vermont Department of Agriculture, six years at the University of Massachusetts as a poultry extension pathologist, and after subsequent appointments as a poultry pathologist at the University of Georgia and in Madison, Wisconsin, he finished his career as a Professor of Poultry Diseases at Michigan State University in East Lansing.

Carlton C. Ellis 1931

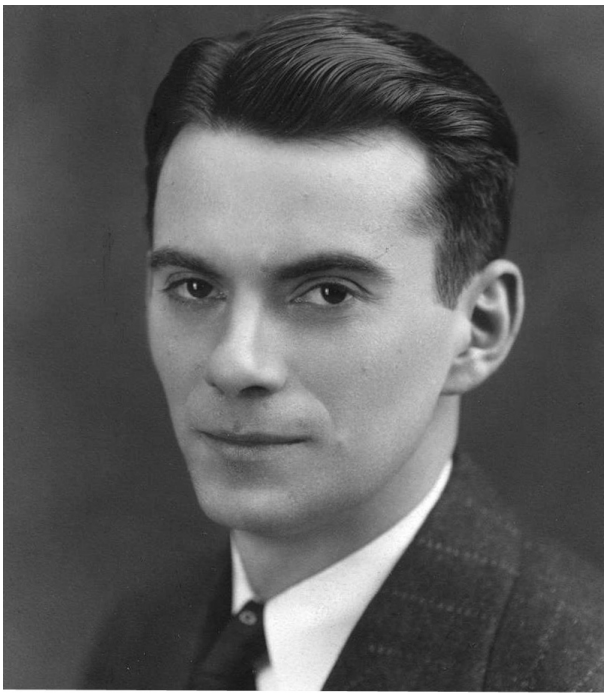
Dr. Carlton Ellis loading fertile eggs into an incubator

Other contemporaries of Dr. Brunett reflected the College's interest in enhancing its research programs, particularly in the areas of parasitology and tumor diseases. Under the heading Staff Changes in the 1934-35 Report, the following paragraph appeared:

> "At the beginning of the year, two new positions were created out of funds supplied by a special appropriation for expanding our work on diseases of poultry. These positions were filled by Dr. Philip Levine, a graduate of this College, who had filled the position of wild-life pathologist in the Fish and Game Division of the New York State Conservation Department for two years, and Dr. Leonard J. Goss, a recent graduate of the College of Veterinary Medicine of Ohio State University. Dr. Levine was assigned, as Research Instructor, to full time work on poultry parasites, and Dr. Goss, with a similar title, to work on poultry tumors and neurolymphomatosis."

P. P. Levine (1935-73). Pincus Philip Levine received a BS degree from City College of New York in 1927 and then matriculated in the graduate school at Cornell where he began studies toward an MS degree in bacteriology. In 1928 he entered the Veterinary College. During the latter part of his four years of veterinary education he worked as a student assistant and in 1932 he received both a DVM and an MS degree. After his graduation, he became a wildlife research pathologist employed by the New York State Conservation Department. Two years later, Dean William Hagan enticed him back to Ithaca as an Instructor (and graduate student), taking advantage of the special appropriation of the State to hire a poultry parasitologist. Whether he also interacted with diagnostic and service programs in addition to his work in the field of parasitology is not known. His graduate work dealt with the biology and control of the cestode, *Davainea proglottina*, resulting in a PhD in 1937. He also worked on ascariasis in chickens and, in 1938 and 1939, he published papers on treatment of the infection with nicotine to remove adult worms, on a new method for embryonating nematode eggs in fecal discharges, and on the viability of ascaridia larvae when exposed to various environmental conditions. Finally, in

this subject area, he studied the infection of chickens with *Capillaria columbae*.



P. Philip Levine 1932

Perhaps the most important of Levine's early research efforts were directed to the problem of coccidiosis. As already mentioned, this parasitic disease was one of the most prominent problems in New York State poultry. His first publications in this field reported experiments on the use of sulfonamides for the control of coccidiosis. Also, he described a new species of avian coccidia, *Eimeria hagani* (named after his PhD mentor, Dr. William Hagan), and presented the results of a survey of New York State flocks for the incidence of subclinical coccidiosis in which all known species were found. His experiments on the use of sulfa drugs such as sulfanilamide, sulfapyridine, sulfaguanidine, flowers of sulfur, and others to control coccidial infections were especially important and they clearly showed the usefulness of chemotherapy for both the prevention and the control of clinical infections. This most certainly played an important role in allowing the industry to undertake poultry production on a large scale since one of the limiting factors, *i.e.*, losses from coccidiosis, could be checked. Levine continued his studies on the comparative efficacy of various coccidiostats for many years. When various pharmaceutical companies wanted to have their new drugs tested in controlled experiments, Dr. Levine obliged by including them in experiments he had already planned. The only conditions were that they had no say in the experimental design or the reporting of results, and they had to pay a premium price for this service. Levine once told this reviewer that he always charged them double the cost, and then put the extra away in a "sock" for later "needs."

His coccidiosis research was not solely directed to control. In addition to his description of the new species he named after Hagan, he discovered yet another species of coccidia in chickens which he named *Eimeria brunetti* after his colleague, E. L. Brunett. This species was much more pathogenic than *E. hagani*. He also investigated the periodicity of oocyst discharge and the excystation of coccidial oocysts, and he described both the successful transmission of coccidia using merozoites and his unsuccessful attempts to cultivate coccidia in chicken embryos.

During the 1930s and early 1940s, Dr. Levine published nine papers dealing with nematodes and cestodes and 13 on the subject of coccidial infections. He also published one paper entitled "The effect of atmospheres of hydrogen, carbon-dioxide, and oxygen, respectively, and of mixtures of these gases on the growth of *Bacillus subtilis*."

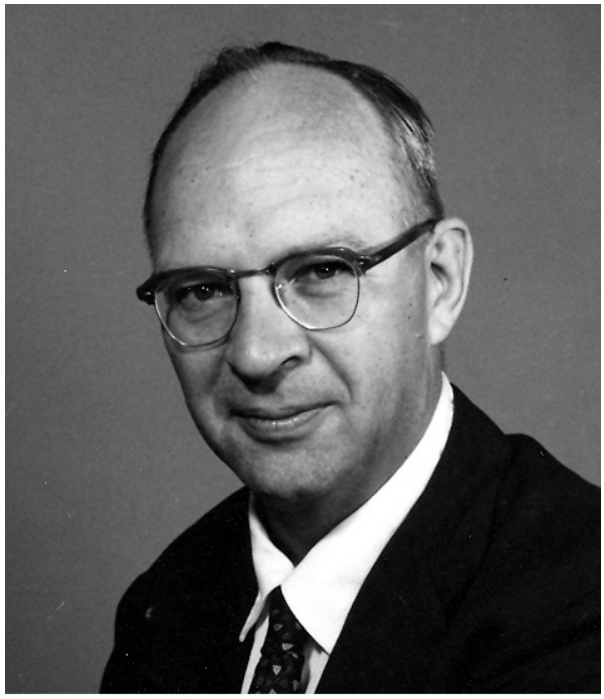
Many of Dr. Levine's enormous contributions to the field of avian medicine at Cornell took place subsequent to "The Brunett Period." His actions and interactions during that period will be detailed in the next section entitled "The Levine Leadership Period."

Leonard Goss (1935-36). The other person who joined the poultry disease group as the result of the 1934 special appropriation was Dr.

Leonard Goss

Leonard Goss, a recent graduate of the College of Veterinary Medicine at Ohio State University. Whereas Levine was directed to work in the field of parasitology, Goss was to work on poultry tumors and neurolymphomatosis. He undertook graduate training as an Instructor in Pathology with Dr. Peter Olafson and received his PhD in 1938 with a thesis entitled "A survey of the mortality in farm poultry flocks with special reference to the incidence of tumors."

Carl Olson, Jr. (1935-36). In 1935, Dr. Carl Olson, Jr. was added as a new Assistant Professor of Poultry Diseases. Prior to coming to Cornell, he had received a DVM from Iowa State University (1931) and MS and PhD degrees from the University of Minnesota (1934 and 1935) while working in comparative pathology at the Mayo Clinic. He had become interested in filterable avian tumor viruses such as Peyton Rous' sarcoma virus and it was this interest in avian tumors that brought him to Ithaca to bolster Cornell's research in that field. In 1936, he authored a paper with Dr. Alexander Zeissig entitled "A study of the antigenic properties of certain normal and pathological lymphoid deposits in tissues of chickens." He subsequently published two other papers on the subject of fowl tumors: "Attempts to transmit fowl paralysis" (which were unsuccessful), and "The basal metabolic rate of chickens affected with fowl paralysis, transmissible fowl leukosis and certain spontaneous neoplasms." Olson's non-tumor studies at Cornell dealt with a reaction to a bacterial infection (with G. R. Goetchius as coauthor) and blood changes associated with an infection with *Capillaria*



Carl Olson

columbae (published with P. P. Levine). Olson resigned at the end of 1937 and moved to the University of Massachusetts where he continued working on lymphoid tumors of chickens.

Clifford Barber (1937-45). Dr. Clifford Barber, who had received his DVM from Colorado, came to Cornell as an Instructor in Disease Investigation in the Department of Pathology and Bacteriology. He undertook a graduate program under Dr. Olafson, completing his PhD in 1935 with a thesis entitled: "A study of fowl paralysis." His studies clearly

dealt with one of the conditions considered to be part of an inclusive group called the avian leukosis complex. The specific manifestation he was working with was known by a variety of names, *e.g.*, fowl paralysis, range paralysis, or neurolymphomatosis, but it is now known that this leukotic tumor disease was a manifestation of Marek's disease with both inflammatory and neoplastic (leukotic) lesions. His project included a description of microscopic lesions in the brain, eyes, and tumors, diagnosis of the disease, and attempts to transmit infection by intraneural inoculation of tissue from diseased nerves. After the completion of his graduate studies he was promoted to Research Assistant Professor of Poultry Diseases, replacing Carl Olson.

Clifford Barber

Until his departure from Cornell in 1945, Barber continued his studies on neurolymphomatosis. He learned that there was little advantage to using progeny from inbred *versus* non-inbred males in terms of resistance to the disease. He also repeated his attempts to experimentally transmit the infective agent(s) of the disease (without success), and studied other factors such as genetics and brooding conditions. Despite his concentrated efforts, he made little headway. The 1938-39 College Report stated that Barber's studies, like those of others over the previous 5 or 6 years at Cornell and elsewhere were discouraging and that it could be concluded that no infectious agent was involved. Given our present understanding of the complexity of Marek's disease in terms of the cell-associated nature of the causative herpesvirus, the importance of genetic makeup, age, virus strain, and other factors, it is understandable that Barber and others were unsuccessful and therefore discouraged by their lack of success in these early attempts. Subsequent studies by Barber were a bit more promising and it became apparent that an agent was, indeed, responsible for the disease. The 1939-40 Report stated that studies on tumors included an inbreeding experiment which showed marked differences between progeny of brother-sister matings in the incidence of tumors. Also, it was reported that nearly 20% of all birds submitted for necropsy had tumors and, of those, the vast majority (over 90%) were of the leukotic variety. Barber's continued work on leukotic tumors indicated that the causative agent is contagious and that age-resistance develops. His work included collaboration with the Department of Poultry Husbandry at the College of Agriculture. The genetically susceptible and resistant strains being developed there, by Drs. Frederick Hutt and Randall Cole, were being tested in the infectious environment maintained by Barber. He continued studies of inbreeding *versus* susceptibility to avian leukotic tumors and he also reported on the effect of rearing environment on the incidence of the avian leukosis complex. The latter confirmed the infectious nature of the disease.

The difficulty of this project and the lack of much progress by Barber and by workers elsewhere no doubt was the basis of a comment made several years later by Dr. Levine. When Martin Sevoian (then at the University of Massachusetts) decided to work on avian leukosis, Levine reportedly told him that

leukosis was an "old man's disease," meaning that one should not undertake studies on this confounding problem until he/she had reached an older age when his/her reputation would have already have been achieved. Luckily, Sevoian ignored this advice and in the early 1960s was a pioneer of methods for the successful transmission of the disease, along with independent work at the same time by Biggs and Payne in England.

Clifford Barber continued his tumor studies until the mid 1940s when he resigned his position at Cornell. Largely because of the difficulty of the subject and the consequent lack of substantial progress, Barber published only two papers, other than his thesis, during the several years he was on the faculty. One, "The effect of the rearing environment upon the incidence of the avian leukosis complex" was reported as part of the College's 1941-42 Report. The other, "Transmission experiments on the avian leucosis complex" was published in 1948, after he had left Cornell. Research on poultry tumors ceased when Barber left, and was not resumed until the early 1960s.

William Monlux (1937-39). Dr. William Monlux was appointed to the position of Research Instructor in Poultry Diseases in 1937. He enrolled as a graduate student and participated in the diagnostic laboratory with Dr. Brunett. Monlux's appointment in poultry diseases was for only two years and his graduate studies were not in that field.

Clement I. Angstrom (1938-41; 1946-73). Drl "Clem" Angstrom came shortly after Dr. Monlux and he, too, undertook graduate studies. However he aborted that program and relinquished his appointment in 1941 in order to join the armed services where he worked with carrier pigeons. He reappeared at Cornell in 1946 with the intention of continuing his graduate studies, but Dr. Levine enticed him to join the staff as Director of the newly opened Poultry Diagnostic Laboratory in Kingston (see later).

Melvin S. Hofstad (1941-45).

Dr. Hofstad, a 1940 graduate of the veterinary college at Iowa State University, earned an MS degree at Cornell (on bovine studies) in 1941 as a Cooperator in the United States Bureau of Animal Industry. He then joined the Cornell team as an Instructor in Poultry Diseases. He initially helped Dr. Brunett in studies on

Melvin S. Hofstad

erysipelas in turkeys in New York State, the results of which were published in 1943 (Dr. Brunett's last publication before his retirement). His attention then turned to the subject of infectious bronchitis. At that time it was a relatively mild respiratory infection affecting growing chickens but it later became a major economic problem in poultry. His first work in this field showed that immunity is apparent a few days after recovery from the disease and lasts at least 7 months. He also learned that carriers do not appear to be a problem. He earned his PhD under Dr. Levine in 1944 with

a thesis entitled "A study of infectious bronchitis in chickens," and he was then promoted to Assistant Professor of Poultry Diseases. Later research work dealt with persistence of virus in young *versus* mature birds (longer in the former), the efficiency of UV-emitting lamps in destroying the virus (not effective against virus in chorio-allantoic fluid or in preventing airborne spread of infection), and attempts to utilize the chicken red blood cell agglutination test as a diagnostic aid. He left Cornell in 1945, the same time that Dr. Barber left. After a brief period at the University of Connecticut, he joined the faculty of the Veterinary Medical Research Institute at Iowa State University's College of Veterinary Medicine where he remained until his retirement in 1985. He became especially well known world-wide when he assumed the editorship of the book *Diseases of Poultry*, considered to be the "bible" in the field of avian medicine.

Efforts to engage veterinary practitioners in the field of poultry disease control

In the mid 1920s, Cornell, like many other institutions, undertook a program which involved veterinary practitioners who apparently were showing an increase in interest in poultry diseases. In 1927, J. M. Hendrickson (Farmingdale laboratory) presented a paper at the Connecticut Veterinary Medical Association Annual Meeting which was published in the Annual Report. Entitled "Why Veterinarians Should be Interested in Poultry Disease Control," the report pointed out that the industry had rapidly progressed from one largely confined to small backyard flocks to an industry in which flocks consisted of several hundreds (or thousands), and that flock owners were making their entire income from such farms. Several major reasons were cited for trying to involve veterinarians and encourage them to include poultry diseases as part of their practice; they were needed to: a) conduct the testing programs needed for the control of bacillary white diarrhea; b) vaccinate flocks for pox, cholera, or typhoid; c) carry out testing for tuberculosis; and d) provide drugs and disinfectants.

A few months later, in June, Dr. Hendrickson presented a second paper on the same subject, this time at the New York State Veterinary Medical Society in Watertown. That presentation was repeated at the 41st American Veterinary Medical Association Meeting in New Jersey. Again, he stressed the value of the poultry industry, its rapid growth, and the changing conditions as production shifted from backyard flocks to large confined housing. The latter was cited as the major reason that veterinary assistance was required; *i.e.,* there was need for the attention of veterinarians as individuals trained in the principles of disease, its prevention, control and treatment.

A paragraph of the 1926-27 Report summarized this plea. It was noted that whereas some practicing veterinarians had begun doing agglutination tests for bacillary white diarrhea, and that although post mortem examinations of fowls sent to the laboratory have been emphasized, there was an important need for poultrymen to call their local veterinarian when birds were sick or dying. The losses from disease in poultry were stated to be the greatest of all livestock in the State and the economic value of poultry products in the US in 1925 was more that one billion dollars.

Certainly, there were sincere efforts to involve practicing veterinarians in poultry disease control. Beginning in 1930, "Poultry Disease Schools" were held to give intensive instruction to veterinarians who had graduated before the curriculum at the College included courses devoted to poultry disease instruction. The second of these was presented for two days in January, 1931 just prior to the Annual Veterinary Conference held in Ithaca. Sessions were offered by E. Sunderville (postmortem anatomy), E. L. Brunett (poultry diseases in New York State, fowl pox control, anthelmintics for internal parasites, miscellaneous diseases), K. F. Hilbert (pullorum disease, avian tuberculosis, miscellaneous diseases), L. M. Hurd (culling),

Dr. Brunett conducting a demonstration necropsy, probably at a course for practicing veterinarians

H. E. Botsford (housing and equipment), and G. F. Heuser (poultry feeding). The latter three individuals were from the Poultry Department in the College of Agriculture. The "school" attracted from 30-45 participants. The 1930-31 Report observed that "there is no doubt that in many parts of the State there is at present no adequate poultry disease control service available to the poultrymen. This industry, which, it is estimated, represents in this State an investment of about $16,000,000, is demanding such service and it is believed that the State through its Veterinary College is obligated to render the necessary assistance until such time as the local veterinary practitioners can handle the situation." In the same report to the Governor there was a special request for an extension worker with the task of giving advice for disease control directly to poultrymen when there were no trained veterinarians available.

Unfortunately, as it turned out, involvement of practicing veterinarians in the field of poultry disease control was limited at best. Graduates who undertook a serious interest in this area were rare, indeed. There were occasional exceptions over the years; one such was a Cornell graduate, Dr. Wilson Miller who established a practice in Pennsylvania which dealt specifically and solely with poultry. There was a great difference between the approach to the control of diseases of individual large animals or pets and that required for poultry flocks. For the latter, because of the small value of individual animals, it was necessary to concentrate on prevention through eradication, immunization, or flock treatment. Research was the key to those approaches and so avian medicine became a specialty which differed greatly from the commonplace veterinary practice of most veterinary college graduates. Although veterinary practitioners never were a significant factor in the control of poultry diseases, they did participate in the pullorum disease testing program as part of a large scale eradication effort, and they were involved in distribution and administration of fowl pox vaccine; both programs were dependent on the supply of antigen and vaccine prepared and distributed by the Ithaca laboratory.

Facilities

It is not clear as to exactly what facilities were available for poultry disease work during the early years and into the first part of Brunett's tenure. Presumably, necropsies of poultry were done in James Law Hall along with all other species examined in the Department of Pathology and Bacteriology. The housing of experimental birds is also an unknown. However, it is known that the need for proper facilities was well recognized by the College. The 1930-31Report included the statement:

> "The last legislature appropriated funds for a poultry disease building to be located on the Veterinary [Experimental] Farm [on Snyder Hill]. This building will be erected and equipped this year. In our request for this appropriation, we also asked for a fund to employ a poultryman who would care for the building and for the experimental birds which will be maintained there, but this was denied."

The Poultry Disease Laboratory, which was completed in 1932 (the photo is undated but probably was taken in the late 1930s or early 1940s)

Cornell University can be seen in the background on the left

The poultry disease experimental farm on Snyder Hill was completed in 1932, a two-story building with two wings. It held a laboratory, feed room and brooding room on the first floor, cages for holding birds on the second floor, incubators and cleaning equipment in the cellar, and 4 brooding and rearing pens and 2 utility rooms in the two wings. Also, there were four laying houses and five brooder houses with yards on the premises. This was a major step, giving the field of poultry diseases the attention it needed if research was to be a focus of activity.

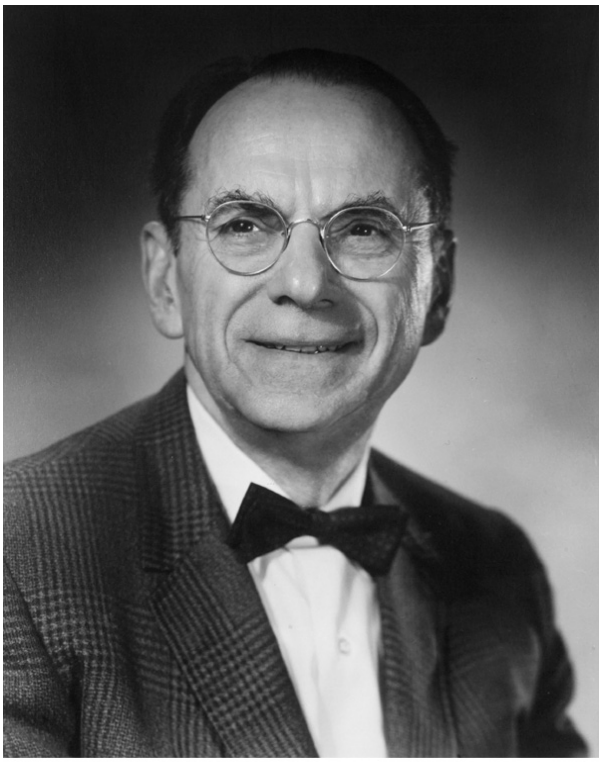
The newly constructed Poultry Disease Laboratory was added to in steps over the years (see later) and was in continuous use until it was vacated in 1995 coincident with a move to new facilities on the campus.

Slightly later, as noted in the 1936-37 Report, plans were initiated for the construction of the Moore Laboratory "to house the Department of Pathology and Bacteriology, which includes faculty assigned to the field of poultry diseases." It is not clear what space was specifically assigned to those faculty at the time the building was opened, but it is known that in the 1940s, when Dr. Levine was in charge of the program (see below), that a good portion of the first floor was devoted to poultry disease work.

Summary

The "Brunett period" can be viewed as the time during which Cornell's avian medicine program "came of age." There were new positions, new objectives, new teaching programs, and new facilities which all came about during this two-decade span. A second center for poultry disease diagnosis and research, the Farmingdale Laboratory (see later) was set up on Long Island. A number of research directions were established, particularly in parasitology and tumor diseases. Disease control programs involving eradication (pullorum disease), chemotherapy (*e.g.*, coccidiosis, cholera), vaccination (cholera, fowl pox) were instituted or enhanced. Teaching programs for veterinary and agriculture college students and graduate training for those interested in poultry diseases were initiated. Extension activities for the poultry industry and practicing veterinarians were given special recognition through the assignment of the first faculty member in the College to have such a charge. Cornell University was most certainly making a mark for itself in the field of poultry diseases with ever increasing activity on a number of fronts.

The Levine Leadership Period (1943-1965)



P. Philip Levine 1965

Coincident with Dr. Brunett's retirement, a new era in the evolution of avian medicine at Cornell commenced. In the 1942-43 academic year, Dr. P. P. Levine was promoted from Research Instructor to Assistant Professor and, in the next two years, he was further promoted to Associate Professor and then to Full Professor. Although Drs. Barber and Hofstad were also faculty members working on poultry diseases, Dr. Levine was clearly the senior member of the group. At that time, the Dean of the College, William Hagan, also served as Head of the Department of Pathology and Bacteriology. However, in 1946 he found that his duties as the administrative officer of the College had increased to the point where he decided to step down from the responsibility of running the Department and so he asked Dr. Peter Olafson to assume the position of Department Head. Whether it occurred when Brunett retired or when Olafson took the reins, it developed that Levine was assigned to the leadership role in the poultry disease section of the Department of Pathology and Bacteriology. There was no special title to designate his role, but the story is that Dr. Olafson (or Dr. Hagan?) said something to the effect: "Levine, you like poultry diseases, so why don't you take responsibility for the program." Regardless of the veracity of that story, it developed that all aspects of the teaching, diagnostic, extension, and research programs, including the selection of faculty and staff for these programs, came under Levine's purview. The only exception was the administration of the Farmingdale laboratory which at that time was headed by Dr. Kenneth Hilbert. Again, a story was circulated that Hilbert believed that he, not Levine, should have been named as the leader of the poultry disease program. He refused to work under Levine's leadership and Olafson let him continue at Farmingdale with the title of Director, answering directly to him. It appears that there was virtually no communication between Hilbert and Levine and that the Farmingdale laboratory operated independently until its closure in 1962, coincident with Dr. Hilbert's retirement.

Although Dr. Levine guided the entire program at Ithaca, and made decisions that would normally be made by a department chairman, he worked under a budget controlled by Dr. Olafson and he needed Olafson's approval and support for all of the important decisions regarding staff appointments, new undertakings, *etc.* None the less, he was a very proactive leader and he instituted many programs that made Cornell a leader in the field of avian medicine.

The Creation of the Department of Avian Diseases

As noted above, Dr. Levine was what might be called a "*de facto"* department chairman without the authority or budget that goes with such an appointment. This was a less than satisfactory arrangement for him but a separate department for the field of avian medicine was not a likely

scenario in our College. However, in 1960 events led to a change in that situation. According to Dr. George Poppensiek, who was Dean of the College at that time, Dr. Levine was offered a very attractive position in another College of Veterinary Medicine. In Dr. Poppensiek's words : "Dr. Levine came to me to tell me about it. He very frankly and honestly was considering that offer with considerable interest. I remember distinctly saying to him, 'Phil, what will it take to keep you here at Cornell?' He responded forthrightly, 'Make me Chairman of a Department of Avian Diseases!'" Dean Poppensiek, using the authority allowing him to determine such arrangements in the College and after conferring with Dr. Olafson (the Head of the Department of Pathology and Microbiology in which the poultry disease program was situated) almost immediately established the Department of Avian Diseases with Dr. P. Philip Levine as it's Chairman. An amiable redistribution of the budget was arranged, and Dr. Levine had finally achieved his long-standing wish for full administrative control of the avian disease program.

Contributions by Dr. Levine

Dr. Levine, by any measure, was a major contributor to the research arena (see above and below). But the added impact of his administrative skills were particularly important to the development and progression of the avian medicine program at Cornell. A few significant examples follow.

Branch Laboratories for Diagnostic and Extension Activities. One of Dr. Levine's innovations was the establishment of branch laboratories for diagnostic and extension activities in East Aurora, Kingston and Oneonta, thus providing service to the major poultry producing areas in New York State. These laboratories, which will be covered in a separate section (see Part 2, below), added very measurably to the value of the avian medicine program by helping the poultry industry throughout the State with readily available diagnostic and extension service. This was especially important given the vacuum that existed due to the absence of participation by practicing veterinarians.

Cornell University Duck Research Laboratory. Dr. Levine was a major participant in the creation of a duck research laboratory at Eastport, L.I., in which a three-way "consortium" involving the College of Veterinary Medicine, the College of Agriculture, and the Long Island duck producers acted in concert to address the needs of the duck industry. The importance of this laboratory and the foresight exhibited by Dr. Levine in initiating the program cannot be overemphasized. The establishment of the Duck Research Laboratory, which will be covered in a separate section (Part 2), was critical in helping the duck industry on Long Island survive. That laboratory became a national and international resource.

Research Leader. Levine's research contributions prior to his assumption of a leadership role are detailed above. After he took charge of the poultry disease program in the Department of Pathology and Bacteriology, he had less time for personal research but he continued to carry on some research on coccidiosis and he undertook small projects such as the investigation of a condition known as "round heart disease." However, much of his research effort afterward was carried out in collaboration with others. He worked particularly closely with Dr. Julius Fabricant after 1949, and the results of their shared research programs will be covered in the section devoted to Dr. Fabricant's career. He also served in an advisory role to faculty members under his supervision.

Respiratory virus infections, mycoplasma-related disease, and tumor research all received his attention through the assignment of existing faculty and research space, the hiring of new faculty, and through his personal contributions as a participant in many of the research programs.

Teacher and Mentor. Dr. Levine remained

committed to teaching, retaining responsibility for the core-curriculum course on poultry diseases given to 3rd year veterinary students. Equally important, he served as major or minor

professor to a succession of graduate students both before and after assuming his administrative duties. These included the following persons for whom he was the major professor: Catherine Grenci Fabricant, Julius Fabricant, Antonio Machado, Wayne Jensen, Martin Sevoian, Bruce Calnek and Richard Witter. There were a number of others for whom he was a minor professor. He was a demanding professor who insisted on carefully crafted experimental designs with special attention to proper controls, detailed record keeping (in bound notebooks to prevent accidental loss of data sheets), and replication of experiments to assure proper interpretation of results. These same rules applied to his faculty who reported their results only with his blessing. This level of standards served the avian disease program at Cornell well over many years, and probably carried over to other institutions when graduate students or faculty members moved on.

One of his admirable facets was his "open door policy" in which a student or colleague could always drop in at his office (even though he was busy as his desk) to discuss research, teaching or other matters. He was a good listener and could quickly digest the important points and offer advice, usually in a manner that made the person seeking an opinion, or help, think they had come up with the answer or solution.

Facilities Enhancement. When Dr. Levine first became the nominal head of the poultry disease program, he and the other faculty were housed in Moore Laboratory (adjacent to James Law Hall) which held the Department of Pathology and Bacteriology. Pathologists were mostly on the second floor and bacteriologists were on the third floor. The avian disease group was clustered on the first floor with a couple of small offices for administration, offices for Dr. Levine and whoever was in charge of diagnostic services, a large poultry necropsy room, two small laboratories for virology, bacteriology and serology, and two bird-holding rooms. One of

Moore Laboratory 1955

the latter was equipped with Horsfall-Bauer isolation cages for holding experimental birds. Also, there was an incubator room in the basement. These facilities were occupied until 1957 when the Veterinary College moved to an entirely new physical plant at the end of Tower Road. There, the poultry disease group was placed on the lower floor of a wing of Schurman Hall where it had an incubator room, a large necropsy laboratory (with an adjacent waiting room for clients), three laboratories (two small and one large) suitable for bacteriology and virology work, a histopathology preparation room, a storeroom , an incubator room, a walk-in cooler, and offices sufficient to house the faculty and staff involved in diagnostic/extension services and administration. Dr. Levine

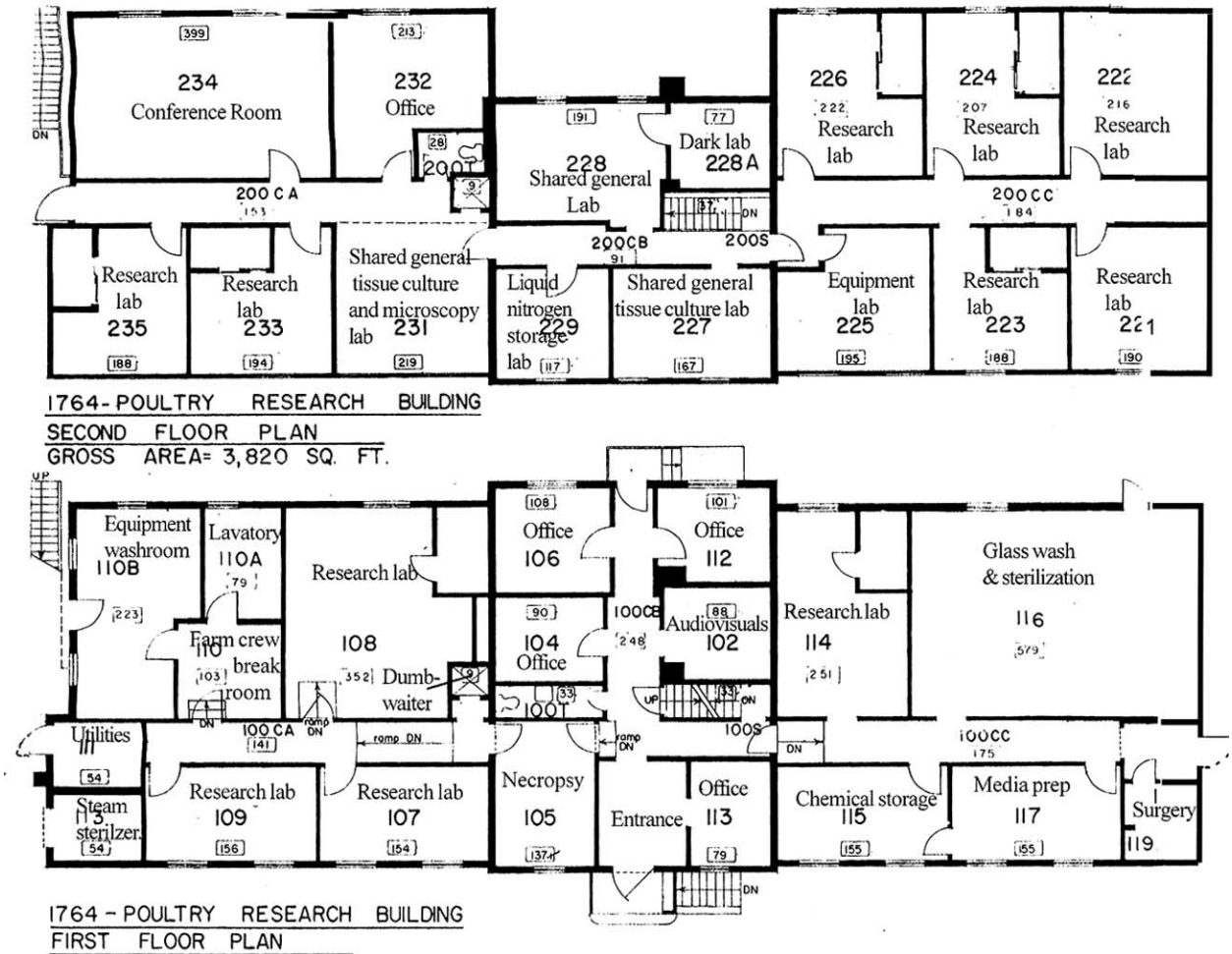
The Poultry Virus Isolation building situated to the west of the veterinary college on the campus

undoubtedly had a good deal of input regarding the space that was allocated to his program.

The construction of a 41-unit Poultry Virus Isolation Building in the late 1950s can be credited entirely to Levine's foresight and persuasive arguing. His goal was a state-of-the-art facility dedicated to research on contagious diseases of poultry. It took nearly 10 years of pleading with those controlling the State budget before they finally agreed to fund the building. He had designed the plan for the building in the shape of an "H" so that, depending on the amount of money that was awarded for the project, it could be built as a large "H" or a small "h," a "T," an "L," or an "I." After all of the waiting, he was surprised and very gratified to receive funding for the full-size building. It had air-lock entry cubicles for each of the units where the person entering could step into boots, don a protective garment and hat, and wash up. Only then would the person enter the isolation room itself. Entry was only from an interior corridor, the "clean side." Materials put into or taken out of the isolation unit were through an exterior door (the "dirty side") which also was well sealed when closed. Each room had an individual air exhaust duct which extended vertically from the roof for several feet and well away from the individual air intakes on the side of the building. Air filtration equipment was not in use at the time the building was erected and so the most highly contagious agents, *e.g.* infectious bronchitis virus, were not effectively controlled, but other agents were rarely spread from one unit to another. Ultimately, in the late 1970s, high efficiency air filtration was added to tighten the system. Levine's foresight and persistence gave Cornell's avian medicine program a huge advantage over most of the other avian disease research programs in the United States and abroad.

He added to the research building on Snyder Hill that had been opened in 1932, more than doubling the laboratory space and providing additional bird-holding pens on the farm surrounding the research building. This was done piecemeal for a number of years, starting in the early 1960s, by gradually adding laboratories on the first floor along the two wings. Then, in the mid1960s, a second floor was added to both of the wings. Funding for these additions came from money that Dr. Levine had wisely accumulated from charges he levied on pharmaceutical companies who had requested that he test their new anticoccidial drugs along with others he was investigating. The new laboratories allowed space for the rapidly expanding graduate teaching program, and to accommodate new programs (*e.g.*, a small

The Levine Laboratory after the wings were added to and after
a second story was constructed over both wings in the mid 1960s



surgery, a dark room for immunofluorescence microscopy, a laboratory used for cell culture, *etc.*).

Dr. Levine also oversaw the addition of a special building for studies on mycoplasma infections. It was funded by the USDA's Bureau of Animal Industry (therefore called the BAI House) and waslocated on the road leading up to the Research Farm from the Ellis Hollow Rd.

Leadership in the profession

Dr. Levine became a highly respected leader in the field of avian medicine. He served as Editor for the journal *The Cornell Veterinarian* for a 5-year period in the 1950s and then, nearly singlehandedly, he started the journal *Avian Diseases* which recently celebrated its 50th anniversary. He offered to transfer responsibility for *Avian Diseases* to the fledgling organization called the American Association of Avian Pathologists (AAAP), and in fact, the AAAP was organized at least in part to provide a home for the journal. He was made honorary lifetime editor following this move. He served as one of the early presidents of the AAAP, and also as the president of the World Veterinary PoultryAssociation in which he had played an important role by representing the UnitedStates. His stature is also reflected in the fact that he was the first choice of the AAAP Board of Directors to become the editor of the book *Diseases of Poultry*, the most important reference book on poultry diseases in the world. He declined and instead, that honor went to Dr. Melvin Hofstad, a former Cornellian (see above).

He was a person who commanded (and expected) respect. The author of this history well remembers a time when, as a young faculty member, he greeted Dr. Frank Witter (Richard Witter's father) by his first name and was "withered" by a look from Dr. Levine who believed that one's elders must be treated with special consideration. Only a few people who were truly his peers (for example, Steve Hitchner) called him by his first name (they were allowed to address him as "Phil"). Even Julius Fabricant, who was his closest colleague, never called him Phil.

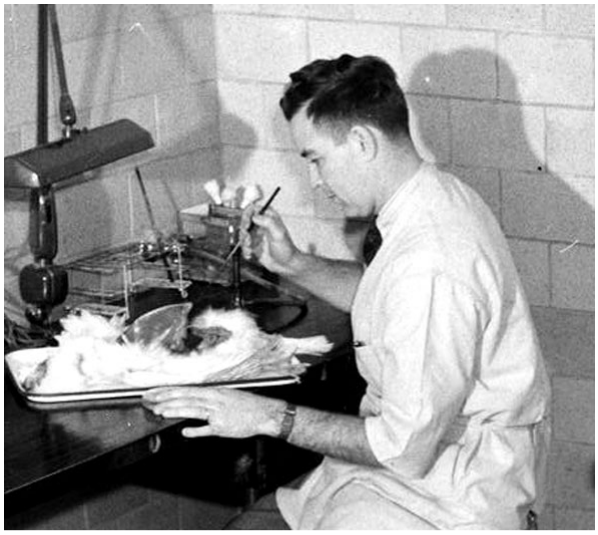
Faculty during the "Levine Period"

When P. P. Levine assumed a leadership role with the avian diseases program at Cornell, there were only two other faculty members: Clifford W. Barber and Melvin S. Hofstad (see the section covering the Brunett period, above). Later additions to the campus faculty, in the order in which they were hired, included James Gillespie, Earl N. Moore, Ellsworth Dougherty III, Julius Fabricant, Malcolm C. Peckham, Clyde I. Boyer, Jr., John S. Sickles, John R. E. Taylor, Martin Sevoian, William Mathey, and Bruce W. Calnek. He also hired the veterinary professionals needed to staff the new regional laboratories that were set up in East Aurora (Grayson Mitchell, Saul Narotsky), Kingston (Clement Angstrom) and Oneonta (Anthony Sylstra, Walter Packer, Jean Hagan), and the Duck Research Laboratory established at Eastport (Ellsworth Dougherty, a transfer from Ithaca, Jessie Price, Louis Leibovitz). The staffing of the peripheral laboratories will be detailed in Part 2, which deals with those facilities.

Some of the appointees were important in expanding the scope of Cornell's avian disease program, examples being the creation of the position filled by Dr. Moore which was dedicated to the study of turkey diseases, the faculty added to enhance the extension and diagnostic programs in Ithaca, and the new positions at the Regional Laboratories and the Duck Research Laboratory.

James H. Gillespie (1945-47). Dr. James "Jim" Gillespie, a recent graduate from the veterinary school at the University of Pennsylvania, joined the faculty as an Assistant Professor of Poultry Diseases in 1945. He assisted in the teaching program and had diagnostic laboratory

responsibilities. Newcastle disease was the subject of his research contributions. With Drs. Levine, Fabricant, Angstrom and Mitchell, he helped carry out studies on pen-contact exposure of susceptible chickens to others that had recovered from Newcastle disease. Also, he worked with Dr. Levine to test the effectiveness of a Newcastle disease vaccine. He and Dr. Fabricant reported the isolation of Newcastle disease virus from a starling.



Dr. James Gillespie 1947

Dr. Gillespie contributed to the poultry disease program for only a couple of years. In 1947, he transferred to another position in the Department of Pathology awhere he began a very productive career in research on viral diseases of cattle, dogs and other mammalian species, and later became Chair of the Department of Microbiology. As an interesting aside, it was said that Jim Gillespie was "lured" away from his position in the poultry disease group by Dr. James Baker, at the Laboratory for Virus Diseases of Dogs, while Dr. Levine was on a sabbatic leave. Because Baker never informed Levine of this "recruitment" until the transfer was effected, it was said that this led to an estrangement of sorts between the two, a situation that was compounded later in a disagreement on the assignment of virus-isolation facilities at Baker's laboratory on Snyder Hill. Six units were assigned to poultry disease work over Baker's objections. Apparently, the two had little or nothing to do with one another after the dust settled. None the less, Dr. Gillespie maintained a very cordial relationship with the poultry disease group over the many remaining years of his career. Although he might not have used the word "lured", he did tell the author of this history that the story was essentially true.

Earl N. Moore (1946-52). In 1946, Dr. Earl N. Moore was added to the staff as Associate Professor of Poultry Diseases. His charge was to devote full time to research and extension work on diseases of turkeys. This position resulted from a special State appropriation which provided for work on diseases of turkeys and ducks, the turkey work to be done in Ithaca and the duck work at Farmingdale. Moore, a graduate of The Ohio State University, had worked in the field of poultry diseases since the early 1930s (1931-43 at the University of West Virginia and 1944-45 at the University of Delaware) so he brought a good measure of experience with him. During his first year at Cornell, he spent most of his time with extension activities and visits to turkey farms so as to become acquainted with the industry in New York State. He established a flock of turkey breeders at the experimental farm on Snyder Hill and had some new small buildings constructed to house turkeys for experimental purposes. His research laboratories were in the Poultry Research Laboratory that had been opened in 1932 and which was sometimes informally referred to as "Brunett Hall."

Earl Moore was soon engaged in work on turkey coccidiosis, a problem that was a natural avenue for his research given the attention that Levine was devoting to the disease in chickens. He tested the safety of sulfaquinoxaline and sulfamerazine for treating turkey poults and found that the tolerance of these drugs by turkeys was similar to that observed with chickens. A study of pullorum disease showed that the agglutination test was not reliable in turkeys, although reactors did develop in infected flocks.

Dr. Earl N. Moore

Working with the assistance of Jessie A. Brown (Experimentalist), Dr. Moore identified two new species of turkey coccidia, *Eimeria adenoeides* and *E. innocua*, the former being pathogenic for turkeys. It was during the time that this work was being carried out that the author of this history was first introduced to the field of poultry disease research. After moving to Ithaca from Trumansburg, where he had become friends with Dr. Moore's son Neil, he was offered a job at the Snyder Hill laboratory washing glassware. He was 16 years old at the time and was thrilled when, after a few months, he was allowed to participate, albeit in a minor way, in the studies on coccidiosis in turkeys. This introduction led directly to his choice of a career in research on poultry diseases, and he worked at the laboratory throughout the rest of his high school years and all of his years in college.

Dr. Moore also investigated a disease of unknown etiology that was variously called "turkey blue comb" or "Washington mud disease." This intestinal infection caused mortality in young poults and could sometimes be transmitted to poults kept on contaminated litter. As was later learned, successful transmission relied on the use of poults from non-immune breeders. Collaborative studies with Dr. Hilbert at the Farmingdale laboratory suggested that treatment with terramycin was successful, but given our knowledge now that the disease is caused by a coronavirus, it seems likely that any effect of the antibiotic was aimed at secondary infections. Failure to obtain susceptible turkey poults stymied further work on this disease.

Dr. Moore resigned his position in Sept 1951 and moved to the Experiment Station at Wooster, Ohio, a part of The Ohio State University. He later served in programs designed to bolster the poultry industries in India and Nigeria. Interestingly, in those assignments he encouraged two veterinarians to enter the field of avian medicine. Drs. Syed Naqi, from India, and Daniel Adene, from Nigeria, both subsequently made significant contributions to poultry disease control, and Dr. Naqi ultimately joined the faculty at Cornell.

Ellsworth Dougherty, III (1949-64). When Dr. Gillespie left for another position in the Department, he was replaced by Ellsworth Dougherty, III, a 1943 graduate of the veterinary college at the University of Pennsylvania. He started as Assistant Professor in Poultry Diseases in 1949 with duties essentially the same as those described for Gillespie. His tenure in this job was very short lived. In 1950, at Dr. Levine's request, he transferred to Eastport on Long Island to become the first Director of the Laboratory, in charge of the turkey and duck disease programs. He remained at the Duck Research Laboratory (DRL) until 1964 when he took a position at the Plum Island Animal Disease Laboratory. His contributions to the field of avian medicine will be covered in the section on the DRL in Part 2..

Julius Fabricant (1949-). Julius Fabricant, yet another a graduate of the University of Pennsylvania (VMD, 1942), came to Cornell for graduate study in 1945 after a year as a meat inspector and a year at Pennsylvania State University to complete studies for a BS degree. At Cornell he completed an MS degree under

Dr. Peter Olafson, studying enterotoxemia in lambs, with a minor in avian pathology. He then continued with studies on infectious bronchitis and Newcastle disease leading to a PhD in 1949, mentored by Dr. P. P. Levine. He was on the staff as a Graduate Research Assistant during most of this period, having taken over the position vacated by Catherine Grenci (later to become Catherine Grenci Fabricant). She had completed her MS degree with studies on penicillin in poultry under Dr. Levine's guidance and then moved to the Department of Bacteriology in the College of Agriculture where she worked on avian tuberculosis and mycoplasma. Catherine's later contributions to the field of avian medicine in the Veterinary College through her work on atherosclerosis will be discussed later.

Dr. Julius Fabricant 1945

In 1949, upon the completion of his PhD program, Dr. Fabricant was appointed to the position of Assistant Professor in the Department of Pathology and Bacteriology. He became a close colleague and research partner with P. P. Levine and they worked together until 1965. According to Dr. Fabricant, they met periodically to discuss which diseases were major problems and what phases of these problems could best utilize their talents, abilities and facilities. Although they planned projects together, Dr. Fabricant was responsible for most of the detail and actual performance of the experimental work. Much of their work was on respiratory diseases, principally Newcastle disease, infectious bronchitis and chronic respiratory disease. They also tackled a new and devastating disease of ducklings in the Long Island duck producing area. The major findings from their collaborative research will be detailed a later section that specifically addresses the major research projects during and after the Levine leadership period. Suffice it to say that Fabricant's career objectives and his approach to research were, as they were for many others of us in the avian disease group, shaped by interaction with Dr. Levine. However, no one worked so closely with him as Julius Fabricant.

After Dr. Levine was no longer involved, Julius continued with a strong but more independent research program for a number of years. In 1967, he received an NIH grant for the "Isolation and Characterization of Mycoplasma" which was continued with two renewals. The research conducted under this grant ranged over a wide area of basic research but much of it concentrated on the development of new media for primary isolation of mycoplasmas from clinical specimens. A number of graduate students and visiting scientists assisted him in this program.

One of the most apparent and important parts of his approach to science was his application of his research findings to problems in the field. As an example, he worked very closely with the Babcock poultry breeding organization in Ithaca to eradicate *M. gallisepticum* from their genetic lines, resulting in Mg-free commercial strains of chickens. Also, in spite of his reservations of having to then turn around and infect "clean" flocks with a live mycoplasma "vaccine" (the F strain), he recognized the special problems with multi-age flocks where it was not economically practical to totally depopulate in order to eradicate the infection from the premises. Thus, while it "hurt" him to do so, he produced F-strain vaccine for distribution in New York

State (a project that was later handed to Dr. Grayson Mitchell at the Kingston Laboratory). Not only was he a good scientist, but he was realistic in his approach to problems.

After many years of concentrating on mycoplasma and chronic respiratory disease, Dr. Fabricant necessarily looked for new worlds to explore. NIH had lost interest in funding further studies on mycoplasma when the major concerns about their role in human disease were solved. He spent part of his time for several years working with Bruce Calnek's group on Marek's disease and got enough of an education in working with this virus to be of value to Catherine Fabricant's project on herpesvirus-induced atherosclerosis.

Interspersed with the previously mentioned studies on mycoplasma and Marek's disease were several other projects. These included investigations with Dr. Hitchner on diagnostic and vaccination procedures for infectious laryngotracheitis. Two other large and multiyear projects involved field studies on causes of egg production problems in laying hens and the incidence of tumors in old laying hens. The latter work was stimulated by the observation that, after Bruce Calnek had eradicated avian leucosis virus and Marek's disease virus from our departmental poultry flocks, these birds remained tumor free until the end of their first laying cycle. He believed it was of interest to hold them for longer periods and he found that it was only later in their life that some very interesting results were obtained (see the later section on research).

Finally, toward the end of his active research career, he collaborated with his wife, Catherine, on a very important project in which a herpesvirus (Marek's disease virus) was implicated in the etiology of atherosclerosis. This work had highly significant implications for human medicine and will be detailed later.

A more detailed discussion of his major research contributions is found in a later section "Research During and After the Levine Leadership Period."

Julius Fabricant has been an extremely important and influential member of the community of avian pathologists. His standards are very high, and he expects his colleagues to adhere to the same standards. Indeed, he frequently serves as an "adjudicator" with sharp critiques of work presented at scientific meetings when he believes it does not satisfy a critical analysis of results, and especially when the work does not have all of the "controls" that Dr. Levine's disciples were encouraged to apply to their research. He has a phenomenal memory and can dig out obscure work from the literature

Dr. Julius Fabricant 1985

that is important to himself or his colleagues. He does not argue with the conclusion that he is "opinionated" and he claims that he has an "open mind, albeit marginally open at times." Fortunately for him, he is right more often than he is wrong. His interests are wide, and go well beyond the world of science. Dr. Fabricant retired in 1985, when he was given the title of Professor Emeritus. However, he continues to be active in the field of avian medicine to this day (2008), at age 89.

Malcolm C. Peckham (1950-84). Malcolm

Peckham received his DVM at Cornell in 1950 and was recruited by Dr. Levine soon thereafter. He joined the faculty as an Assistant Professor in the position that had previously been filled by Drs. Gillespie and Dougherty. He was promoted to Associate Professor in 1953 and was a Full Professor from 1960 until his retirement in 1984.

Dr. Malcolm Peckham 1952

His major responsibilities were teaching and diagnostic work, with some research which was largely related to problems he encountered as a diagnostician. At various times during his career he taught the course on poultry diseases for students in the College of Agriculture and four times he took responsibility for the poultry disease course which was part of the core curriculum for students in the Veterinary College, once when Dr. Levine was away, and three times after Dr. Stephen Hitchner had retired. A continuing and major teaching role for Peckham was the instruction of 4th-year veterinary students who spent one week of each of their three clinical rotations in the poultry diagnostic laboratory. He taught them necropsy techniques and approaches to diagnosis of poultry diseases and he also oversaw their work in learning to handle accessions from poultry farmers.

Dr. Peckham participated in extension work, writing articles for the periodical called "Poultry Pointers" which was distributed by the Department of Poultry Science in the College of Agriculture. He also gave talks to regional meetings of poultrymen, as did several of the faculty in avian medicine and he helped in the infectious bronchitis immunization program by periodically holding vaccination clinics in Syracuse and Palmyra. He was a frequent contributor to the Northeast Conference on Avian Diseases, presenting the findings of his diagnostic accessions or his personal research.

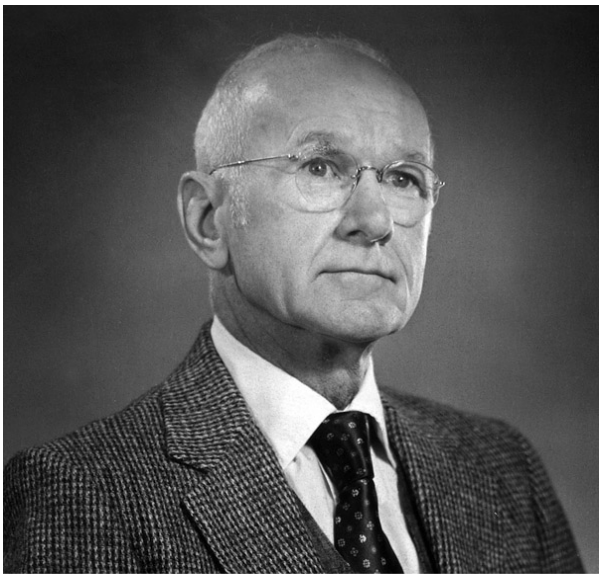
Dr. Peckham did his own bacteriology, virology, serology and histopathology to support his diagnostic efforts and his personal research. Further, he developed fine skills as a photographer. Over the years, he took many hundreds of pictures of a wide range of gross lesions and parasites that he encountered as part of his diagnostic laboratory duties. These were superbly done with proper background lighting and without the presence of distracting material. Many of his photographs were used by himself and others in the book entitled *Diseases of Poultry* for which he was one of the authors, and he offered sets for sale to interested persons or companies. Because such material is classified by the University as having "dual ownership," duplicate copies of his slides were eventually made available to the Department for teaching and other purposes and these, along with many photographs taken by other individuals in the avian medicine program, are now available as a "Cornell Collection" of digital images for use by other persons.

Research carried out by Dr. Peckham was primarily on conditions which he encountered as problems in New York State poultry flocks. He was the first to identify a relationship between lens opacities and avian encephalomyelitis in chickens. The use of immunodiffusion tests for infectious bursal disease was the subject of one of his studies, and he provided a description of a so-called "temporary tumor" of pigeons

among other miscellaneous conditions he encountered as diagnostic accessions.

He isolated and identified an anaerobe that is the etiologic agent for ulcerative enteritis, often referred to as "quail disease." His subsequent work on this disease included tests of the efficacy of therapeutic drugs, and characterization of the etiologic agent. Also, some of the pioneering work on vibrionic hepatitis in chickens was reported by him in the late 1950s.

Dr. Peckham authored several chapters for the most important book in the field of avian medicine, *Diseases of Poultry*, published by the Iowa State University Press. These included chapters on the two diseases for which he had become well known and which were entitled "Ulcerative enteritis and quail disease" and "Avian vibrio infections." Other chapters in *Diseases of Poultry* that he contributed were "Vices and miscellaneous conditions" and "Poisons and toxins." All of his chapters were well illustrated with his own photographs. Additionally, he authored a chapter entitled "Quail disease" for *Diseases of Wild Birds*, which also was published by the Iowa State University Press.



Dr. Malcolm Peckham 1984

Although he helped many individuals in various ways during his tenure, there were only a couple of collaborative studies listed among his publications. One dealt with inclusion body disease (caused by a herpesvirus) in falcons, a study carried out by Dr. David Graham *et al*. The other was a research note detailing the use of a bivalent vaccine against Marek's disease in a study by Bruce Calnek *et al*.

Clyde I. Boyer, Jr. (1952-65). Dr. Clyde Boyer, Jr. came to Cornell in 1952 as a replacement for Dr. Earl Moore. A graduate of the University of Pennsylvania (VMD, 1940), he had been employed at the veterinary diagnostic laboratory in Tifton, Georgia. His appointment was as an Assistant Professor and he was charged with continuing Cornell's research program on turkey diseases.

Dr. Clyde I. Boyer, Jr. and Jessie Brown *ca.* 1953

As had his predecessor, Earl Moore, Dr. Boyer was blessed with the assistance of Jessie Brown, a skilled Experimentalist. "Brownie," as he was known, worked closely with Dr. Boyer on virtually all of the research projects involving turkeys. This not only helped provide a seamless continuum of the studies on coccidiosis and "mud fever" in turkeys that had been initiated by Dr. Moore, but it made for a two-person team during Dr. Boyer's entire tenure as the turkey

pathologist for the avian disease program.

For coccidiosis studies, Dr. Boyer worked with Dr. Levine and Jessie Brown to carry out comparative testing of coccidiostatic agents in turkeys. They found two sulfa drugs that were efficacious. Boyer and Brown isolated two new species of coccidia from guinea fowl; one of these infected turkeys as well as guinea fowl. Unfortunately, the work on the enteric infection called mud fever, now known to be a coronavirus-induced enteritis, was less rewarding. Although a few transmission trials were effective, subsequent attempts to study the disease were stymied by the fact that poults from all available New York State sources became refractory, no doubt the result of infections in breeding flocks with the consequence of maternal antibodies in progeny. The disease was reported to be characterized by a monocytosis, but the author of this review (who worked as a student technician for Dr. Boyer) found that there was a moderate heterophilia but no evidence of monocytosis.

Boyer soon turned his attention to new projects. Erysipelas, infectious sinusitis (mycoplasma infection), and salmonellosis in turkeys commanded most of his attention. For the former, he developed methods for experimental infection, tested a commercial bacterin, and most importantly, he developed therapy protocols for the disease. A key finding was that the administration of procaine penicillin in the drinking water provided effective control which was further enhanced by the addition of terephthalic acid to the water.

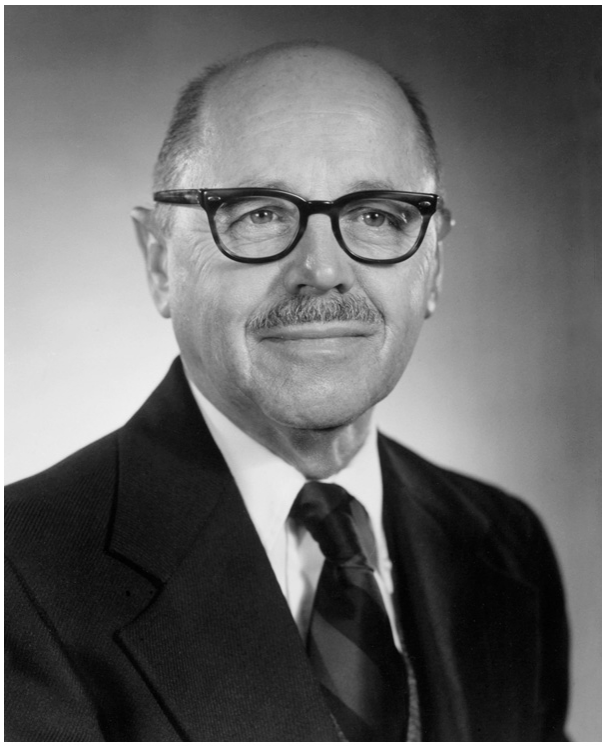
Mycoplasma studies were mostly carried out in collaboration with colleagues (Fabricant, Levine, Calnek) and included therapy trials with various antibiotics, the isolation and description of new types of "PPLO," *i.e.*, mycoplasmas, not isolated from chickens, and trials with egg-dipping in antibiotic solutions to control egg transmission of the organisms. Unlike the situation with chicken eggs, the latter was ineffective with turkey eggs. Interestingly, Boyer found that there were nonspecific reactions to PPLO test antigen in turkeys following vaccination with erysipelas bacterin.

Research on salmonellosis in turkeys included the identification of species of salmonella that were involved in outbreaks and then determining their source. Boyer and Brown tested feed and feed ingredients and found that contamination was due to the addition of meat scraps and they concluded that these contaminated feeds apparently played a role in outbreaks of salmonellosis.

Other subjects that commanded Dr. Boyer's attention included the evaluation of a new fowl cholera vaccine grown in embryonated eggs. It was found to be protective in ducks, chickens and turkeys. He also studied the use of a complement-fixation test to detect ornithosis antibodies in turkey sera (a 1956 project done in collaboration with Dr. Ahmed Shimi, a visiting Professor from Iran). *Clostridium botulinum* toxin, the cause of botulism in avian species, was yet another subject of research carried out by Boyer and Brown and was also the thesis project for a graduate student, Dr. Eduardo Aycardia from Columbia, who earned an MS degree under Dr. Boyer's supervision in 1965. Boyer also briefly attempted isolation of enteric viruses of chickens and turkeys using cell culture techniques.

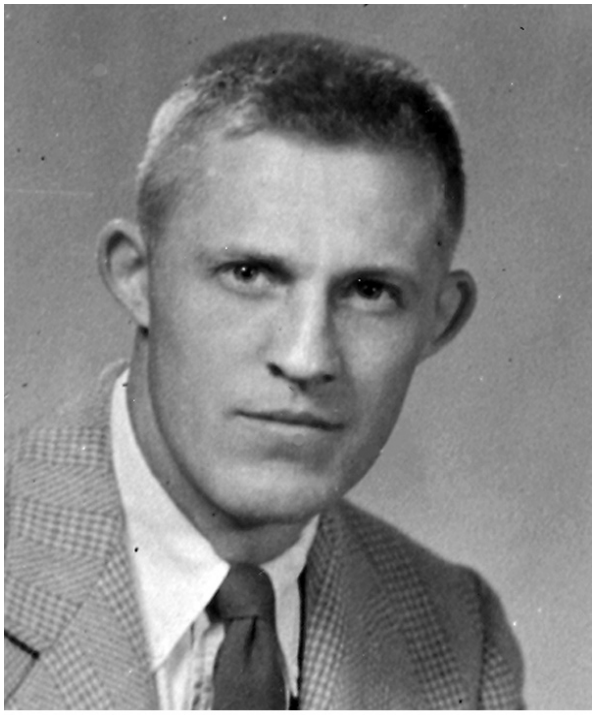
Dr. Boyer was a methodical, creative and careful worker with a wide variety of interests. He was happy to collaborate with colleagues on a varied palette of subjects. Even so, he was a bit disappointed when, in the early 1960s, Dr. Levine asked him to switch his focus from turkeys to chickens because the turkey industry in New York State had dwindled to the point that it could not justify a full-time turkey specialist. That, plus his wide spectrum of interests most certainly contributed to his eventual move to a new field, laboratory animal medicine. In June, 1965, he resigned his position in the Department of Avian Diseases to become a Professor of Laboratory Animal Medicine and the Director of the Diagnostic Laboratory at the College. He made a major

contribution to the College in that role, and importantly, he remained a colleague with whom many of us interacted for many years after he left the poultry disease program.



Clyde I. Boyer, Jr.

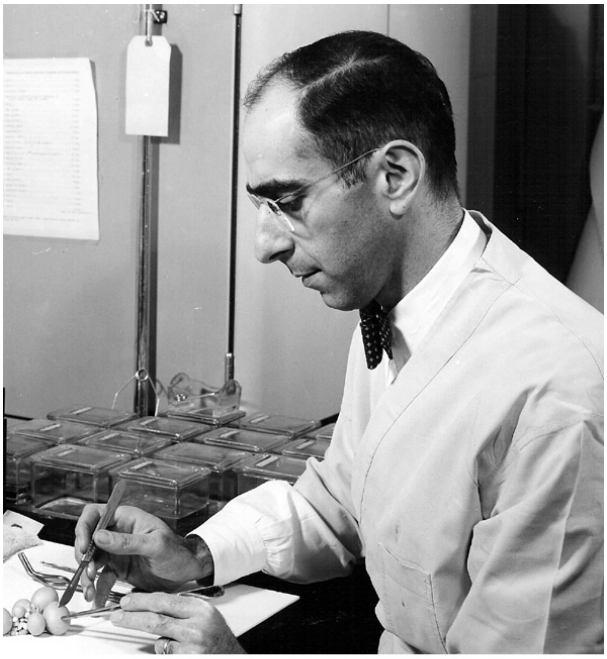
John S. Sickles (1952-54). John S. Sickles was the first of four relatively short-term appointments to a position that was created to relieve some of the pressure on Dr. Levine, given his administrative duties, teaching commitments, extension activities, and his research programs. By this time, Regional Poultry Disease Laboratories had been established in Kingston and East Aurora, and a third one was being envisioned for Oneonta (see later). Dr. Sickles, a Cornell graduate (DVM, 1951), was hired in 1952 as an Assistant Professor to help administer those laboratories, do extension work, and assist with research programs. He helped Dr. Angstrom, the Laboratory Director at Kingston, with attempts to control an acute outbreak of cholera in chickens and he assisted Dr. Boyer with a study of antibiotic medication in a field outbreak of sinusitis in turkeys. He remained at Cornell for only a short time, resigning the position in 1954. He apparently was disappointed that although he was given the responsibility for extension and administration of the branch laboratories, he was not given much authority to oversee the programs. This interpretation is not founded on hard fact; rather it is a bit speculative based on conversations this author had with him and another person who later held the same position (Taylor, see below).



Dr. John Sickles 1951

Martin Sevoian (1954-55). In 1953, Martin (Marty) Sevoian completed his VMD degree at the University of Pennsylvania and came to Cornell as a Graduate Assistant. A year later he was awarded the MS degree for studies on infectious bronchitis with Dr. Levine as his major professor. Dr. Levine then hired him as an Assistant Professor of Poultry Diseases, in part to handle some of the administrative duties that needed attention while he was away on sabbatic leave. Also, he participated in research on the therapy of respiratory disease in turkeys conducted by Boyer. When Dr. Levine returned, Sevoian left for a permanent position at the

University of Massachusetts, his home state, where he remained for his entire career and where he made very significant contributions in the field of avian tumor viruses. There was a strong bond between Drs. Levine and Sevoian



Dr. Martin Sevoian 1955

over the years.

John R. E. Taylor(1956-58). John Taylor, a graduate of the Ontario Veterinary College, also came to Cornell as a Graduate Assistant in Poultry Diseases and, in 1954, he initiated graduate studies under the mentorship of Julius Fabricant. In 1956, he earned an MS degree with a thesis entitled "Studies on the isolation of the pleuropneumonia-like organism of chronic respiratory disease of fowl." He then assumed the position of Assistant Professor with duties essentially similar to those that had been assigned to John Sickles. Dr. Taylor was very energetic and he generally had a number of "irons in the fire." He continued studies on "PPLO" (mycoplasmas) looking at survival of the organisms in eggs, *in vitro* methods for the isolation of the organisms from the respiratory tracts of chickens, and antibiotic therapy in chronic respiratory disease (CRD), a complex in which mycoplasmas, infectious bronchitis and *Escherichia coli* played a role. He collaborated with Dr. Fabricant in efforts to reproduce CRD and with Calnek in research on transmission of mycoplasma through the egg. Also, he initiated studies with Levine on avian encephalomyelitis (AE) in which they tried, unsuccessfully, to induce egg transmission with the AE virus, and to determine the pathogenicity and immunogenicity of the Kimber strain of AE virus in chickens of various ages.

In his role of overseeing the Regional Laboratories, he interacted with Directors of the East Aurora, Kingston, and Oneonta labs by carrying out some research on the effect of fat in the ration on the course of avian hepatitis (with Dr. Angstrom), on the use of histopathology in the differential diagnosis of avian hepatitis (with Drs. Angstrom, Saul Narotsky, and Jean Hagan), and on the control of cannibalism with chemical repellants (with Dr. Morley Kare and Dr. Angstrom).

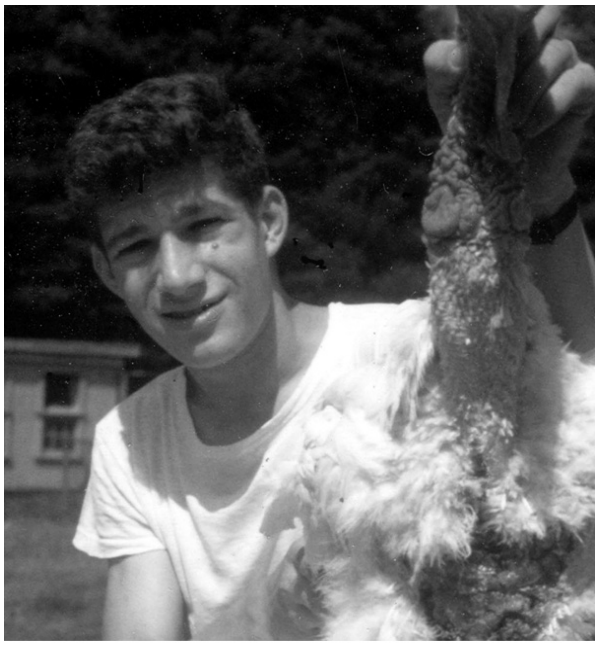
Together with Dr. Levine, Dr. Taylor found that the coccidiostat Nicarbazine was the cause of mottled yolks in eggs, a problem that had arisen with flocks in New York State, and he also helped Levine study the condition known as "round heart disease"(without any conclusions as to etiology).

Dr. John R. E. Taylor *ca.* 1957

John Taylor, like John Sickles, found the position to be somewhat unattractive for lack of authority in the areas for which he was supposed to be responsible. In 1958, when an opportunity arose to assume a position at DeKalb Agricultural Research in Illinois, he resigned. At DeKalb, Dr. Taylor had a continuing interest in avian encephalomyelitis, a disease problem of concern to poultry breeders. He developed a screening protocol to detect susceptible flocks in a large scale program. The aim was to avoid the sale of infected chicks by not hatching eggs from a flock until it had become naturally infected and thus provided parentally immune chicks.

William Mathey (1958-60). Dr. William Mathey, from California, joined the faculty in the position vacated by Dr. Taylor in 1958. It is not clear what contributions were made by Dr. Mathey in his brief tenure at Cornell (he resigned in 1960), since there are no references to his work found in the Annual Reports of the College. Presumably he had duties similar to his predecessors in the position.

Bruce W. Calnek (1956-57; 1961-). The final appointment during the "Levine" era, was that of the author of this history. Bruce Calnek had actually started working in the poultry disease program in 1948, when Dr. Earl Moore hired him (as a 16-year-old high school student) to wash glassware at the Snyder Hill research laboratory. Coccidiosis research was the main activity at that time. Within the next year he was allowed to assist, albeit in a minor way, with Dr. Moore's research. This was represented largely by working with Jesse Brown collecting and processing fecal samples, inoculating turkeys with coccidial cultures, *etc.* It was Earl Moore who encouraged him to consider avian disease research as a career and suggested that he go to veterinary college. Throughout Dr. Moore's remaining time at Cornell, and continuing when Moore was replaced by Dr. Clyde Boyer, Calnek worked at the Snyder Hill laboratory full time during summers and whenever there was free time during his entire 6-year education as a pre-veterinary and then veterinary student. He was allowed to do some semi-independent research, *e.g.*, studying the hematology of turkey poults experimentally infected with so-called mud-fever (coronaviral enteritis). During his last two years in veterinary college he was given the task of doing all of the necropsy work in the poultry diagnostic laboratory (with end-of-day checking up by Dr. James Gillespie) for a few days in the summer when all of the poultry disease faculty were attending the Northeastern Conference on Avian Diseases.



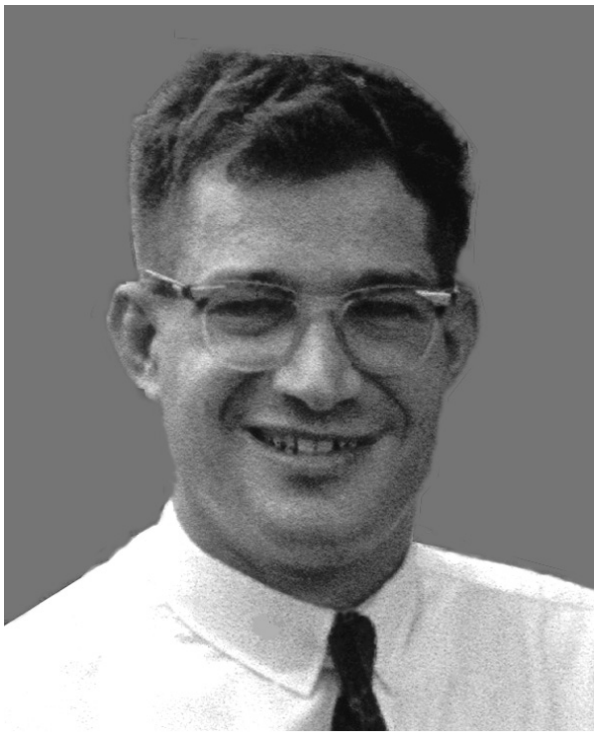
Bruce W. Calnek 1949

After receiving his DVM degree in 1955, he was appointed to the position of Graduate Assistant with the usual requirement of assisting in the poultry diagnostic laboratory, doing serological testing (*e.g.*, HI tests for Newcastle disease), conducting the weekly infectious bronchitis vaccination clinic, and other miscellaneous tasks. A first for this position was the added responsibility of teaching the course on poultry diseases offered to students in the College of Agriculture. These duties, collectively, required a fifty percent time commitment. The remaining time was devoted to the pursuit of a graduate degree. In Calnek's case, an MS degree was the goal, and it was completed in one year under Dr.

Levine's mentorship. His 1956 thesis was entitled "Studies on experimental egg transmission of pleuropneumonia-like organisms in chickens."

In 1956, Dr. Julius Fabricant took a sabbatic leave and Dr. Levine appointed Calnek to a 1-year position as Acting Assistant Professor to carry on Fabricant's research programs on mycoplasma infection and chronic respiratory disease. During this time, studies were aimed at determining the rate of PPLO shedding by infected hens, inoculation of egg embryos to produce PPLO infection in chicks, determining the pathogenicity of different strains of PPLO for embryos and learning about shell penetration by PPLO. At the end of the year, Dr. Calnek accepted a position as Associate Professor in the Department of Veterinary Science at the University of Massachusetts in Amherst. There, he spent the next four years working on avian encephalomyelitis (AE), determining the pathogenesis of the infection and developing the vaccine which is still in world-wide use for the control of this disease.

Dr. Calnek returned to Cornell as an Associate Professor in September, 1961. His duties were



Dr. Bruce W. Calnek 1961

extension and research, with emphasis on the latter. The extension activities included holding occasional meeting with poultrymen, largely in conjunction with the three Regional Laboratories in E. Aurora, Kingston, and Oneonta. He also was asked by Dr. Levine to oversee the laboratories in the same way that they had been supervised by Drs. Sickles and Taylor. However, based on conversations with those two individuals, Calnek opted to serve only as the "liason," visiting each location at least three times yearly but leaving all decision making to Levine (who he assumed would do so anyway).

The opportunity for research was the major attraction for Calnek. Just before arriving at Cornell in 1961, he attended a meeting in Detroit where Harry Rubin, a Cornell graduate who was on the faculty at Berkeley, gave a talk on a new test (RIF, for resistance-inducing factor) useful in detecting the avian leukosis virus. He pleaded with Dr. Levine to allow him to pursue tumor virus studies but was informed that the only monies available were for mycoplasma research. Thus, he initially engaged in work with PPLO by helping with an ongoing eradication program and developing methods for isolation and cultivation of mycoplasmas in cell culture. However, Levine soon decided that the field of tumor virus research would be suitable and he encouraged Calnek to take up the subject and to apply for support through a research grant from the National Institutes of Health (NIH). On his first try, in 1962, he was awarded 3-year grant from the National Cancer Institute and that set the stage for the majority of his research effort throughout his career at Cornell. With consecutive 5-year awards after the first one, he ultimately received NIH support for 28 years.

Initially, he concentrated on the Rous sarcoma virus (RSV) and avian leukosis virus, the RNA retroviruses which are the cause of a transmissible sarcoma and a group of leukotic neoplasms, respectively. His first graduate student, Robert Giordano, an MS degree candidate, joined him in 1962 and worked on attempts (unsuccessful) to substitute

cytopathogenic viruses for RSV in Rubin's RIF test. Other retrovirus studies by Calnek included a simplified test for leukosis virus and RSV antibodies, growth studies with RSV in cell culture and embryonating eggs, and the observation of morphological alterations in fibroblast cultures due to prolonged infection with leukosis viruses. He also carried out a survey of commercial breeding flocks for genetic resistance to leukosis virus and studied the incidence and rate of embryo infection. Finally, he described lesions in young chickens induced by the the virus.

Also in 1962, Dr. Richard Witter, who had just completed an MS degree with studies on an immunodiffusion test for infectious bronchitis under Dr. Fabricant's supervision, undertook a PhD program under Dr. Levine's mentorship. Following strong urging from Calnek, he chose avian leukosis as his subject and Dr. Levine suggested that he have Calnek as his major professor. However, following Calnek's urging, he retained Dr. Levine as his major professor (Calnek believed no one should give up the opportunity of having Dr. Levine serve in that role). However, Dr. Calnek served on his committee as "thesis advisor," in effect helping to mentor his research. During the period of Witter's research on vertical transmission of avian leukosis virus, the importance of a second leukotic tumor disease was being recognized. It was clear that although avian leukosis was important in commercial flocks of chickens, the condition that was often referred to as neural lymphomatosis was becoming a much more significant cause of mortality in the field. This disease, now called Marek's disease (MD), spread much more rapidly and affected much younger birds than was true for avian leukosis. They differed very significantly in that avian leukosis was spread largely by vertical transmission (through the egg) whereas MD was spread horizontally from chicken to chicken. Witter's research on vertical transmission of avian leukosis virus was interrupted by the appearance of leukotic tumors in his group of control chickens. It turned out to be what was later called Marek's disease and this heralded a new and important direction of our work on tumors at Cornell. A change in direction of Calnek's research was soon reflected by a change in the goals of research supported by the first 5-year renewal of his NIH grant.

The primary aim of Dr. Calnek's studies on Marek's disease was to learn about the pathogenesis of the disease and the effect of factors such as genetic constitution, virus strain, age, maternal immunity, immune responses, *etc.* by conducting experiments with single variables.

Teamwork was the order of the day for Calnek's research program. Following the early input of Drs. Giordano and Witter, there was a succession of graduate students who studied various aspects of the Marek's disease problem. Indeed, there was even a second generation. One of Dr. Calnek's students, Dr. K. A. "Ton" Schat, joined the faculty after completing his PhD, and for a number of years he worked on MD in conjunction with Calnek. Dr. Schat also had graduate students who undertook projects related to the disease. Dr. Stephen Hitchner collaborated with Dr. Calnek on some Marek's disease projects in the late 1960s. Additionally, Dr. Julius Fabricant joined the program to carry the MD studies when Dr. Calnek was away on a sabbatic leave, and he then continued to contribute as a collaborator. Dr. Stephen Bloom, who transferred from the College of Agriculture when the Department of Poultry and Avian Sciences was disbanded, helped with cytogenetic studies on MD tumor cell lines and he also had a graduate student whose project related to MD. Altogether, 23 graduate degrees were awarded to students who studied tumor viruses. Further, there were several visiting scientists who worked on the project, many of them for a year or more. Weekly meetings of the faculty, students and visiting scientists allowed frequent and valuable interchange of ideas, discussion of findings, and collective plans for experimental approaches, and this made the entire program dynamic and exciting as well as very productive.

In addition to his work on tumor viruses, Dr. Calnek carried out or participated in projects on several other agents or diseases during his career. These included avian encephalomyelitis (at the University of Massachusetts, UMass), mycoplasmas, adenoviruses, reoviruses, chicken infectious anemia, infectious laryngotracheitis (during a sabbatic leave in Australia), duck adenovirus, several psittacine viruses, Type III duck hepatitis virus, infectious bursal disease virus, reticuloendotheliosis in ducks, and avian infectious hepatitis (at UMass). Some of Calnek's work will be discussed in more detail in later sections.

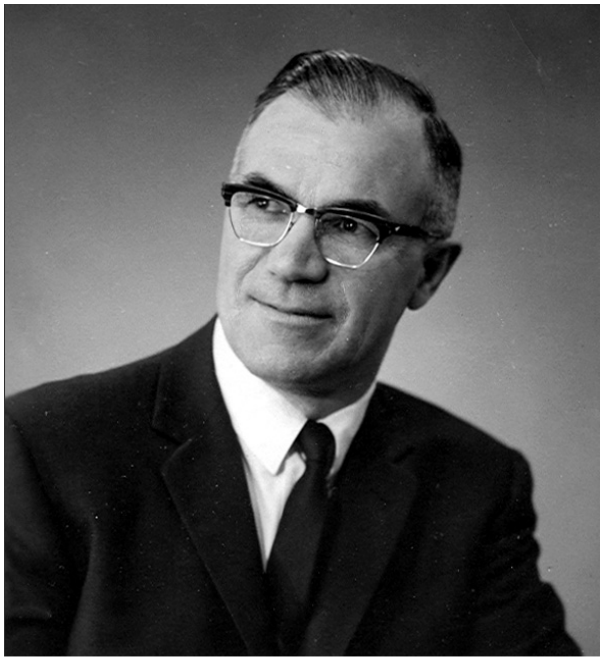
Visiting Scientists

There were several individuals who spent some time at Cornell during the years that Dr. Levine was in charge of the poultry disease program. Those for whom there is a record (or recollection on the part of Drs. Calnek and Fabricant) include the following. In the 1940s, Dr. Herbert Trenchi spent several months visiting from Uruguay. In the 1950s there were two visiting scientists from Iran; Dr. S. Sohrab, and Dr. Ahmed Shimi. No record is available regarding Dr. Sohrab, but Dr. Shimi is known to have been here for the 1955-56 year. Dr. Arnold "Rosy" Rosenwald was at Cornell for a year (1966) when he substituted for Dr. Fabricant in field studies on the eradication of mycoplasma from poultry breeders. It was during that time that Dr. Levine enlisted Rosy as his replacement for the editorship of *Avian Diseases*.

Summary of the Levine Leadership Period

There is little doubt that the growth and shaping of the College's program in the field of poultry diseases was directly attributable to Dr. P. P. Levine's inspiring leadership and foresight. He developed a program that was well balanced with teaching, graduate training, service (both diagnostic and extension), and research all receiving significant supportive attention. He improved the facilities immensely with additions to the research laboratory and experimental farm and especially with the poultry virus isolation building that he masterminded. He led by example, set high standards and, very importantly, he steered Cornell University to the forefront of investigative research in the important fields of respiratory disease and tumor research.

The Hitchner Chairmanship Period (1966-1975)



Stephen B. Hitchner 1966

When Dr. Levine announced his plan to retire in 1965, Dean George Poppensiek initiated a search for his replacement as Chairman of the Department of Avian Diseases. One of the candidates was Dr. Stephen B. Hitchner who was at that time a Director of Research for Abbott Laboratories in Chicago. He had previously been a co-owner of L&M Laboratory, a poultry vaccine company in Maryland that had been purchased by Abbott Laboratories. Steve had gotten his VMD degree at the University of Pennsylvania in 1943 and held successive faculty appointments at Virginia Tech (then known as Virginia Polytechnic Institute) and the University of Massachusetts. He had gained considerable fame for his work on Newcastle disease and his B1 strain of the virus which has been used as a vaccine strain world-wide. After leaving the University of Massachusetts (the same position that Calnek later held), he went into the commercial world by accepting a position with American Scientific Laboratories (ASL) in Madison, WI, where he developed and produced a number of poultry viral vaccines. After several years, he left ASL with two colleagues to form the L&M Laboratory. It is not an understatement to say that he was one of the most respected members of the field of avian medicine based on his technical expertise, his honest approach to everything he did, and the productivity and excellence associated with his work. Thus, it was not surprising that all of the faculty in the Department put him at the top of the list of desirable replacements for Dr. Levine.

Unfortunately, Dr. Hitchner felt an obligation to stay with Abbott Laboratories since he had just sold them his business, and they wanted him to head up a research and development program. Therefore, he declined the offer that was made to him, and other candidates were interviewed. None of those seemed to the Dean or to the faculty to be the right "fit" and so those of us on the faculty at that time urged Dr. Poppensiek to try once again to recruit Hitchner. To his enormous credit, he personally went to Chicago and convinced Dr. Hitchner to change his mind and accept the Cornell position.

Thus, Steve Hitchner came to Cornell as Department Chairman in 1966. He resigned that position in 1975 but remained as a faculty member until his retirement in 1981 when he became an emeritus professor.

Contributions by Dr. Hitchner

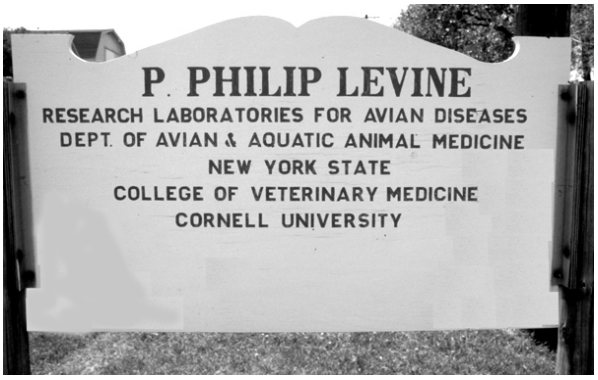
Steve Hitchner led by example. In addition to his administrative duties, he carried out independent research, collaborated with others in their research projects and directed work by assistants such as Barrett Cowen, a Research Associate. When Dr. Levine resigned in 1971, he took over responsibility for the core curriculum course on poultry diseases offered to veterinary students, teaching it through 1980. Also, he served as the mentor for graduate students: Benjamin Lucio (MS 1969, PhD 1979), Barrett Cowen (PhD 1973), and Thomas

Toth (PhD 1975). He was a wise and steady influence for the faculty and staff in the Department allowing each to do his/her job without being overbearing, and he had the respect of all in the College.

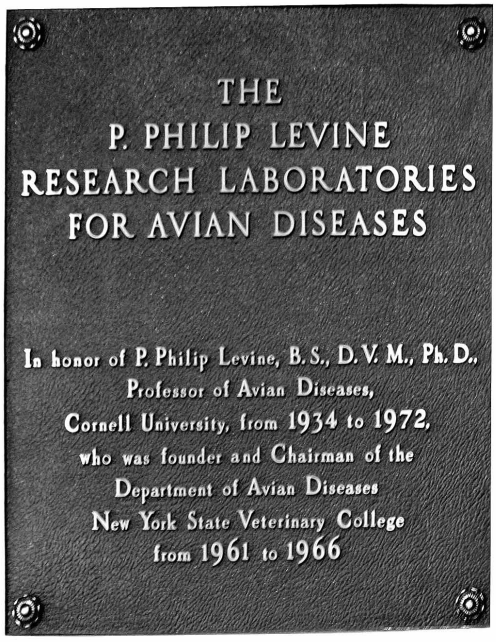
There were several administrative matters that bear noting. He took a strong position in administering the Duck Research Laboratory (DRL). Dr. William Urban, who had come from California in 1964, was serving as the Laboratory Director when Hitchner took the reins in the Department in 1966. There was a good deal of friction among the staff at the DRL at that time, particularly between the Director and the Field Veterinarian. He was unable to determine just what and who really constituted the problem and decided to "shake things up" (his words). He transferred Dr. Urban to Kingston to replace Dr. Angstrom upon his retirement, and he appointed Dr. William Dean, the nutrition specialist at the DRL as the new Director. Later, he completed the shuffling by bringing Dr. Leibovitz, the Field Veterinarian doing the diagnostic work at the DRL, to Cornell to head up the newly formed aquatic animal program. Things smoothed out for the laboratory.

State fiscal problems forced the College to significantly reduce budgets in the early 1970s. The major impact for the Department of Avian Diseases was the need to close two of the Regional Poultry Laboratories. Thus, Dr. Hitchner had the unpleasant duty of requiring the resignation of Dr. Saul Narotsky in East Aurora and Dr. Jean Hagan in Oneonta. At that time the number of accessions at those laboratories had dropped making them more vulnerable than the laboratory in Kingston which had a heavier accession load.

On the more positive side, he originated the idea and then orchestrated the official naming of the research laboratory on Snyder Hill "The P. Philip Levine Research Laboratories for Avian Diseases." This was signified by a sign at the entrance to the research farm and a large brass plaque affixed in the entrance to the lab. The building had sometimes been informally referred to as Brunett Hall but this was not a commonly used name and it had never been officially recognized. The Levine Laboratory name was considered very appropriate and was

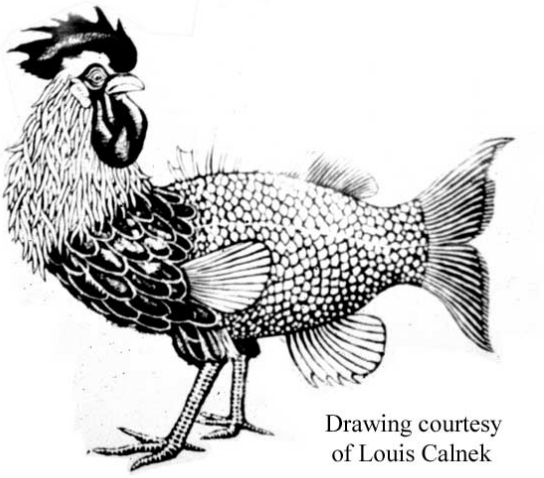


warmly accepted by the College and its staff. Dr. Levine later said (in an interview conducted by Dr. Ellis Leonard) that he was deeply moved and felt sincerely honored by this action.



One of Dr. Hitchner's major contributions was to broaden the scope of the Department to include the field of aquatic animal medicine. The College had determined that this discipline should have significant attention but it was not decided who should have administrative control over the program. Dr. James Gillespie, the Chairman of the Department of Microbiology

and Immunology, was interested in assuming responsibility for the program, but the Department of Avian Diseases also wanted to expand its programs. The argument put forth by Steve Hitchner was that 1) we were already a species-oriented department, 2) we had considerable experience in dealing with "population medicine," *i.e.*, we had to think in terms of flocks rather than individual animals, thus requiring approaches such as eradication, immunization programs, large-scale treatments, *etc.*, and 3) we had both facilities and personnel that could deal with this discipline, given the necessary approaches to disease control for fish or shellfish.



Drawing courtesy of Louis Calnek

An appropriate mascot for the new Department of Avian and Aquatic Animal Medicine ?

The Department had the large Poultry Virus Isolation Building with rooms that could be adapted for fish or shellfish research, and Dr. Louis Leibovitz had already initiated studies on shellfish diseases while at the DRL on Long Island. Also, faculty members expressed an interest in expanding their programs to include some work on fish diseases in their specialties of virology, immunology, pathology, *etc.* The upshot was that the College administration agreed with Hitchner and, in 1973, the Department of Avian Diseases became the Department of Avian and Aquatic Animal Medicine with the interesting acronym, DAAAM. Dr. Leibovitz was transferred from the Duck Research Laboratory and appointed as Associate Professor to initiate the aquatic animal medicine program. Although this history covers only avian medicine, it is fair to say that the work of Leibovitz, and subsequently Drs. James Carlisle, Marilyn Wolfe, Jan Spitsbergen, and especially Paul Bowser, have made a strong statement for the aquatic animal program on its own merits.

Another of Steve Hitchner's administrative contributions was related to the licensing of vaccines produced at the Duck Research Laboratory. The situation leading to this move is detailed in the later section entitled "The Cornell University Duck Research Laboratory." Essentially, Hitchner insisted that the laboratory should obtain a federal license for the production of biologics. Having been the owner of a licensed biologics company before coming to Cornell, he knew exactly what had to be done to achieve that goal and he prompted the DRL Cooperative to construct a biologics production facility and to develop protocols for production, storage and distribution that would satisfy the stringent rules of the federal government. This was accomplished, thanks to the efforts of all of the staff at the DRL, but Steve Hitchner must be given credit for getting it all started.

One of the skills Hitchner brought to Cornell was particularly useful. He had considerable experience in the preservation of viruses and other micro-organisms by the process of lyophilization, *i.e.*, freeze-drying. Over a period of a few years he preserved a large number of strains of various poultry viruses, mycoplasmas, *etc.* His knowledge in this area was especially valuable in a collaborative project with Bruce Calnek in which they tested various stabilizers for preserving cell-free Marek's disease virus which had been obtained from the feather follicle epithelium of infected chickens. The best of the stabilizers was then tested with what were thought to be the small amounts of turkey herpesvirus (HVT) extracted from infected cell cultures disrupted by ultrasonic vibration. When Calnek tried the method, he took a shortcut by

scraping cells off the culture dish directly into the stabilizer, and then sonicating the cells. This technique resulted in very high titers of cell-free virus, much to the astonishment of Calnek and Hitchner. Very likely, the stabilizer protected the virus from cellular enzymes that could inactivate it during a normal disruption of the cells. This discovery was patented and used in the preparation of cell-free HVT vaccine by several commercial companies. It would not have happened had it not been for Hitchner's background in this field. Interestingly, the patented process also was useful in the production of the human vaccine for chicken-pox. Merck, Sharp and Dohme, who initially urged Cornell to patent the process, was first in line to obtain a license from the Cornell Research Foundation who held the patent rights. Unfortunately, Merck was unable to get government approval for the chicken pox vaccine until after the patent ran out.

Yet another major contribution from Dr. Hitchner was the initiation of a program involving pet and exotic bird diseases. After he stepped down as Chairman he concentrated on a new area which he felt had been largely neglected, *i.e.*, pet bird medicine. Of course, diagnostic accessions in the Department occasionally included species other than domestic poultry, but there was no concerted effort to investigate diseases of pet birds. Canaries, budgerigars, parrots, *etc.* were species Hitchner concentrated on with his new focus, and given his background and his interests in disease prevention, it is not surprising that he undertook research aimed at the viral diseases that afflicted these species. Initially, he was assisted in his work by a visiting veterinary microbiologist from Gifu University in Japan. Dr. Katsuya Hirai carried out many of the virus isolation attempts in searching for virus infections in psittacines, and several were isolated using chicken embryos. These included paramyxoviruses, orbiviruses and herpesviruses. A "red herring" arose when it was thought that a coronavirus was isolated, but it turned out to be a mistaken identification.

One of the herpesvirus isolates was used in an inactivated vaccine that Dr. Hitchner developed to immunize birds against Pacheco's disease. A live Pacheco's disease vaccine was prepared using virus which Hitchner and Calnek had "attenuated" by numerous passages in both chicken embryos and cell culture. It was safe and effective in budgerigars but, unfortunately, it was found to still be lethal for parrots (sadly, Hitchner tried it on a pet parrot he kept in his office) and so it was not pursued. However, better success was achieved with a live canary pox virus which he attenuated in chicken embryos. That virus was provided to a commercial vaccine company and has been available for use in canaries for many years. Also, it has served as a vector of genetically-engineered vaccines.

Doing diagnostic work with psittacines carried a special risk, *i.e.*, chlamydial infections (the cause of psittacosis), a danger that had to be

Dr. Stephen Hitchner with experimental parakeets

recognized. Hitchner had obviously been exposed numerous times because he had a high antibody titer against chlamydia. In fact, his antibody titer was so high that he donated serum for use in fluorescent antibody tests on suspect tissues that were carried out by the College's diagnostic laboratory. This danger prompted him to install a high security laminar-flow hood in a small necropsy room that was used for conducting post mortem examinations on exotic

birds.

This interest in pet bird medicine was not dropped when Dr. Hitchner retired in 1981. Dr. David Graham was hired to specifically address this field as will be detailed in a later section (see the Calnek Chairmanship Period).

In addition to administrative duties that were specific for the DAAAM, Dr. Hitchner served on several of the more important College committees during his tenure at Cornell. Also, he undertook a number of "extracurricular" activities. These included consultancies to the Pan American Health Bureau in Argentina (1967) and the Department of Agriculture and Fisheries in Bermuda (1970), serving as an advisor to the USDA (1970, 1972), chairing the editorial committees of the AAAP which published two editions of the manual *Isolation and Identification of Avian Pathogens* (1975, 1980), serving on the USDA Technical Advisory Committee on Newcastle Disease (1972), and serving on the editorial committee of *Avian Diseases* (1979, 1983, 1989). He was not one to shirk responsibilities and was quick to offer his services wherever they were needed. He helped establish the American Association of Avian Pathologists in 1957, and was its President in 1960-61. He enjoyed many other honors during his career, as well.

During his career in avian medicine, he authored or coauthored 55 publications, 31 of which represented work at Cornell.

Faculty and Professional Staff during the "Hitchner Period"

When Dr. Hitchner assumed the chairmanship of the Department of Avian Diseases, the following faculty members were in place: Professors P. Philip Levine, Julius Fabricant and Malcolm Peckham, Associate Professor Bruce Calnek, Laboratory Directors Saul Narotsky (E. Aurora), Clement Angstrom (Kingston), Jean Hagan (Oneonta), William Urban (Eastport), and Field Veterinarian Louis Leibovitz (Eastport).

Persons who were added to the staff during Dr. Hitchner's chairmanship included Barrett Cowen, Grayson Mitchell, Sajjad Haider, Tirath Sandhu and Thomas Toth. All but Barrett Cowen filled positions at Kingston (Mitchell) or the Duck Research Laboratory and are discussed in the relevant sections of this account.

Dr. Barrett Cowen. Barrett Cowen first came to Cornell in 1968 as a Research Specialist. He had been at the University of New Hampshire and was brought to Cornell to assist Dr. Hitchner with his research on respiratory viruses. He then undertook a graduate program

Dr. Barrett Cowen

under Hitchner and, in 1973, was awarded a PhD with a thesis entitled "Classification studies of avian infectious bronchitis virus strains." Dr. Cowen was subsequently elevated to the position of Research Associate. He continued work with infectious bronchitis virus and described a new serotype, Clark 333. In

addition to working with Dr. Hitchner, he collaborated with Dr. Calnek on avian adenovirus classification, later taking a leadership role in both basic and applied research with that virus. His adenovirus studies centered on serotype relationships, broad antigenicity of certain strains, and clinical effects of infection. He also conducted a field survey of infection with avian adenoviruses. Collaborative research with Drs. Calnek and Menendez (a visiting scientist from Argentina) was related to avian reovirus infections. In 1978, he left Cornell to work with a major poultry breeder in New Hampshire.

Visiting Scientists

Over the years, a number of visiting scientists spent periods varying from a few weeks to two years at Cornell. Their interests were varied and many of them contributed significantly to the programs of the avian disease faculty. There were several visitors during the "Hitchner Period" who should receive special mention.

Dr. Katsuya Hirai, a professor from Gifu University in Japan, was at Cornell for two years (1977-79), working with both Dr. Calnek and Dr. Hitchner. His collaboration with Hitchner centered on the isolation of viral agents from psittacine birds (see above). With Calnek, he worked with infectious bursal disease virus (IBDV) and they successfully infected bursal lymphocytes and a lymphoid leukosis cell line *in vitro*. Their studies concluded that surface immunoglobulin IgM-bearing B-lymphocytes are the target cells for infection with IBDV. Interestingly, the cell line (called CU10) was derived from a transplantable tumor that had been developed by Dr. Carl Olson after he left Cornell. The line was of bursal cell origin that was initiated from a lymphoid leukosis tumor.

Dr. Ionel Patrascu, a veterinary scientist from Romania, spent a year (1971-72) with Dr. Calnek to learn techniques for the production of turkey herpesvirus (HVT) as a vaccine for Marek's disease. His contributions resulted in publications on *in vitro* assays, minimum infective and protective doses and the time required for development of resistance to challenge with Marek's disease in chickens vaccinated with cell-free HVT. When he returned to Romania, he headed a large governmental poultry biologics facility. An interesting sidelight is that some years later he gained world-wide prominence when he discovered a major problem of infection with human immunodeficiency virus (HIV) in babies held in Romanian orphanages.

Dr. Peter Long, from the Houghton Poultry Research Laboratory in England came to Cornell to work on coccidiosis with Dr. P. P. Levine in 1968-69. Sadly, Dr. Levine, who was an emeritus professor at the time, was ill and so Dr. Long worked mostly on his own during the year. However, he made significant contributions with studies on infection of chicken embryos and cell cultures with avian coccidia.

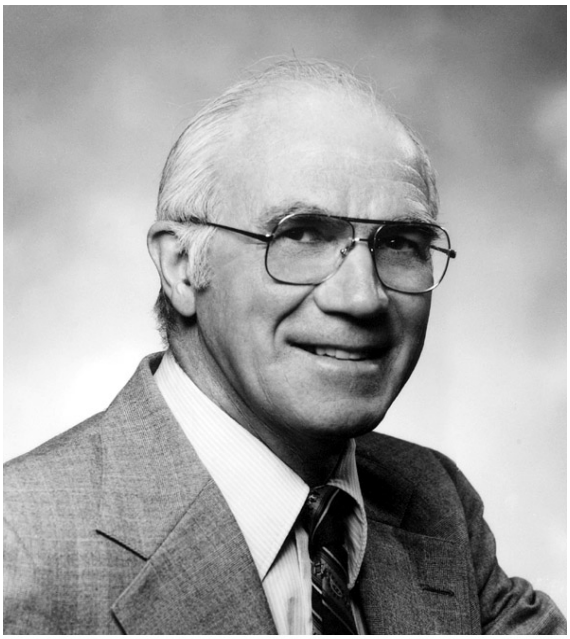
Dr. Nestor Menendez from Argentina, was at Cornell for a year (1970-71) when he worked with Drs. Calnek and Cowen on avian reovirus infections. He published the first report of experimental egg transmission and also on the localization of the virus in tissues of mature chickens. He returned to Cornell for a period in the late 1970s (see the Calnek Chairmanship Period below).

Other visitors who came to Cornell during Hitchner's leadership period included Dr. Celedonio Garrido from Mexico (with Calnek ,in 1969, to observe Marek's disease studies), Drs. Charles Whiteman (1967 from the University of California, Davis), Johan Linblad (1972 from Sweden) and Karl Harrigan (1969 from Melbourne University, Australia), all of whom spent time in the poultry diagnostic laboratory with Dr. Peckham,

Summary of the Hitchner Chairmanship Period

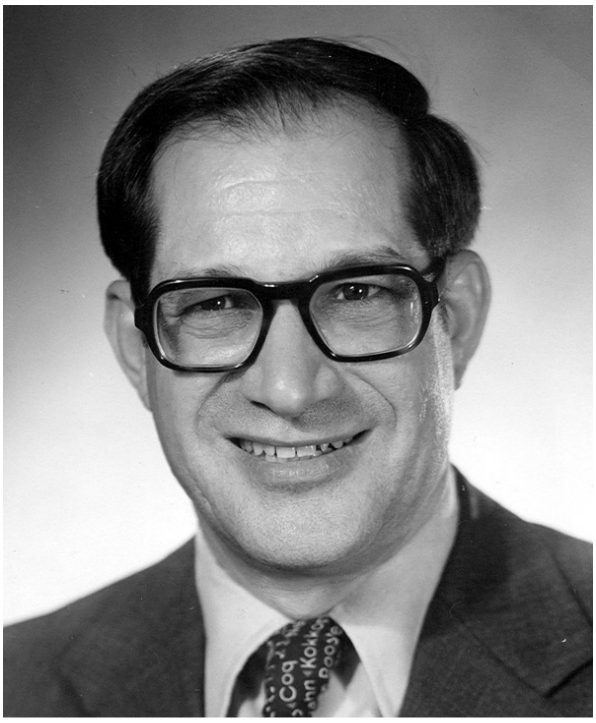
Steve Hitchner had very large shoes to fill when he followed Dr. Levine. All of us who were on the faculty at the time were delighted that he chose to join us in a leadership role and we were not disappointed in the least. He led by example, contributing personally by initiating new research areas and by adding many strengths to those already in place. He supported the various faculty members in a non dictatorial role and at the same time encouraged them to "aim high." He always could provide helpful suggestions and he was innovative. He shouldered responsibility for the teaching program and participated at various levels in College administration and affairs.

A partial list of his contributions would include: 1) expansion of the Department's scope to include aquatic animal medicine; 2) the firm hand he took with the Duck Research Laboratory, especially the push to establish a federally approved biologics production program there; 3) the development of the "pet and exotic bird program;" and 4) his mentoring of graduate students.



Dr. Stephen Hitchner 1981

The Calnek Chairmanship Period (1976-1995)



Dr. Bruce W. Calnek 1977

In 1974, Dr. Hitchner announced that he would relinquish the chairmanship of the department the following year (1975). Dean Edward Melby approached Bruce Calnek about assuming the chairman's role for the Department. Calnek had never had any aspirations to take on an administrative position. In fact, years earlier he asked Dr. Levine point blank why he ever assumed such responsibilities when he clearly was so good at, so happy with, and so involved in, research. Dr. Levine's response was something to the effect that there were some rewards to ease the burden. Calnek replied that *he* would never be caught in such a trap, to which Dr. Levine responded by warning that one should never say "never" and that one couldn't be sure that it wouldn't happen in time. Perhaps, as it turned out, he had a crystal ball. More likely it was yet another example of his foresight.

Appointment

Because of his reluctance to assume an administrative role, Calnek resisted the offer by Dean Melby. None the less, he accepted a temporary assignment as Acting Chairman in 1975 with a request that a search for a new Chairman be initiated. By chance, at about that time there was an external review of the Veterinary College's programs, including research. The report from the review committee lauded Calnek's program and included a statement that, in effect, said that he should be protected from having administrative responsibilities placed on him that would interfere with his research. That no doubt helped convince Dean Melby that he should try to find another person for the job. A search resulted in two very good candidates being interviewed, but in the end neither was selected by the Dean. Shortly afterward, two department chairs independently told Calnek that Dean Melby was discouraged and that if he (Calnek) would not take the position he would have to consider disbanding the department and relocating its faculty in other departments. This was a not an attractive option and Calnek quickly made an appointment with the Dean who persuaded him to change his mind by suggesting that he keep mornings strictly for research (*i.e.*, no meetings, no phone calls, *etc.*), and by offering him the "best administrative manager in the College." Thus, he was appointed to the Chairmanship in 1976. The arrangement that Dean Melby suggested turned out to be quite workable with mornings spent at the Levine Laboratory on Snyder Hill and afternoons devoted to administrative duties in his office on the campus. A major reason it worked is that the faculty at the time were all experienced and required very little direction, at least for the first 10 years until some retired and were replaced by younger persons needing more help in establishing their careers.

There were other positive factors: Dr. Calnek's administrative manager, Genevieve Potter, was extremely skilled in handling budgetary and personnel matters, and soon gained a reputation as a "mother hen" who looked after both staff and faculty. Also, he had the help of a highly skilled research assistant, Raymond Harris, who was invaluable in keeping the laboratory studies on an even keel. Yet another development that helped make it possible for Dr. Calnek to combine research and administration was the addition of Dr. Karel (Ton) Schat to the staff after he completed his PhD in 1978 (see later).

Left: Genevieve Potter, the Department's "Mother hen." Right: Raymond Harris, the Department's senior technician

Bruce Calnek's approach to chairing the Department was a bit like that of his predecessors, Steve Hitchner and P. P. Levine. All followed the old standby characterized as a "benevolent dictatorship." Many decisions were made with only informal discussions with other faculty. These were sometimes one-on-one with the individual most concerned with the question at hand, but often they involved several faculty and took place during informal gatherings. Particularly important decisions were discussed in a more formal setting, but these were the exception rather than the rule. Everyone was busy with their own agendas and seemed quite happy to leave the administration of the Department to the Chair.

Actions and Contributions by Dr. Calnek

At least one of Calnek's decisions was made without prior discussion since he was quite certain that some of the faculty would not agree with him at the time. This was related to the matter of giving up the Levine Laboratory facility when, in 1988, the College was engaging in a program that was to lead to major renovations and additions to the physical plant on the campus. Two architectural firms from New York City (Russo and Sonder, and Davis, Brody) had been engaged to develop a plan that would involve the entire College, making major additions to the teaching space (lecture rooms, teaching laboratories, clinical teaching), the library, and very importantly, to the large and small animal hospitals and the research laboratories. The program was long overdue since, aside from the addition of research space in the Veterinary Research Tower in the 1970s, the physical plant was over 30 years old (first occupied in 1957). Rick Sonder came to the Levine Laboratory in 1988, inspected it, and declared "this is a fire trap!" Renovations to the building would not solve the problem and he asked Dr. Calnek what his "druthers" (his word) were – replace the building on the site of the research farm or have new space provided as part of the new construction that would take place on the campus. It must be understood that the Levine Laboratory was "special" to those of us who worked there. We were a "family" made up of individuals representing the lowest position to the highest. We worked together, took breaks together, and were closely united. Furthermore, we were isolated from much of the politics and other down-sides that faced other departments. Calnek was sure that people would not want to give up this idyllic situation. However, he also had to address the fact that Snyder Hill was isolated. Research at academic institutions was becoming more complex and involved many collaborations that were not really part of earlier periods. It was difficult to attend seminars and other College-wide affairs, and it was Calnek's opinion that our future

demanded a more integrated approach. So, he responded to Sonder that "we must move to the College."

When faculty and staff learned of this, there was a good deal of grumbling, but on reflection, they all agreed that it was the right thing to do. Calnek was sure that if it had been up for a vote, we would have remained isolated on Snyder Hill and he was convinced that it would have been the wrong choice. Even when the other faculty members agreed that we should move to the campus, it was a difficult decision.

One of the easier tasks for Dr. Calnek as Chairman, was managing the budget, at least for the first 10-12 years. Not only did he have a very competent Department Manager (Genevieve Potter), but also the departmental coffers during his chairmanship were well filled. When he took the reins, NIH grants, such as those covering his avian tumor research and Julius Fabricant's mycoplasma project, brought in considerable funds. Also, it was possible to recover salary dollars representing the percentage of time spent on an NIH grant project. This meant that if, for instance, there was a 45% commitment on the part of an investigator to conduct the research, the NIH would add an amount equal to 45% of the investigator's salary to the award. The State continued to provide funds for the full salary amount and so the College passed on the savings to the department involved. This could then be used at the discretion of the Chairman. Additionally, patent royalties distributed to the College by the Cornell Research Foundation (who owned any patents awarded to Cornell investigators) were given over to the Department from which the patents originated, and for several years this added to the "extra" funding over and above the Department's normal State allocation. Both of the Marek's disease vaccine patents (cell-free HVT and SB-1) yielded royalties. Also, there were several small grants from commercial companies who were willing to support various projects of mutual interest. USDA, BARD, and other competitive grants were yet other potential sources of income. So, all in all, there was money for many purposes such as construction of high-tech buildings for holding specific-pathogen-free chickens, hiring of additional personnel to support the research efforts, providing graduate student assistantships, purchasing equipment, *etc.* Ultimately, money was placed in the University's long-term investment pool to permanently fund a graduate assistantship with the interest.

Unfortunately, the State budget did not always fare so well. In the late 1980s and early 1990's funding from New York State to the "contract Colleges" at Cornell (which included the Veterinary College) was repeatedly cut. After trimming as much "fat" as possible, it ultimately became necessary to reduce programs. As had happened earlier in Dr. Hitchner's period as Chairman, Dr. Calnek was forced to close the last Regional Poultry Laboratory (Kingston) and reduce personnel at the Duck Research Laboratory. The former was relatively easy because the shrinking poultry industry in the eastern part of the State made it a logical move. However, the reduction of personnel at the duck laboratory was another matter. Because there had been a partnership between the Long Island Duck Research Cooperative and Cornell University, the former elected to help by accepting responsibility for some of the workers who had been paid by the latter.

Faculty Additions

One of the first major changes during the Calnek chairmanship period was the initiation of the specialty program in pet and exotic bird medicine, effected by Stephen Hitchner after he relinquished the chairmanship. His contributions to this program are detailed above. When he retired in 1981, the program was filling an important need. The faculty wished to have a replacement for Hitchner who could continue to develop studies in this field. Also, it was believed that the Department should have an individual with a strong interest and skills in pathology. Dean Melby gave permission to con-

duct a search and, as a result, Dr. David Graham, a board-certified pathologist with special interests in birds, joined our faculty as a Full Professor in 1981. His contributions, outlined below, were exactly what was needed to bolster this new field of activity.

There were several other hirings of importance to the avian disease program. One was relatively minor for the avian side of our department; Dr. James Carlisle joined the faculty in 1976, primarily as a fish pathologist. However, he also assisted in some of the research on poultry diseases by contributing his general pathology training.

As noted above, Ton Schat. joined the faculty, first as a Senior Research Associate in 1978 and then two years later as an Assistant Professor. His position was a new one which was created largely to help Dr. Calnek with his research program on Marek's disease. The two worked as a team for many years. Ultimately, Calnek urged Schat to undertake some totally independent work in addition to their collaborative MD studies. He rose through the ranks to the position of Full Professor which he attained in 1989. His many contributions will be discussed in more detail below. Tumor virus research grew to constitute the largest program in the Department as a result of the independent and collaborative programs that these two individuals carried out with their colleagues, graduate students, and several visiting scientists.

The opening for a person to oversee the diagnostic laboratory service that was created by the retirement of Malcolm Peckham in 1984 resulted in a succession of individuals covering this important responsibility. The position was first filled when Dr. H. L. Shivaprasad was hired as an Assistant Professor in 1985. He was followed, in 1989, by Dr. Benjamin Lucio, who had been at Cornell as a Senior Research Associate during the previous two years. Dr. Lucio was appointed as an Associate Professor charged with diagnostic and extension service, teaching, and research, much as had been the case with Dr. Shivaprasad. When it was necessary to close the last of the Regional Poultry Laboratories (Kingston) in 1988, it was decided to change the position that Dr. Mitchell had held to one with State-wide responsibilities in poultry disease extension work. Dr. Ahmed Mutalib was hired to fill this position with the understanding that he would travel throughout the state wherever he was needed. He was to work closely with Dr. Lucio in handling the poultry diagnostic activities for which the Department was responsible. This arrangement did not work out well and Dr. Mutalib left in 1993, taking a position at the University of Mississippi. Dr. Lucio then moved into the Mutalib position as a Senior Extension Associate continuing in that capacity to the present.

In 1987, following Dr. Fabricant's retirement, Dr. Syed A. Naqi came to Cornell to fill the vacancy. Syed had an interesting history. After completing his veterinary training at Osmania University in India, he took a position as a Research Associate with the US Agency for International Development (USAID) India Program, managing a large poultry operation in that country. Dr. Earl Moore, who had been on the Cornell faculty as a turkey pathologist in the late 1940s and early 1950s, was in India at the time working with the USAID program helping to modernize the poultry industry. He met Dr. Naqi and, impressed with his abilities, convinced him to come to the United States for advanced work in avian medicine. Syed did so, earning an MS (1967) and a PhD (1969) at Texas A&M University and ultimately joining the avian disease faculty there. Thus, there was a link between Naqi and Calnek in that they both were indebted to Earl Moore for the nudges that steered them into research careers in avian medicine. Dr. Naqi gained a strong reputation for both his teaching and his research skills and represented an ideal addition to our faculty. Accordingly, he was aggressively recruited and was appointed as a Full Professor with tenure.

During much of Dr. Calnek's tenure as the

Department Chair, the faculty and staff numbered about 45, not including joint and courtesy appointees, postdoctoral associates, and graduate students.

Reappointment

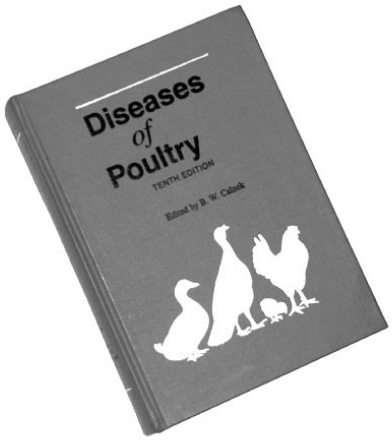
When his first five-year appointment was completed, Dr. Calnek was asked by Dean Melby to continue for a second five-year period and he agreed to do so since it had become clear that he was able to continue his research program in addition to carrying out his administrative duties. When that period had passed by, the College had a new Dean, Dr. Robert Phemister. Calnek's relationship with him became a very cordial and easy one; the two often found themselves "on the same page" when discussing issues important to the DAAAM and the College. There was a suspicion on Calnek's part that the Dean would have liked him to consider becoming an Associate Dean, but no such offer was made, perhaps because Calnek had made it abundantly clear that administration had never been a goal of his. None the less, Dean Phemister did convince him that he should continue as Department Chair for an additional five years.

It should be noted that Calnek's rapport with Dean Phemister had a less direct but important aspect. The Department was viewed by most of the rest of the College as an "anomaly." Why should avian, or aquatic animal, medicine be given special recognition through being an independent group? All individuals could easily be assimilated in the various discipline-oriented departments, most notably the Department of Pathology and the Department of Microbiology, Immunology and Parasitology. It had been Dr. Levine's judgement that the avian medicine program would suffer without its administrative independence; indeed that was his argument when the Department of Avian Diseases was established in 1961. The issue was periodically raised, particularly when there was talk of reorganizing the College's departmental structure. With Dr. Phemister in charge when some of the grumbling was aimed at the "species-orientation" of our Department, it fell upon Dr. Calnek to defend the *status quo*. He took the strong position that although poultry was no longer a major agriculture industry in New York State (as it had been in the early years), there were persuasive arguments for maintaining the Department as a discreet entity. One of the more important arguments was that we (the avian disease program) constituted a "national resource;" Cornell was one of very few veterinary colleges with such a program. Also, it seemed foolhardy to risk erosion of a program that had proven itself to be extremely productive. We had in place the personnel, the facilities, the genetic strains of chickens, and the wealth of experience in poultry disease research that made it seem wasteful should the program be broken up, particularly when it would end up in units that had agendas that the majority of the faculty would deem more important. These arguments were accepted as valid by Dean Phemister, and it became apparent that the DAAAM would have his support, at least as long as the two of us were involved the decision making.

Other Activities

In addition to chairing the Department, Dr. Calnek was active on other fronts as well. In the mid 1970s, he was appointed to the editorial committee for the revision of the major reference book in the field of avian diseases, *Diseases of Poultry*, published by Iowa State University Press. This multi-authored text, considered "the bible" in its field was revised at approximately six-year intervals. The first five editions were edited by Drs. Biester and Schwarte who were on the faculty of Iowa State University. Following their retirement, a new editorial board, appointed by the American Association of Avian Pathologists, consisted of an Editor (Dr. Melvin Hofstad – see The Brunett Period, above), and four Associate Editors, of which Calnek was one. Calnek became Editor for the 9th and 10th editions. This

job was very demanding, particularly for the two years preceding each new edition; his work on the 10th edition extended past his retirement in 1995.



10th Edition of
Diseases of Poultry

Another time-demanding task was a four-year appointment on the Virology Study Section of the National Institutes of Health, reviewing in excess of 100 grant applications three times a year.

Yet another "extracurricular" five-year commitment that Calnek took on was to chair a large "Central Planning Committee" which Dean Phemister appointed to work with the College community of faculty and staff and with the architects during the planning for major additions and renovations to the College. This work began in 1987 and continued until the construction was well underway in the early 1990s. At the time, it was the most expensive construction project ever undertaken at Cornell; the final price tag was over $90 million. Although Dean Phemister estimated that Dr. Calnek would need to devote up to 35% of his time to this project, in truth it required up to 90% during some particularly active times. He took on this major commitment believing he owed it to the College and that it would help compensate for the fact that he was never burdened with much teaching.

The demanding jobs of editing *Diseases of Poultry* and overseeing the Central Planning Committee made it difficult for Dr. Calnek to devote the amount of time he would normally spend on his research and routine administrative tasks. Some of the faculty were extremely generous in helping him. For instance, Dr. Schat took over the responsibility of reviewing grant applications from other faculty, and Dr. Naqi helped oversee the work being done at the Duck Research Laboratory. All faculty and staff were considerate, tolerant and understanding. However, it had its penalties, the largest being that the NIH grant for studies on Marek's disease was not renewed after 28 years of continuous support. The lack of time to pursue the research program was likely to blame, at least in part.

Dr. Calnek had decided to step down from the chairmanship after his third five-year stint. He related this to Dean Phemister who informed him (confidentially) that he, too, was contemplating retirement within a very few years. He did not want to have to face the issue of what to do with our Department and pleaded with Dr. Calnek to remain in place until they could "go out together." Calnek relented, and thus he ended his chairmanship and his position at about the same time as Bob Phemister, *i.e.*, in 1995. His "reluctant" administrative role as a Department Chair had lasted 20 years!

Facilities Enhancement

Dr. Levine had enhanced the Department by providing some excellent new facilities and improving some already in existence. He had added appreciably to the research space at the Levine Laboratory on Snyder Hill, enhanced the bird-holding capacity of the research farm by the addition of new poultry houses, added a new building for birds used in mycoplasma research (the "BAI" house) located near the research farm, and very importantly, he had spearheaded the construction of the 41-unit Poultry Virus Isolation (PVI) building on the campus.

However, when Dr. Calnek took charge, there was still more that was needed as our research programs expanded and became more demanding with specialized needs. For instance, the establishment of specific-pathogen-free flocks required much more secure breeding facilities and holding pens for the several different genetic strains that would be free of all known pathogens and antibodies against such. Also, there was the major problem with the Poultry Virus Isolation building on the campus. It had an "open" ventilation system which depended on the air exhaust from pens being several feet away from air intakes. This was less than perfect, and cross contamination with some agents, like infectious bronchitis virus, was almost a certainty. Keeping birds free of Marek's disease on the research farm also was nearly impossible because of the lack of suitable isolation.

The first modification of bird-holding facilities that dealt with these problems was the addition of a high-efficiency (HEPA) air filtration unit to the intake duct of one of the large isolation units at the PVI building. This allowed us to maintain some of our SPF breeding chickens free of Marek's disease virus as well as other pathogens. Soon thereafter, four large air filters were placed on the roof of the building to supply the remaining units in that building. These filters had been tested by Drs. Calnek and Hitchner and were found to be effective in preventing the spread of the most contagious virus that we worked with, *i.e.*, infectious bronchitis virus. The success of tightening up the air handling systems suggested that SPF breeders could be maintained on the Levine Laboratory research farm if filters were installed on some of the existing houses. This worked for the most part when air filtration was coupled with management practices that reduced the likelihood that MDV and other pathogens would be tracked into those houses. But there were still occasional "breaks" with MD on the farm.

Subsequently, two very high security breeding and rearing buildings, each with about 4,000 net square feet, were constructed to hold SPF chickens. The first was located just south of the Levine Laboratory and was occupied in 1982. Funds for this building were provided in part by a grant that was awarded to Dr. Calnek from the National Cancer Institute. The grant covered one-half of the $350,000 cost. The remaining

Specific-Pathogen-Free Production Facility
Completed in 1982

amount came from patent royalties (cell-free turkey herpesvirus vaccine), salary recovery from NIH-supported faculty, and miscellaneous other sources. The building was a limited-access, shower-in facility. Bagged feed was brought in through a room in which the bags were fumigated before they entered the building proper. Virus-free fertile eggs and chicks up to 8 weeks of age were exported for use in the laboratory as a source of embryos for virus-inoculation studies or tissues for the preparation of cell cultures. Chicks needed for experimental purposes were transported to the Poultry Virus Isolation Building on the campus.

This building was used very successfully but after a few years the needs for SPF fertile eggs and young chicks gradually increased. This taxed its capacity to the point that a second high-security breeding and rearing building was constructed in 1987 across the road to the east of the Levine Laboratory. Funding for this $400,000 building came from salary recovery, patent royalties (then including the SB-1 vaccine) and a generous gift of $100,000 from Dr. Hiram Lasher, a Cornell graduate and friend of the Department.

The second SPF facility
Completed in 1987

Dr. Hiram Lasher (right) presents a check for $100,000 to Dean Phemister (center) and Dr. Calnek to help fund a second SPF breeder facility at Cornell

The last of the facilities enhancements that occurred during Dr. Calnek's chairmanship was again related to the poultry virus isolation (PVI) building. By the 1990s, this building was showing its 30+ years of age. For instance, it was in need of serious upgrading of the entire air-handling system to meet the requirements for accreditation. Also, there was a problem in moving materials in and out of the isolation units when they were occupied by infected animals. Finally, there was an issue that will never be confirmed (and probably is not true), but Calnek believes it may have been a factor in upgrading the building. As noted below, there were major additions to the College that were completed in the early to mid 1990s. The new large animal hospital buildings extended to the east so that they approached the location of the PVI building. They were new, attractive, and in sharp contrast to the old poultry building with its myriad of old rusty air exhaust ducts extending upward from the flat roof. In short, the PVI building was not in keeping with the new visage of that end of the College's main facility. The architects, who were very proud of their creation, commented on the disparate nature of this juxtaposition and "jokingly" suggested that the poultry building was out of place and should come down. Calnek, as the Chairman of the Central Planning Committee,

The Levine Laboratory Annex 1991

and thus closely involved with the entire construction project, was just a bit unsure of how serious the architects were and he declared in no uncertain terms that the building would come down "over his dead body!" It is probably happenstance, but lo and behold, two million dollars suddenly became available for refurbishing the building. This involved all new air handling equipment, installing access ports for each isolation unit, and very importantly, making the building more attractive by installing a new peaked roof and painting the entire structure to make it blend with the new college additions. Dr. Levine would certainly have been pleased.

Move from the Levine Laboratory to the College

As noted above, the Department moved into the new facilities at the College. There were new small- and large-animal hospitals, more space for the library, additional lecture halls, basic science and clinical science teaching laboratories, and new generic research laboratories suitable for any of the College's departments. The intent in forming the planning committee that Dr. Calnek chaired was to make sure that the College ended up with what the faculty and staff believed they needed, rather that what the architects thought they would be happy with. Although the planning occupied a good deal of Calnek's time over the next five years, it had the salutary effect of giving him a good deal of input into the kinds of new space that would be created and, therefore, what the Department of Avian and Aquatic Animal Medicine would have as a substitute for the Levine Laboratory.

The move of the Department had to be "staged" and actually was a reverse move for a period of about five years. This was necessitated because the corridor on the lower floor in Schurman Hall that housed the campus section of the Department needed to be vacated to allow physical changes related to the new construction. That was the area that had offices for departmental administration, and offices and laboratories related to the poultry diagnostic service and the aquatic animal program. Relocation meant that poultry necropsies were conducted in the large post mortem facilities of the Pathology Department. The pet-bird program went into remission when Dr. David Graham left Cornell, so that was not a problem. However, the aquatic animal program and the departmental administration needed to be moved. The solution was the creation of additional space in the form of an annex adjacent to the Levine Laboratory. Three double-wide "trailers" that had seen considerable use by the

General Electric company were moved to Snyder Hill, joined side-by-side and connected to the back side of the Levine Laboratory by a walkway. They were completely refurbished and redesigned to make a single building with laboratories for fish studies, offices for all of the faculty, and a large conference room. There were some misgivings regarding this upheaval, but actually it worked out well and there was more of a feeling of "togetherness" when the entire department was located in one place for the first time. This arrangement lasted until the entire department was moved to the new Veterinary Medical Center (VMC) which consisted of 4 floors of research laboratories and offices located above the new Small Animal Hospital.

It was possible to arrange for a cluster of laboratories and offices on the fourth floor of the new VMC that would be devoted to avian disease research. Although laboratories and offices were largely "generic," there were some special facilities unique to our Department that were included in the planning (*e.g.,* a small necropsy room and a special glassware and media-preparation room). Dr. Calnek successfully argued for a series of isolation rooms suitable for aquatic animal experimentation that were very important for departmental faculty working on diseases of fish. The laboratories, offices and seminar rooms clustered for faculty doing avian disease work were informally named the "Levine Laboratory" and the brass plaque that had graced the entrance to the Levine Laboratory on Snyder Hill was relocated to a prominent space on the wall in that section of the building, along with a photographic portrait of the Department's founder.

It was not known during this planning phase that the Department would merge with The Department of Microbiology, Immunology and Parasitology just before the move into the new facilities, so some of the rooms assigned to DAAAM turned out to be redundant (*e.g.*, departmental administrative offices). None the less, much of the space remained with assignments as planned.

Avian Health Advisory Council

In 1993, Dr. Calnek established an "Advisory Council" made up of individuals who represented a spectrum of groups associated with the poultry industry in New York State. The intent was to bring together researchers, administrators, regulatory groups, and very importantly, poultry producers. The aim was to encourage dialogue and facilitate interactions to benefit the industry. Membership was made up of individuals from the DAAAM (including the Duck Research Laboratory), Cornell's Diagnostic Laboratory, the College of Agriculture and Life Sciences, the New York State Department of Agriculture and Markets, and prominent members of the poultry industry in the State. A member of the poultry industry group was named chairman and day-long meetings were held semi-annually.

This approach turned out to be extremely beneficial. For example, when problems such *Salmonella enteritidis* - infected table eggs were causing great concern as a public safety issue, the interactions between the poultry industry, the diagnostic and extension personnel and the State regulatory agency were invaluable. There was give and take so that the regulations regarding such issues as mandatory or voluntary testing programs, State control over marketing restrictions, determining important research directions, *etc.* could be worked out on a face-to-face basis. Coordinated approaches to working with the State legislature in obtaining and maintaining funding year-to-year also were outlined in part by the group. Each meeting provided time to bring up and discuss special disease problems arising within the poultry industry such as the threat of avian influenza or Newcastle disease.

It is fair to say that this new program was long overdue. It brought a largely research-oriented department into a closer relationship with the poultry industry to the benefit of both. And, it taught the poultry industry more about what the research programs of the College had to offer

them, both directly and indirectly. The success of the Council is attested to by the fact that it continues to function smoothly to this day, with agendas organized by Dr. Benjamin Lucio.

Faculty Additions During the Calnek Chairmanship

James Carlisle (1976-82). Dr. James Carlisle came to Cornell in 1976. Although his duties were mostly in the field of aquatic animal medicine, he collaborated with Dr. Calnek and others in a study of the comparative pathogenesis of Marek's disease and with Dr. Schat and others on the pathogenesis of infectious bursal disease in bursectomized chickens.

Karel A. Schat (1978-). Dr. Karel A. ("Ton") Schat received his veterinary degree at Utrecht in The Netherlands in 1970. After 5 years in Mexico as part of a Dutch State Department program helping the Mexican Department of Agriculture, he came to Cornell to undertake a PhD program under Dr. Calnek's mentorship. Following his graduation from Utrecht, he had worked with Dr. Bart Rispens and was part of the team that developed what became known as the "Rispens strain" of Marek's disease virus (MDV) that has been used as a vaccine against MD for many years. Thus, he had an interest in MD and this influenced his decision to come to Cornell.

Dr. Calnek encouraged him to follow up on studies of low-virulence strains of MDV that had begun with Dr. Maurice Smith's PhD project in which he isolated the CU2 strain of MDV from the departmental PDR flock. Dr. Schat did so, and this line of research ultimately resulted in the development of the SB-1 strain of virus which has been successfully used world-wide as part of a bivalent MD vaccine along with the turkey herpesvirus (HVT) strain FC126. Interestingly, the latter was isolated and characterized by yet another Cornellian, Dr. Richard Witter, after he had located at the USDA Regional Poultry Laboratory in Michigan.

Dr. Schat completed his PhD in 1978. He inquired as to whether a spot could be found for him on the research team at Cornell. By this time Dr. Calnek had assumed the chairmanship of the Department and he was easily convinced that Dr. Schat could be a real asset on a continuing basis, and so Ton was hired as a Senior Research Associate. He held this title for two years and, in 1980, was promoted to the position of Assistant Professor. In 1982 he was further promoted to Associate Professor and in 1989 to Full Professor.

Dr. Karel A. Schat

He and Dr. Calnek worked very closely over many years, sharing in the development of research strategies, the execution of the experimental studies that resulted, and the reporting of results. Dr. Schat became a co-investigator on the NIH research grant that Dr. Calnek had first been awarded in 1963. They concentrated on aspects of infection, pathology, immunology, *etc.* many of which were related to pathogenesis of the disease and control of infection. Both individuals had a series of graduate students, sometimes shared.

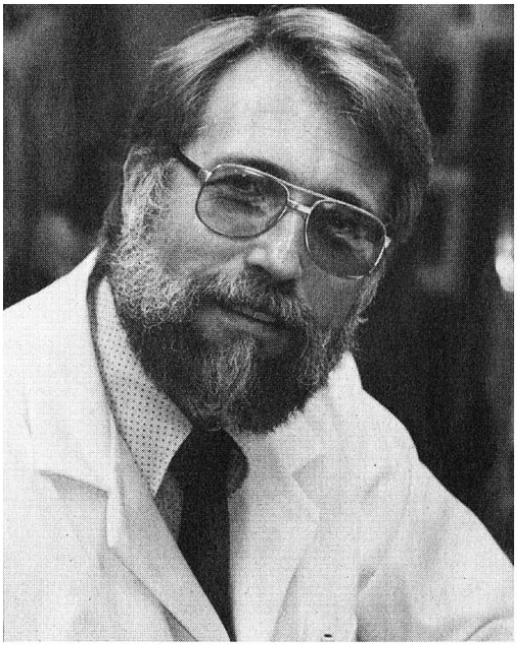
Ultimately, it became important for Dr. Schat to establish himself as an independent researcher, and Dr. Calnek encouraged him to undertake research totally unrelated to their shared interest in Marek's disease. He did so and soon gained a reputation for his work on rotavirus infection and chicken infectious anemia. He had several graduate students and visiting scientists who worked with him on these projects. He also moved into areas of MD research that did not overlap with Dr. Calnek's interests (and expertise). This was particularly true of some of the more definitive aspects of immunology and also applications of molecular biology techniques.

Dr. Schat co-edited the book *Avian Immunology* and contributed several chapters to the book *Diseases of Poultry*. He enjoyed teaching and offered courses at the graduate level (in virology and immunology) and also at the professional student level (international veterinary medicine). He has participated in the problem-based learning program that was adopted at the College in the early 1990s. He is a fair but demanding reviewer for a number of professional journals, and he travels extensively to speak to groups around the world. All of these have made him one of our more visible faculty members at Cornell.

Highlights of Ton Schat's research contributions are discussed in some detail in the section entitled "Research During and After the Levine Leadership Period."

David Graham (1981-87). Dr. David Graham had earned a fine reputation as a Professor at Iowa State University. As a board-certified pathologist with a particular interest in pet and wild-bird medicine, he was very attractive as a person who could continue and expand the program that had been initiated by Dr. Stephen Hitchner. He joined the Cornell faculty in 1981 as a Full Professor and quickly developed a diagnostic service which, in addition to offering necropsy and pathologic examinations of specimens submitted to the Department from local veterinarians or individuals, accepted wild- and pet-bird specimens from all parts of the United States. This service was a resounding success and provided Dr. Graham with abundant material for teaching and research. Also, accessions from outside New York State could be charged a substantial fee and this gave him monies to support his programs.

One of the hazards associated with conducting diagnostic work on specimens from psittacines is the danger of exposure to chlamydia. Both Dr. Graham and his predecessor in the business of examining pet birds (Dr. Hitchner) carried high titers to this pathogen. The virulence of chlamydia was amply demonstrated when, several years earlier, a number of individuals in the Department contracted psittacosis from an infected turkey poult submitted to the poultry diagnostic laboratory. Although this was an unusual instance of exposure, the danger from



Dr. David Graham 1981

the examination of psittacine birds was much greater. To reduce the chances of exposure for diagnosticians and others who helped them with their work, a separate laboratory was equipped with a high-security laminar-flow biosafety cabinet. This was critical so that shipping containers with potentially infected specimens

could be opened and necropsies performed without endangering the personnel involved. Dr. Graham participated in the teaching program by covering the portion of the avian medicine core course that dealt with pet and wild birds, pairing up with Dr. Shivaprasad who taught the portion dealing with domestic fowl. His knowledge and skills as a lecturer-presenter resulted in numerous requests for presentations in many venues.

A major subject of research for Dr. Graham dealt with a papovavirus infection called budgerigar fledgling disease. This disease resulted in mortality in nestlings, mostly between one and three weeks of age, and was particularly prevalent in birds hand-fed as nestlings. In a study with Bruce Calnek, the virus was isolated and the spectrum of lesions from 44 cases was described in detail. A fluorescent antibody conjugate was prepared that was useful for diagnostic purposes.

Another area of research was with so-called inclusion body disease of falcons (a herpesvirus-induced disease of pigeons and raptors). He also participated in studies by Dr. Schat, *et al.* on the pathogenesis of infection with attenuated MDV strains, and in experiments on the pathogenesis of reticuloendotheliosis virus infection in ducks carried out by Li, *et al.* Although he published little, his contributions to other's research by covering the histopathology were very important.

In 1987, Dr. Graham left Cornell to accept a position at Texas A&M University where he benefitted from a two-million-dollar endowment supporting a program in pet bird medicine.

H. L. Shivaprasad (1985-89). Dr. H. L. Shivaprasad joined the faculty as an Assistant Professor in 1985 as a replacement for Dr. Peckham. His responsibilities included diagnostic and extension service, teaching and research. He assumed responsibility for teaching both the course on poultry diseases offered to students in the College of Agriculture and the one given as a "core" course on poultry and pet bird diseases to veterinary students. He also instructed 4th year students when they took their rotations in the poultry diagnostic laboratory. He was a good teacher who took these responsibilities seriously.

Dr. "Prasad" is well endowed with enthusiasm. In addition to teaching, he carried out several research projects and was a collaborator on a number of others, particularly those requiring help in pathology. Such projects dealt with tumors in budgerigars, chicken anemia virus, and duck virus enteritis. He was more heavily involved in studies on *Salmonella enteritidis* (SE), collaborating with colleagues in both our Department and the Department of Microbiology and Immunology. He was the senior author on papers dealing with egg transmission and pathogenesis of the infection of chickens with SE, and he collaborated with others in the

Dr. H. L. Shivaprasad

Department of Microbiology and Immunology in studies of other aspects of this infection. Additionally, he investigated a number of problems of clinical importance in laying flocks in New York State.

In 1989, he left for a position at the University of California at Fresno where he has enjoyed a very good reputation for his diagnostic skills.

Benjamin Lucio (1987-). Dr. Benjamin Lucio has had a long, albeit initially fragmented, association with Cornell. Both he and his wife (Eglantina, also a veterinarian) moved to Ithaca from Mexico City in 1967 where they resided for two years while they both completed MS degrees (she in the Department of Physiology). Ben studied under Dr. Hitchner, finishing after two years. They returned to the National Autonomous University of Mexico (UNAM) where Ben was appointed as an Assistant Professor and subsequently became Chairman of the Department of Avian Diseases. In 1977, he and his wife returned to Cornell to continue graduate studies. Ben earned his PhD in 1979, again under the tutelage of Dr. Hitchner. He stayed at Cornell for an additional 6 months as a postdoctoral associate and then resumed his appointment in the UNAM as a Full Professor.

In 1986, he once again came to Ithaca, this time as a Visiting Professor. A year later, he was appointed to the position of Senior Research Associate II in the Department of Avian and Aquatic Animal Medicine at Cornell, and in 1989 he became an Associate Professor with a commitment to carry out research on significant poultry diseases. Several of his early contributions, mostly done with Dr. Hitchner as a collaborator, were in studies of infectious bursal disease (IBD). He is the author of a number of publications dealing with infectious bronchitis, chicken infectious anemia (CIA), and *S. enteritidis,* and he assisted Calnek and others in studies on the pathogenesis of Marek's disease. These contributions will be described in the section entitled Research During and after the Levine Era.

In the teaching arena, Dr. Lucio was responsible for the course on poultry diseases offered to poultry science students from the College of Agriculture. Also, he served as the committee chairman for a graduate student, Dr. Liangbiao Hu.

In 1993, Dr. Lucio switched his attentions from a primarily research-oriented appointment to one that centered on extension and diagnostic work. His title changed to Senior Extension Associate II, and Director of the Avian Diagnostic Laboratory, and he continues in this position to date. He has gained a very strong reputation and is extremely well respected in the poultry industry for his many contributions. He helps to monitor New York State flocks for *Salmonella enteritidis* infections, avian influenza, Newcastle disease, *etc.* Also, he has an important role in interacting with the New York

Dr. Benjamin Lucio

State Department of Agriculture and Markets and many other groups involved in poultry disease control on a regional or national level.

As the level of activity in the field of poultry diseases diminished following the merger of the Department of Avian and Aquatic Animal Medicine and the Department of Microbiology, Immunology and Parasitology, it became appropriate for Dr. Lucio's position to be moved to the Animal Health Diagnostic Center at the College. A move was therefore made in 2002 and he continues there to date.

Syed A. Naqi (1987-). After joining the Cornell group, Dr. Naqi concentrated his efforts on the subject of infectious bronchitis. This disease had continued to plague the poultry industry, largely because current vaccines did not protect from viral variants that had become a serious problem. With the help of graduate students, he tackled several aspects of the disease (*e.g.*, diagnosis, pathogenesis, immunology) and he also studied variability of the etiologic agent. His specific contributions through his research are detailed in a later section (Research During and After the Levine Leadership Period). They included the development of extremely useful monoclonal antibodies for distinguishing the most troublesome serotypes of infectious bronchitis virus, studies on the evolution of variants, and practical studies on vaccination protocols. Additional monoclonal antibodies specific to chicken immunoglobulin classes (IgM, IgG, IgA) and chicken IgA secretory component were developed. These reagents have served as useful tools for the study of avian immunology. He was awarded grants from the USDA, the US Poultry and Egg Association, and a commercial vaccine company to support his research at Cornell.

Dr. Syed A. Naqi

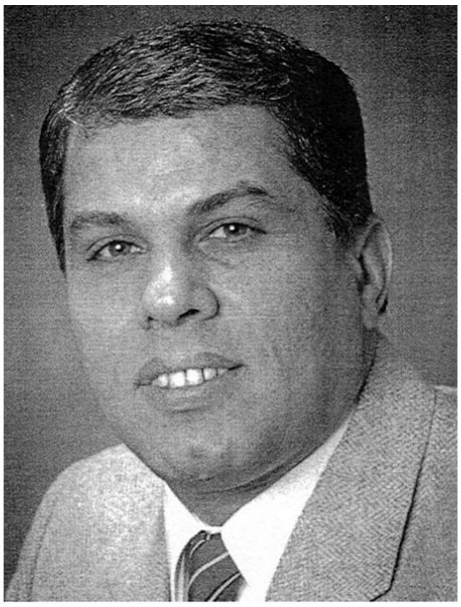
Dr. Naqi also assumed responsibility for teaching at the professional student and graduate student levels. He presented the College's core course on poultry diseases (1987-94), and he participated in the "case-based DVM curriculum (1995-2001), and a distribution course entitled "Diseases of Birds" (1997-2002). Also, he taught an advanced immunology course (1997 and 1999) and he trained several graduate students. His teaching was a real strength. He had been honored with the Norden Award for teaching while at Texas A&M University, and he continues to this day to be honored for his skills as a teacher. After his retirement, he was appointed to the faculty of the Weill Cornell Medical College in Qatar and he received two teaching awards at that institution in 2008.

Following the merger of the Department of Avian and Aquatic Animal Medicine with the Department of Microbiology, Immunology and Parasitology in 1995, Dr. Naqi served for several years as the Director of the Unit of Avian Health in the combined department. He retired in February, 2002 and is presently an emeritus professor. He moved back to Texas to be closer to family. However, as noted above, he returned to academic work by accepting an appointment in Qatar at the Medical School.

Ahmed Mutalib (1989-93). Dr. Ahmed Mutalib was the first appointee in the newly created position of Senior Extension Associate. He had emigrated from Iraq to Canada where he received the DVM and MS degrees at the University of Saskatchewan. His duties at Cornell took him to poultry farms across New York State, filling a void created when the last of the Regional Poultry Laboratories (Kingston) was closed. By that time (1989), the number of poultry farms in New York State had diminished greatly although several of those

remaining were quite large. The position that Dr. Mutalib filled was designed to provide personal visits to farms not only when they were experiencing disease problems but also on a routine schedule to monitor flock health. Specimens from cases requiring laboratory work were to be brought back to Ithaca where Dr. Lucio was in charge of the diagnostic service.

Dr. Mutalib took an independent stance by promoting the concept that the poultry industry did not need to interact with the Department. This was very contrary to the *modus operandi* that had characterized the Department over the many years of its existence and seemed to ignore the close relationship between academia and industry that had existed (examples: the eradication of both mycoplasmas and avian leukosis virus from breeding stock by working hand-in-hand with industry personnel, the field testing of a novel bivalent vaccine against



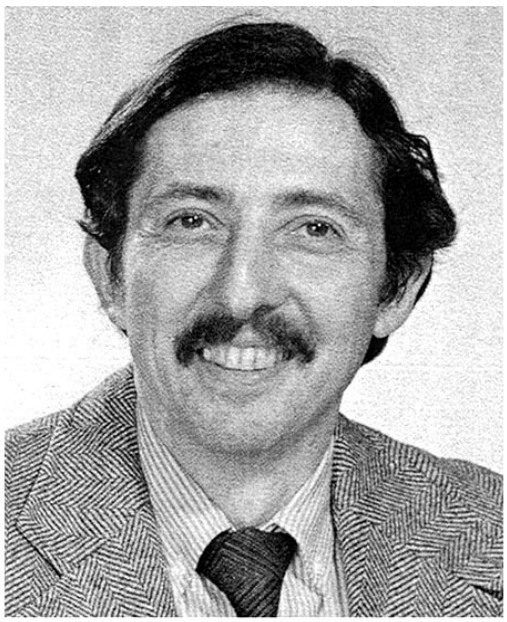
Dr. Ahmed Mutalib

Marek's disease on a farm that was being devastated by newer more virulent strains of the virus, the testing programs to determine the efficacy of using a mycoplasma "vaccine" on multi-age layer farms, *etc.*). This incompatibility resulted in his leaving Cornell in 1993.

During his four-year tenure at Cornell, Dr. Mutalib carried out some field-oriented research on *Salmonella enteritidis* (SE), reporting on an environmental survey and monitoring tests. He also studied the transmissibility of a tissue-culture-modified laryngotracheitis vaccine and reported on a case of erysipelas in caged layers. He was one of a large group who worked with Dr. Patrick McDonough (Veterinary Diagnostic Laboratory) on the interpretation of antibody responses to SE.

Stephen Bloom (1990-). Dr. Stephen Bloom had received MS and PhD degrees from Pennsylvania State University before coming to Cornell. He joined the Department of Poultry and Avian Sciences in the College of Agriculture in 1968 as an Assistant Professor. He had advanced to the rank of Professor by 1982 and was well established as a highly respected scientist in the fields of cytogenetics and immunogenetics.

When his department was eliminated by the Dean of the College of Agriculture and Life Sciences in 1990, Dr. Bloom, like all of the faculty in that department, had to find a new "home." Many of his colleagues relocated in the Department of Animal Science. Three came to the Veterinary College. Drs. James Marsh and



Dr. Stephen Bloom

Rodney Dietert chose to join the Department of Microbiology, Immunology, and Parasitology (MIP), and Dr. Bloom came to the Department of Avian and Aquatic Animal Medicine. He was allocated office and research space at the Levine Laboratory, although he was able to continue using his laboratory space at Rice Hall for a period after the dissolution of his former department. Following the merger with MIP, Dr. Bloom and his group remained associated with the Unit of Avian Medicine which was formed within the merged departments.

Dr. Bloom's work was largely in the field of cytogenetics. He used the chicken embryo and virally-transformed avian and human lymphoma cell lines in a wide range of studies related to gene expression, DNA replication and structure in avian and mammalian chromosomes, the metabolic activation of environmental chemicals, and the effects of environmental and chemotherapeutic chemicals on various cellular functions, including apoptosis, in B-lymphocytes. He and one of his graduate students, Franklin Moore, collaborated with Drs. Calnek and Schat in studies of chromosomal aberrations in Marek's disease lymphoma cell lines.

Randall Cole. Dr. "Randy" Cole, recognized throughout the world as an eminent poultry geneticist, was a very active emeritus professor in the Department of Poultry and Avian Sciences following his retirement. Like others, he lost his office and "home" when that department was eliminated in 1990. Because of his long-time interest in genetic control of poultry diseases and the many interactions he had with members of the DAAAM, he was warmly invited to join our group. He was given office space at the Levine Laboratory, and subsequently moved with our faculty into new space at the College in January 1996, sharing an office with Dr. Fabricant. He continued to assist others in his field of poultry genetics until his death in 2006.

Dr. Cole had been very important to our studies on Marek's disease. He had developed genetic strains of chickens that he made available and which were essential for our studies on pathogenesis of the diease.

Dr. Randall Cole

Postdoctoral Associates and Research Associates

During the period in which Dr. Calnek chaired the DAAAM, and after the merger with MIP, a number of postdoctoral associates worked with Dr. Schat: These included Gary Ross, Zehava Uni, Carol Cardona, Reem Yunis, Yuyou Duan, Bhawna Poonia, Keith Jarosinski, Mike Piepenbrink and Jia Wei.

Research Associates included Barbara Sneath in Dr. Calnek's laboratory and Donna Muscarella and Mary Delaney in Dr. Bloom's laboratory. Research Associates who assisted Dr. Schat included Randall Renshaw, Gary Ross, Keith Jarosinski, and Keila Dhondt.

Visiting Scientists

In 1981, Dr. Nestor Menendez, from Argentina, returned to Cornell for several months (he had

been here in 1973-74 when he studied reovirus infections). During his second visit, he assisted Dr. Calnek and others in research on avian adenoviruses. He helped to "clean up" various adenovirus strains by eliminating the adeno-associated virus (AAV) that contaminated most of our virus stocks. These AAV-free strains were then used to determine serological cross reactivity in an enzyme-linked immunosorbent assay. Dr. Menendez also collaborated with Dr. Cowen and others in a study of the effect of avian adenoviruses on egg production, shell quality and feed consumption.

Two scientists from Nigeria came to Cornell; Dr. Bamji Fasina worked with Dr. Fabricant on hemorrhagic enteritis in turkeys in 1980, and Dr. Daniel Adene spent a year with Dr. Calnek (1986-87) studying immune responsiveness *versus* susceptibility to Marek's disease.

There were three visiting scientists from Israel. In 1976-77, Dr. Joram Weisman came to Cornell to work with Dr. Hitchner on infectious bursal disease virus. They compared virus neutralization and agar-gel precipitin tests for detecting serological responses and also attempted to infect turkeys and Coturnix quail with the virus. Dr. Marius Ianconescu joined Drs. Calnek and Fabricant in 1974 to study the comparative effects of host and viral factors on early pathogenesis of Marek's disease. Dr. Daniel Heller was at Cornell in 1983-84, working on the pathogenesis of Marek's disease with Drs. Calnek, Schat and Fabricant. He also collaborated with Dr. Schat on immunological aspects of Marek's disease and the involvement of natural killer cells.

Ms Shela Shafqat, from Pakistan, visited in 1976 for a period of several months to learn cell culture techniques in Dr. Calnek's laboratory.

China sent three persons to Cornell for one-year periods. In 1981, Dr. Jinsong Li, from the University of Nanjing, came to Dr. Calnek's laboratory for a year during which he worked on the pathogenesis of reticuloendotheliosis virus infection in ducks. Dr. Yu Pu Guo, from Beijing University, spent a year at Cornell in 1984-85. A major part of his time was spent at the Duck Research Laboratory to learn methods of duck biologics production. In 1992, Zhou Wenping worked with Dr. Schat for one year on molecular studies with Marek's disease virus.

Visiting scientists from Mexico included Dr. Benjamin Lucio in 1986-87 (see above) and Dr. Eliseo Hernandez. Dr. Hernandez spent time with Dr. Schat in 1987 to learn techniques for making monoclonal antibodies; he produced one against rotavirus as part of this exercise.

Dr. Katsuya Hirai was at Cornell for two years (1977-79) as a visiting scientist from Gifu University in Japan. He worked primarily with Dr. Hitchner on viruses from pet birds (see above), but also with Dr. Calnek on the infection of cultured lymphocytes with infectious bursal disease virus. Dr. Yoshi Yamaguchi, also from Japan, spent time in Dr. Schat's laboratory in 1999-2000. He found QT35 cells (chemically transformed quail cells) to be latently infected with MDV.

Dr. Peter Stiube, from Romania, came to Cornell in 1980. Dr. Stiube, who was a colleague of Dr. Ionel Patrascu (a visiting scientist during the Hitchner administration) was interested in Dr. Calnek's Marek's disease research program, but he also participated in a study leading to an examination of avian adenovirus serotypes using an enzyme-linked immunoassay.

Dr. Nelson Rodriguiz Martins worked with Dr. Schat on chicken infectious anemia virus vaccines in 2004.

Summary

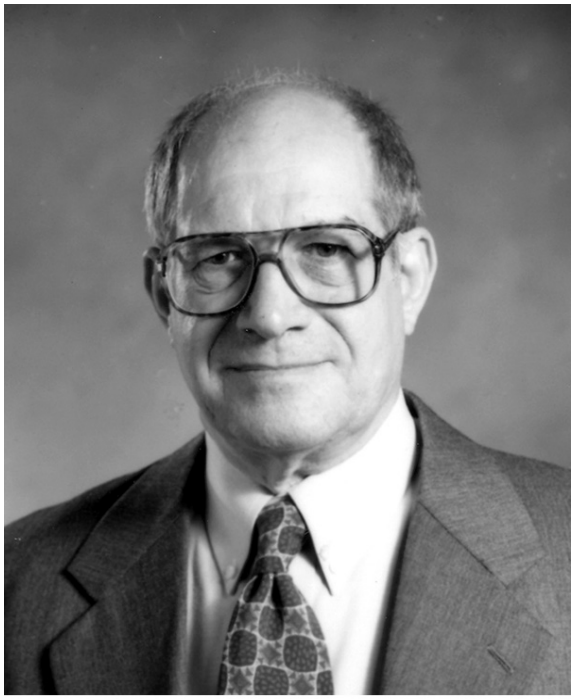
In spite of Dr. Calnek's reluctance to be an administrator, he chaired the Department of Avian and Aquatic Animal Medicine for 21 years (1975-95). Mostly, he tried to "keep a lid on things." He was responsible for recruiting and working with a number of new faculty. He

also oversaw a continuation and strengthening of departmental research programs in terms of scope and funding, an expansion of the companion bird species program, and evolutionary changes in the service/extension programs related to avian medicine. He added significantly to the facilities through the addition of two high-security buildings to house SPF breeding stock, and made important modifications to the Poultry Virus Isolation Building. Also, he orchestrated a move of the Department to all new office and laboratory space within the Veterinary Medical Center building at the College.

All of this was carried out in the face of competing demands on his time: conducting research at a level necessary to maintain funding through an NIH grant, serving on an NIH Study Section, chairing the College's Central Planning Committee which oversaw a $90+ million dollar major facilities expansion project completed in the 1990s, and serving as Associate Editor and then Editor for five editions of the "bible" in the field of avian medicine, *Diseases of Poultry.*

Things in the Department began to unravel by the late 1980s and early 1990s. Reduced funding by New York State compromised some programs at both the Duck Research Laboratory and the College. One of the casualties was the program devoted to pet bird medicine which ceased when Dr. Graham left Cornell. His position was not filled because of fiscal shortcomings at the College level. Also, it was apparent that other positions, including that held by Dr. Calnek, likely would be eliminated for fiscal reasons as individuals retired. Or, equally bad for the avian medicine program, those positions could be placed elsewhere in the College. Also, as Dean Phemister's retirement approached, the likelihood that realignments among the College's departments would be considered might well mean the loss of the DAAAM. As a consequence, it seemed prudent to the faculty to consider a merger with a sister department (MIP). The merger did take place (see below). Dr. Calnek retired, although he continued to carry on some research of interest to him, to edit, and to participate in national and international meetings. However, it was clearly the end of an era.

In spite of some of the downsides, in Dr. Calnek's view it had been a most rewarding period and overall, one that kept Cornell University on everyone's list as a preeminent contributor to the field of avian medicine.



Dr. Bruce W. Calnek 1995

The Merger (1995)

For a number of years, Dr. Roger Avery, the Chairman of the Department of Microbiology, Immunology and Parasitology (MIP) had urged Dr. Calnek to consider merging their two departments. His argument, not without merit, was that we did essentially the same things, the only difference being that the Department of Avian and Aquatic Animal Medicine was species-oriented.

One has to consider how the DAAAM came into existence to understand the reason for it being the only species-oriented department in the college, all others being discipline-oriented. First, going back to the 1920s, it was obvious that most veterinarians were not interested in dealing with poultry. Efforts were made to encourage veterinary practices to include avian species but, other than helping with pullorum testing, and distributing vaccines such as the one produced for fowl pox, little interest was generated. It was because of this, and the fact that the poultry industry was a significant part of agriculture in New York State, that the College made an effort to provide the special help needed by poultrymen. Most of the faculty in the Department of Pathology and Bacteriology, which had responsibility for addressing diseases of all species, were disinterested in poultry, preferring to concentrate on mammalian species. Thus, individuals such as Dr. Brunett and others, and later, Dr. Levine, were assigned to specifically take charge of the teaching, service and research needs related to avian medicine. It developed that, in Dr. Levine's tenure, he was given responsibilities that made him a *de facto* department chairman but without the authority that would accompany such an appointment. Ultimately, in 1960, he was successful in gaining the recognition he believed was fully deserved by having his poultry disease group given the status of an independent department.

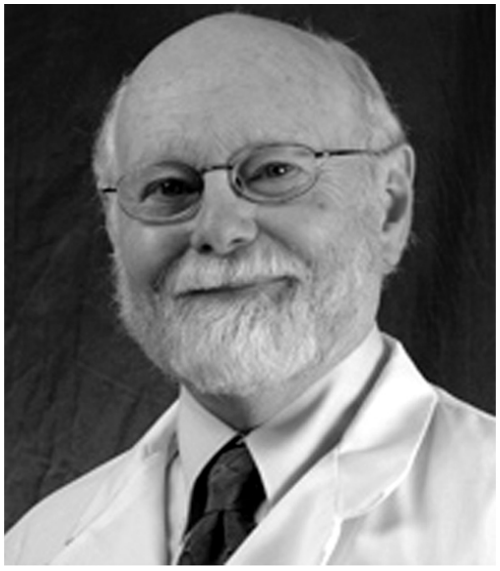
Because the Department of Avian Diseases was small and "different" (in that it was species oriented), it was subject to special scrutiny by other departments in the College. Not everyone believed it should have independent status. An opportunity to strengthen its place in the College presented itself when, in the early 1970s, it was decided that aquatic animal medicine should be added to the programs at Cornell. By that time, Dr. Hitchner was the chairman of the Department, and he, with strong support from his faculty, successfully argued that aquatic animal medicine had much in common with avian medicine in terms of appropriate methods of control, *etc.* Thus, the scope of the Department was expanded and it gained a new name, the Department of Avian and Aquatic Animal Medicine. The acronym DAAAM gave rise to some interesting fallout; for instance, there were chuckles when it was time to prepare for the "DAAAM Annual Report."

The combined activities were particularly helpful in preserving the precarious small and species-oriented department, particularly when fiscal problems arose. As already noted, there was an erosion of the avian medicine programs during Dr. Hitchner's chairmanship when he was forced to close two of the three Regional Poultry Laboratories. Furthermore, when positions were vacated it was difficult to gain permission to refill them. For instance, after Steve Hitchner retired in 1981, it took strong persuasive arguments to allow us to recruit Dr. Graham to fill the vacancy, and when Graham left in 1987, the position was lost. Also in the late 1980s and the early 1990s, reductions in State appropriations cost two positions at the Duck Research Laboratory and required the closure of the last of the Regional Poultry Laboratories (Kingston).

The upshot was that a small department was becoming even smaller and its existence as a stand-alone department was again being examined carefully. We remained intact largely because, as noted above, Dr. Calnek was able to convince Dean Phemister that, as a "national

resource," we deserved to be independent. Also, it is likely that he wished to delay any potential action until after he left office. None the less, the handwriting on the wall was becoming ever so much more readable. Compounding the problem was the fact that it was likely that there would be some reorganization of departmental structures across the entire College by the mid 1990s, when Dean Phemister would complete his term. Our chances of escaping notice at that time were slim at best. Finally, Dr. Calnek had taken a 3-year terminal appointment in 1992, giving up his tenure in return for some benefits in his favor. It was made clear that with the fiscal constraints in the State budget, his position would likely be lost when he retired.

The upshot of all of this prompted Dr. Calnek to talk seriously with Dr. Avery about exploring his long-standing proposal that our departments should merge. We believed that a pre-emptive move like this could benefit us both when an anticipated College-wide reorganization was carried out. The next step was to consult independently with our respective faculties. At that time the DAAAM had six faculty and MIP had 18. Given all of the facts and possibilities, it seemed to both parties that a merger was the appropriate action. The Dean was consulted and he concurred.



Dr. Roger J. Avery

The only issue that was debated hotly was what the merged department would be named. Interestingly, this occupied more time, generated more memos, and resulted in more meetings than any other issue associated with the merger. Names were proposed, voted on, then re-voted on until a majority was determined using the Hare System. The initial choices were: 1) Infectious Diseases, 2) Infectious Diseases and Immunology, 3) Microbiology and Immunology, and 4) Microbiology, Immunology and Parasitology. The first round of voting eliminated numbers 2 and 4 and the second round resulted in the selection of number 3. It had already been agreed that the new department would have a discrete section named the "Unit of Avian Medicine" with a Unit Leader.

On May 3, 1995, a Memorandum of Understanding was signed by Dean Phemister, Dr. Avery and Dr. Calnek stating that the Department of Microbiology and Immunology would result from the merger of the two departments effective July 1, 1995. Budget cuts that had been assigned to the two departments from reduced funding by the State University of New York and the New York State Department of Agriculture and Markets would be effected independently before the merger, and savings resulting directly from the merger were to be shared equally by the two departments and used to ameliorate the budget cuts. Dr. Avery was named the Chair of the new department, and he, in turn, named Dr. Syed Naqi as the Unit Leader for the avian medicine group. Dr. Calnek retired at the end of August that year, pleased that the faculty of the DAAAM had been able to participate in the definition of their fate.

In January, 1996, the faculty and staff moved to new quarters in the newly opened Veterinary Medical Center. Space that had originally been assigned to the Department of Avian and Aquatic Animal Medicine became part of the merged departments, with the avian medicine group remaining in a cluster of laboratories.

Veterinary Medical Center - Completed in1995

Dr. Levine's portrait and the plaque that honored him at the Levine Laboratory were placed in the main corridor near that cluster.

After the Merger (1995 -)

For a period of several years, the Unit of Avian Medicine within the merged department functioned well, with research, teaching, and service to the poultry industry continuing much as it had during the pre-merger period. The Duck Laboratory was supervised by the new department, but much of the interaction remained the responsibility of members of the Unit; for instance Dr. Schat took charge of overseeing the scientific portion of their program.

As was expected, the loss of individual departmental status gradually took its toll. The first "casualty" occurred when Dr. Naqi retired in 2002. There was no departmental support for replacing him with a person whose specific interests were in the field of avian medicine. As it turned out, the position he vacated was eventually filled by Dr. Nikolaus Osterrieder, a herpesvirus specialist who, although he worked on the molecular biology of Marek's disease virus as well as equine herpesviruses, had no background or interest in poultry diseases and, in any case, he has now returned to Germany.

Dr. Roger Avery left Cornell in 1999 to accept an administrative post at Virginia Tech. and was replaced by Dr. David Russell. Dr. Avery was a strong supporter of the avian disease program, having himself been in that field earlier in his career while at the Houghton Poultry Research Station in England. His replacement, Dr. David Russell, had no such background. Dr. Bloom, who had transferred from the Department of Poultry and Avian Sciences eventually changed his focus to areas that were unrelated to poultry. Dr. Lucio continued as before for the first few years, but in 2002 it was decided that he should be moved to the Diagnostic Laboratory at the College,

where his position was more appropriately placed. Also, responsibility for administering the Duck Research Laboratory was transferred to the Department of Population Medicine. That left Dr. Schat as the sole individual with an interest in, and a commitment to, poultry disease research in the Department of Microbiology and Immunology. His program continues to flourish with very active investigations on Marek's disease and avian influenza, helped by a continuum of graduate students, post doctoral associates, *etc.* However, he plans to retire in 2012. It is probable that if his position remains in the Department, it will be "up for grabs" and it would seem highly unlikely that there will be an effort to specifically recruit a replacement who is interested in avian medicine.

In addition to the loss of personnel and program, the ultimate closing act was the razing of the Levine Laboratory in 2008. The building did not meet present day minimal standards for fire safety and had remained essentially unoccupied since it was vacated at the beginning of January, 1996. The SPF buildings remain and continue to provide fertile eggs and chicks for persons who have need for such. The Poultry Virus Isolation building on the campus is still operational but there are plans to switch all experimental animals to a new building constructed near the Veterinary Research Tower in the near future. The ultimate use of the PVI is not apparent to the author of this history.

January 2008: The beginning of the end

Demolition of the Levine Laboratory - May 2008

s i n

The Levine Laboratory site - June 2008

Selected Research Highlights from Studies During and after the Levine Era

After Dr. Levine assumed the leadership of the poultry disease program at Cornell, intensive and broadly based research programs proliferated. Teaching, other than graduate student training, required little time from most of the faculty, and the diagnostic and extension activities were not the province of many of them. Thus they were free to concentrate on investigative research. The facilities and resources of the Department of Avian Diseases were highly supportive of such. Assets included: 1) a 41-unit Poultry Virus Isolation building, the envy of many other institutions doing research on avian diseases, 2) availability of specific-pathogen-free flocks of chickens of various genetic strains, 3) a well equipped research laboratory at Snyder Hill, and 4) a succession of Department Chairmen who, themselves, were productive researchers. All of this spelled success, and success spelled financial support through research grants from industry and the federal government (USDA, NIH) and royalties from patents. Cornell achieved a reputation as one of the leading centers for avian disease research in the United States, and indeed, in the world.

The research areas that were addressed beginning with the "Levine era" were quite varied and depended largely on the overall importance of the problems being investigated. Many addressed specific conditions encountered in the diagnostic laboratory. Some of the research, particularly isolated investigations tackled by a single individual, is covered in the sections on individual faculty members. However, certain areas stand out and/or involved teamwork, and are covered in more detail here. These include respiratory infections (Newcastle disease, infectious bronchitis, mycoplasmosis), neoplastic diseases (lymphoid leukosis, Rous sarcoma, Marek's disease, tumors of unknown etiology), herpesvirus-induced atherosclerosis, and miscellaneous virus infections and their associated diseases (rotavirus, chicken infectious anemia virus, adenovirus, infectious bursal disease virus).

Respiratory Infections

Respiratory infections were a strong focus for a number of years in Dr. Fabricant's career. The earliest projects which he and Dr. Levine tackled were concerned with Newcastle disease epidemiology and vaccinal immunity. When successful vaccination programs became commercially available with La Sota and Hitchner B1vaccines, their interests turned to infectious bronchitis. Not only did they investigate basic problems such as egg transmission, duration of infection and carrier possibilities, but they soon became involved in efforts to control the potential egg production

Dr. Fabricant at infectious bronchitis clinic, *ca.* 1949

losses in laying hens. This involved infecting 9- to12-week-old pullets with a live virus so that they would be immune by the time they reached

laying age. An immunizing strain was selected which would spread well within the flock and was of relatively low pathogenicity. This "early infection" approach was the basis for a successful statewide program which was in use until commercial vaccines became available. The program, which was in place in Ithaca and all of the regional poultry laboratories, was carried out by inoculating about 1% of a flock (brought to the laboratory premises by the flock owner) which would then be returned to the flock to infect all other birds.

The bronchitis control program that Fabricant and Levine developed and carried out by immunization of growing birds led to an interest in what was first termed chronic respiratory disease (CRD), later as avian respiratory disease and even later as avian respiratory mycoplasmosis. Some of the bronchitis-vaccinated flocks did not show the usual pattern of complete recovery from respiratory symptoms after about two weeks but continued to evidence respiratory symptoms for prolonged periods. An investigation conducted on these flocks failed to yield bronchitis virus but material inoculated into chick embryos did cause some mortality. On the supposition that these organisms might be chlamydia (then known as *Miyagawanella*), isolation procedures were changed and soon an organism was identified that did not fit the description of a *Miyagawanella* but clearly grew well in chicken embryo yolk sacs. This was first known as the agent of CRD. It had similar characteristics to the agents previously described by Delaplane as a virus and by Nelson as a coccobacilliform organism. This was the beginning of a research program that lasted over 20 years.

It soon became apparent that an organism associated with a relatively mild chronic respiratory disease in layer replacements was related to similar organisms from infectious sinusitis and airsacculitis in turkeys and a severe disease in broilers later called complicated chronic respiratory disease. The organisms were first called pleuropneumonialike organisms (PPLO) and later named mycoplasmas.

Most of the early research at Cornell was concerned with techniques for the isolation of these organisms. Drs. Fabricant and Levine needed to find the best methods for isolation of PPLO in chick embryos. When it was later recognized that they could be grown on culture media, a new series of projects was needed. First, it was necessary to find suitable culture media for primary isolation of PPLO from diseased birds. Second, methods were needed to differentiate the pathogenic PPLO from other nonpathogenic PPLO in the same tissues. This, in turn, required a proper method of characterization and classification of the organisms. When the pathogen of the respiratory form of CRD became known as *Mycoplasma gallisepticum* (MG) the emphasis shifted to include the development and evaluation of serological procedures for diagnosis.

The use of these improved and standardized diagnostic methods resulted in a much clearer understanding of the nature and biology of CRD. First was recognition of the role of vertical (through the egg) transmission of mycoplasma. Also, it was learned that essentially all primary breeders were already infected with the agent. This mandated studies of how to prevent egg transmission and thus allow the production of MG-free chicks from infected parent flocks.

Meanwhile, studies indicated that the disease responsible for important mortality and condemnation losses in broilers was so-called "complicated chronic respiratory disease." This was caused by a combination of MG, infectious bronchitis and terminal infection with pathogenic *Escherichia coli* resulting in a severe peritonitis and pericarditis. An interrelationship amongst the various etiologic factors, particularly the significant role of MG infection in facilitating the secondary *E. coli* infection, was determined. It became evident that without previous MG infection, secondary *E. coli* infection was of relatively minor economic importance.

Accordingly, the major emphasis of the research program switched to trying to elucidate the

patterns of natural and experimental egg transmission of MG and methods for the prevention of such. This was a long and expensive project that required the culture of many thousands of individual eggs or chick embryos obtained from trapnested hens. It was found that vertical transmission (from hen to egg to chick) occurred at a high level shortly after infection and decreased with time. However, on a flock basis, vertical transmission persisted over very long periods of time. Even very low rates of egg transmission were enough to ensure that some chicks in the resultant replacement or broiler flocks would be infected. It was, therefore, necessary to completely prevent egg transmission in breeding flocks to produce MG-free progeny and reduce the losses due to CRD. It had already been shown that antibiotic treatment of breeder hens would reduce but not completely prevent egg transmission. Two different methods of solving this problem were investigated. During studies on egg transmission patterns, it was observed that pullets infected with a highly virulent strain of MG during the growing period (9-12 weeks of age) recovered fully from the infection and did not lay any MG-positive eggs when they came into production. This was successfully tried under field conditions and was an effective means of control. Unfortunately, during the period after infection, the growing pullets were dangerously exposed to secondary *E. coli* infection. The second control method, which turned out to be both safe and effective, was based on treating the hatching eggs, and not the hens, with effective antibiotics. This procedure used a method patented by Vineland Poultry Laboratories for hormonal treatment of hatching eggs in the hope that it would yield all female chicks (it didn't work). Eggs were first warmed to incubator temperature and then placed in an ice-cold solution of antibiotic. The shrinkage of the egg contents upon cooling caused the "sucking in" of the solution through the pores of the rigid egg shell. This "dipping" procedure ensured the entry of sufficient antibiotic into the egg to destroy any MG present. Under both experimental and field conditions this method proved to be 100% efficient.

Once the effectiveness of the procedure was established, a cooperative program was set up with a local primary breeder of egg-laying stock (Babcock) to convert their entire breeding farm, from basic breeders through to parent stock, from MG-positive to MG-negative. This was done by "dipping" all hatching eggs from infected breeders and raising the progeny on separate MG-free premises.

Dr. Fabricant dipping eggs in antibiotic to eliminate mycoplasmas

As a result of collaborative studies with Dr. Levine on avian mycoplasma, Dr. Fabricant was awarded an NIH grant for the "Isolation and Characterization of Mycoplasma" which was continued with several renewals. The research conducted under this grant ranged over a wide area of basic research but concentrated on the development of new media for primary isolation of mycoplasma from clinical specimens. This

first involved isolation from cases of clinical respiratory disease in poultry and later extended to other species and organs, especially from the reproductive tract. Two problems were encountered: 1) a variety of mycoplasmas were found in some tissues (some pathogenic, some non-pathogenic), and 2) the need to produce pure (single species) cultures of the various mycoplasmas became apparent. This required the development of various biochemical and serological tests so that these organisms could be more easily identified. The resultant work led to Dr. Fabricant's service for many years on an international study group on mycoplasma taxonomy.

During this period, one of Dr. Fabricant's graduate students, Dr. Richard Chalquest, carried out some important work on *Mycoplasma synoviae*, the cause of infectious synovitis in chickens and turkeys. He was able to culture the organism on artificial media and reproduce the disease with these pure cultures.

Other investigations in the field of respiratory infections included a study by Drs. Hitchner and Fabricant on diagnostic and vaccination procedures for infectious laryngotracheitis. Also, there was a large multiyear project which involved field studies on causes of egg production problems in laying hens. During the 1970s, there were complaints from commercial poultry farms that some flocks of laying hens failed to reach expected peak egg production or experienced unexplained drops in egg production, especially in early periods of the laying cycle. These problems tended to reoccur on the same premises. With the cooperation of the agricultural extension service and some of the involved poultrymen, a prospective case-incidence study was organized. Blood samples, culture swabs and feed samples were collected at monthly intervals so that the occurrence of exposure to various potential pathogens could be correlated with the occurrence of egg production problems. The first trials yielded no conclusive results. A second set of trials in which culture swabs were taken from the cloaca as well as the trachea did show a correlation between multiplication of infectious bronchitis virus in the intestinal tract and these egg production problems. This led to two conclusions: first, that infectious bronchitis virus could infect the intestinal tract of vaccinated birds without causing respiratory disease, and second, that this type of infection could affect egg production.

The subject of infectious bronchitis was revisited in a serious fashion in more recent years. Drs. Lucio and Hitchner characterized the tissue tropism of cloacal isolates of IBV by studying the distribution of virus in the digestive tract. When Dr. Naqi joined the faculty in 1987. he initiated studies of various features of infection and the ensuing immunity. His work was systematic and it applied modern technology to significant and practical aspects of this infection. Dr. Naqi took advantage of the many isolates of IBV that Dr. Fabricant had wisely stored away in the 1940s, carrying out a series of genetic and antigenic studies comparing isolates from the 1940's to those from the present. This provided meaningful insights into the evolution and emergence of IBV serotypes and antigenic variants. Indeed, it is the evolution and subsequent development of variants that continue to plague, the poultry industry.

At the time Dr. Naqi initiated his work on IBV, serotyping was, and still is, a difficult task. It remains essential for chicken producers (especially large poultry companies) to know which serotypes are causing problems in their flocks so that appropriate vaccination strategies can be formulated. Dr. Naqi and his graduate student, Dr. Kemal Karaca, developed several monoclonal antibodies (Mabs) that distinguished the important serotypes and these were used to develop MAb-based immuno-assays. They were found to be immensely helpful to large poultry companies. As an example, one large poultry operation in the United States reported to Dr. Naqi that his help in serotyping identified the Arkansas strain as a major problem and, as a result of this finding, they were able to use the right vaccine and thus saved substantial amounts of money. These MAbs also

have become a convenient research tool and are being used internationally.

Unique studies were conducted in which shedding of IBV vaccine virus and persistence of IBV in tissues were examined in individual maternal-antibody-positive (MAb+) and MAb- chickens vaccinated at 1-day of age and maintained under strict isolation. When vaccine was applied to MAb- chickens, the virus persisted in the respiratory tract and internal organs for 27 and 163 days, respectively. In contrast, in MAb+ chickens, the virus persisted predominantly in the respiratory system and rarely in the internal organs. These observations reaffirmed that, while maternal antibody protects the internal organs against virus persistence, the respiratory tract remains susceptible to virus replication. Interestingly, the virus isolates from persistent infection exhibited no change in their genetic and antigenic characteristics, suggesting that, unlike the mammalian coronaviruses, a propensity for frequent genetic change may not be inherent in the IBV genome.

Dr. Naqi's research also addressed a frequently expressed concern about whether IBV vaccination of day-old chicks, as was frequently practiced by the industry, helps or hurts chickens. His trials showed that vaccination of day-old MAb+ chicks does not induce a significant local or systemic immune response. Indeed, it appeared to compromise a response to a subsequent vaccination. On the other hand, allowing maternal antibody levels to decline by vaccinating at a week or ten days of age resulted in a good and lasting primary response and a good secondary immune response. Such studies were especially useful in helping producers to make informed decisions about vaccination.

Dr. Syed Naqi "at the bench" *ca.* 1990

Development of Specific-Pathogen-Free (SPF) flocks

One of Dr. Calnek's major objectives in the 1960s was essential to his studies on tumors. That was to establish a flock of chickens free of avian leukosis virus at the Snyder Hill poultry disease research farm. The "PDR" flock that constituted the breeding stock for poultry disease research was already free of mycoplasmas (by chance). So, a flock of leukosis-virus-free leghorn chickens was developed by testing breeders for infection with avian leukosis virus, selecting progeny from "non-shedders" and raising them separately from infected birds. Female PDR-strain birds were later crossed with males from the University of Connecticut's SPF flock of White Leghorns to help improve egg production and hatchability. The strain was then identified as PDRC. In 1968, progeny from that flock were hatched in our Poultry Virus Isolation building and raised in a building (called the BAI house since it had been built for mycoplasma work and was funded by the USDA's Bureau of Animal Industry). The BAI house was separated by a few hundred yards from the departmental research farm and the chickens had a separate caretaker. This flock remained free of Marek's disease for a year and constituted our first MDV-free flock at Cornell. Progeny were raised in the BAI house and also in selected pens on the research farm. Eventually, various pens of these SPF chickens became serologically positive for MDV and it was not until some of the research farm poultry

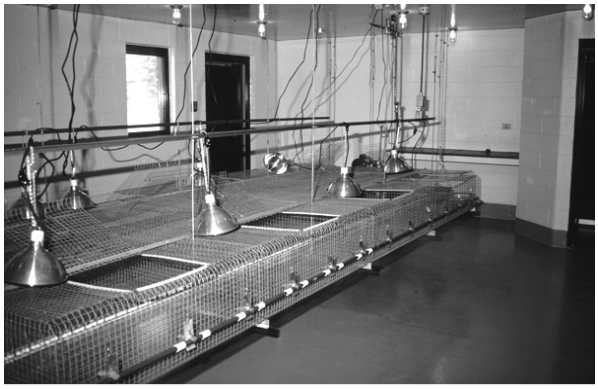
houses were fitted with special air filtration that it was possible to maintain an MDV-free status. Similarly, some birds were hatched and raised in filtered-air isolation units in the Poultry Virus Isolation building on the campus to assure that they remained free of MDV infection.

Beginning in 1971, other genetic strains useful for our MD research were developed as SPF flocks. Fertile S-strain and P-line (highly

BAI house 2008

susceptible to MD) and N-line (highly resistant to MD) chickens were provided by Dr. Randall Cole in the College of Agriculture. These underwent procedures to render them free of two pathogens known to be egg-transmitted, *i.e.*, avian leukosis virus and mycoplasmas. They were dipped in tylosin before incubation to eliminate mycoplasmas and then hatched in "pedigree" trays which had compartments that would hold 6-8 eggs. Chicks from each compartment were then placed in an individual Horsfall-Bauer isolation cage. After 4 weeks, the chicks were tested for the presence of avian leukosis by the RIF test and all chicks from cages with any infected birds were eliminated. The remaining chicks were vaccinated against MD using turkey herpesvirus vaccine to protect against losses should an adventitious infection occur, and raised in filtered-air isolation units. Ultimately, progeny from these and a few other strains (such as the highly inbred 003 strain obtained from Dr. Hans Abplanalp in California) were raised without vaccination and were used for research on Marek's disease and a variety of other infectious agents.

Unvaccinated and vaccinated flocks of PDRC, S-strain, P-line and N-line were raised on the research farm in filtered-air houses until the 1980s when two high-security SPF buildings for breeding and rearing were constructed on lots adjacent to the farm (see Facilities in the Calnek Chairmanship Period section). These buildings were "shower-in facilities," with limited-access, where breeders were kept in wire cages. Progeny were held in wire battery units for up to 8-weeks of age.



Chick caging in SPF facility 1982

Both eggs and chicks were exported to serve as a source of embryos and tissues needed for laboratory studies as well as for use in experiments on live animals. All birds in the SPF facilities were bled periodically for a battery of serological tests that proved them negative for avian pathogens including MDV, avian leukosis virus, adenoviruses, reovirus, reticuloendotheliosis virus, infectious bronchitis virus, infectious bursal disease virus, Newcastle disease virus and mycoplasmas. All birds that died were necropsied to ascertain the cause of death. This monitoring was fundamental to the studies that were undertaken by all researchers in the avian disease group. The availability of the poultry virus isolation building for preventing adventitious infections in experimental groups, coupled with the ready supply of genetically well-defined SPF chickens, constituted major pluses for our studies on tumor viruses and many other infectious diseases as well.

Later, more definitive genetic testing and selection was done on the N-line and P-line

chickens to make them uniform not only for their B-alleles (N-lines were B-21 and P-lines were B-19), but also for the C2 allele. Poor fertility in the P-2 line was the reason to generate an F1 cross by mating P-2 and N-2 birds. The F2 generation was separated, based on blood group typing, into new N and P lines which were identified as N-2a and P-2a, respectively.

In the 1990s, infection of these SPF flocks by chicken infectious anemia virus (CIAV) occurred inexplicably. Perhaps it originated due to investigations on this infection that were being carried out in the Poultry Virus Isolation Building on the campus. It was possible that this very hardy virus was carried by poultry farm personnel who, because of fiscal cutbacks, were required to occasionally work both on the farm and in the virus isolation building, albeit with special care to (hopefully) prevent the inadvertent transfer of any infections. However, the virus that was isolated from the SPF flocks was not the same as that which had been studied in the PVI building. Other possible sources include the feed. In any case, the term "Specific-pathogen-free" for departmental flocks necessarily excluded CIAV after the infection occurred. It has not been possible to eliminate this virus from the flocks due to its very hardy nature, but luckily its presence has not precluded most of the other research that is carried out with SPF chicks.

Neoplastic Diseases

Beginning with Dr. Calnek's tenure at Cornell, research on a number of tumor diseases and their causative viruses was carried out by Drs. Calnek, Schat, Fabricant, Lucio, twenty two graduate students, and several post doctoral associates and visiting scientists. From 1964 to the present, over 170 scientific papers on avian tumor viruses have been published by the group. There were several highlights from this work that merit elaboration and are discussed in this section.

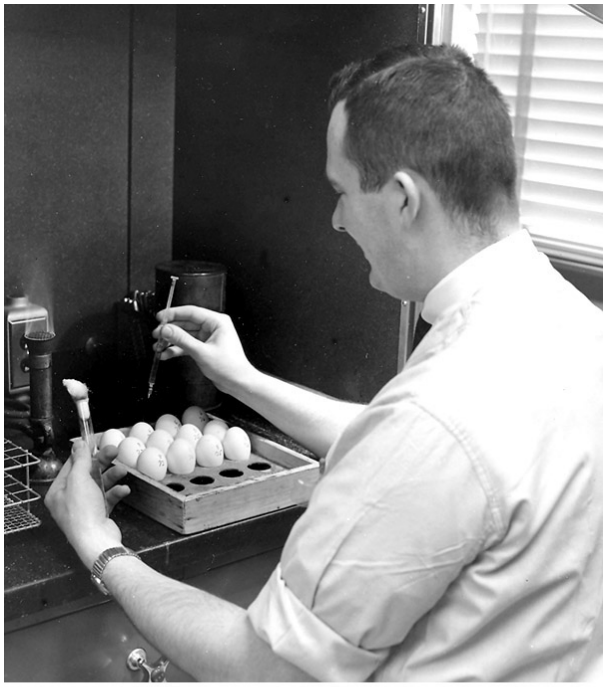
Leukosis/Sarcoma

The earliest work in the field of avian tumor viruses undertaken by Dr. Calnek dealt with the avian leukosis virus (ALV) that causes lymphoid leukosis (LL) and the sarcoma virus that had been isolated by Peyton Rous in the early 1900s, and became known as Rous sarcoma virus (RSV). Because sarcomas caused by viruses such as RSV were of minor significance in poultry, the virus was studied mostly as a model. It causes rapidly developing sarcomatous tumors in chickens and it also induces "micro tumors" in cultured chicken embryo fibroblasts. Calnek's studies on these viruses were stimulated by the new discovery that ALV could be detected in tissue cultures using a procedure named the resistance-inducing-factor (RIF) test. The RIF test was developed by Harry Rubin (a Cornell Veterinary College graduate who was a Professor at the University of California, Berkeley). The test was predicated on the fact that chicken embryo fibroblast (CEF) cultures of a susceptible phenotype could be infected with ALV. Cell cultures infected with ALV were rendered resistant to RSV. Originally, Rubin did not know the reason why some of his CEF cultures did not respond to inoculation with RSV, but he soon found that fluids from resistant cultures could render otherwise susceptible cultures resistant, hence the term resistance-inducing-factor. It was only later that he discovered that his RIF was, in actuality, ALV. ALV is spread vertically by nonlethal infection of chicken embryos derived from infected hens. This new test opened the door to research on lymphoid leukosis. Previous methods to detect ALV required that chickens be held for months after inoculation to determine if tumors would develop. At that time, researchers (at least those in the United States) did not distinguish between lymphoid leukosis and Marek's disease, lumping them together under the heading "avian leukosis complex."

With this background, Calnek enthusiastically undertook a research program with funding from an NIH grant awarded for "Studies on the Avian Leukosis Complex." First, were studies

on the RIF test itself, determining some of the important parameters of the procedure. Dr. Robert Giordano, Dr. Calnek's first graduate student, tested other cytopathogenic viruses to see if they could substitute for RSV (they could not).

Calnek then developed a simplified test using RSV to detect antibodies against the related avian leukosis virus. Dr. Richard Witter, another graduate student, undertook a PhD project in which he examined the influence of ALV maternal antibodies on the development of lymphoid leukosis in chickens. Interestingly, a group of uninfected controls for that experiment developed tumors that were not related to infection with avian leukosis virus. This helped convince us, and other American workers, that the Europeans were correct when they distinguished between "lymphoid leukosis" and "Marek's disease."



Dr. Richard Witter *ca.* 1960

Other studies by Calnek on lymphoid leukosis and Rous sarcomas included a description of lesions in young chickens that were induced by by ALV, and the discovery of morphological alterations in RIF-infected chicken embryo fibroblasts. Also a survey of commercial chicken breeder flocks was conducted to determine the extent of genetic resistance to ALV and the incidence of embryo infection with two subgroups of the virus. Finally, the regression of RSV tumors was found to vary greatly in different genetic strains of chickens but the regression rates did not correlate with genetic susceptibility or resistance to Marek's disease.

The need to eradicate ALV from commercial stocks became clear in the 1980's but this proved to be difficult in some of the genetic lines of the Babcock group, a major poultry breeding group located near Ithaca. Drs. Calnek and Schat developed a method using inoculation of whole blood onto C/E CEF cells (resistant to only endogenous ALV) to detect the few remaining positive hens. Eggs from these birds were removed from the incubator before the next generation was hatched. This approach was highly successful and allowed the Babcock stock to become completely free of ALV. The same approach was later also used successfully by Hy-Line, a poultry breeder located in the midwest.

After these projects were completed, attention was turned almost exclusively to the study of Marek's disease since this was clearly the most important of the leukotic diseases of chickens.

Marek's disease

Many MDV isolates were studied in comparisons of virulence and oncogenicity, pathogenesis, immunosuppression, immunogenicity, and molecular makeup. Topics in this subject included studies on the localization of infection, the sequential events from the point of infection to the induction of tumors, identification and characterization of significant variables (age, genetic constitution, route of exposure, virus strain, immune responses including vaccinal immunity, *etc.*) that influence those sequential events, and the development of models such as *in vitro* infection of lymphocytes and cell line development.

We developed methods for production and lyophilization of cell-free turkey herpesvirus (HVT) vaccine. Also, we isolated and characterized the nononcogenic, serotype-2, SB-1 viral strain and carried out laboratory and field testing of this virus as a component of a bivalent vaccine. The experimental reproduction and characterization of MDV herpesvirus-induced atherosclerosis using a low-virulence MD virus (CU2) and genetically susceptible chickens was an independent but related study. And finally, molecular studies were conducted in an effort to determine characteristics associated with oncogenicity and pathogenicity.

One of the earliest projects addressed the need to store MDV-infected cells because the virus is so highly cell-associated. Intact viable tumor or blood cells were required transmit infection. Dr. Lloyd Spencer, for his MS degree project, established methods for storing live, infected cells in liquid nitrogen tanks.

Later, in his PhD project, Dr. Spencer developed fluorescent antibody reagents and techniques for detecting MDV-infected cells and tissues. Drs. Calnek and Hitchner then carried out virus localization studies that laid much of the groundwork for understanding the pathogenesis of the disease. Very importantly, they identified the feather follicle epithelium (FFE) as a prominent target of infection. Further work showed this site to be the source of fully infectious cell-free virus which could contaminate the environment. This novel finding was the solution to the enigma of how this highly cell-associated virus could spread so readily from bird to bird whereas attempts to transmit the virus experimentally required the use of viable blood or tumor cells. It helped put Cornell's program on the map. By inducing MD tumors through the use of cell-free virus inocula, we provided the first definitive proof that a herpesvirus could, indeed, be oncogenic. Those who considered certain human herpesviruses to be oncogenic, but for obvious reasons could not test this thesis, were delighted!

The finding of infectious cell-free virus from the skin led to a secondary finding of importance. Calnek and Hitchner developed a technique for

Drs. Hitchner and Calnek with a batch of lyophilized HVT vaccine

the extraction and lyophilization of cell-free virus from cell cultures infected with a nononcogenic turkey herpesvirus (HVT). This virus had been isolated from apparently healthy turkeys by Dr. Witter after he left Cornell. It found world-wide use as a vaccine against MD. Liquid nitrogen storage of whole cells infected with HVT was commonly used in the United States for distribution of the vaccine to hatcheries where it was injected into day-old chicks. Cornell's method of extraction and lyophilization of cell-free HVT was patented but found limited application in the US because the liquid nitrogen storage and delivery system was in place. However, it was found to be particularly useful in countries where liquid nitrogen was less available. The patent yielded royalties to Cornell, a large portion of which could be applied to our Marek's disease studies.

Another highly significant milestone was the isolation, characterization, and application as a vaccine, of the SB-1 strain of MDV. When Dr. Ton Schat began his graduate studies in the mid

1970s, he followed up on Dr. Maurice Smith's work. Dr. Smith had isolated and studied low-virulence MDV strains which he compared to more highly oncogenic strains isolated by others. In the course of seeking additional strains of low virulence, Dr. Schat isolated a virus from S-strain chickens maintained by Dr. Randall Cole in the College of Agriculture at Cornell. These birds were highly susceptible to MD, but had reached maturity without experiencing any losses from the disease, a highly unusual event. Dr. Schat isolated a virus which he named SB (S for the strain of chickens and B for their location, the B House on the poultry farm). The first clone was therefore named SB-1. It was antigenically related to oncogenic strains of MDV (serotype 1 MDVs) but was clearly different from them, and ultimately it was classified as a serotype-2 virus. Calnek had already developed methods to enhance oncogenic responses to Smith's low-virulence serotype-1 strains (CU-1 and CU-2) through the use of immunosuppressed chicks and *in ovo* inoculation. When these methods were applied to SB-1, there were no tumors at all. This suggested the potential value of the virus as a vaccine against the oncogenic strains of MDV, much as the nononcogenic serotype-3 HVT was found to be protective. Indeed, SB-1 worked as anticipated and the strain was patented by Schat and Calnek. Because HVT was working well at the time, SB-1 sat on the shelf for about five years. Then, it was discovered that it worked synergistically in conjunction with HVT as a bivalent vaccine useful against the more virulent field strains of MDV that were appearing. These "hotter" strains were not well protected against by HVT alone.

We ran a field experiment with SB-1, with approval from New York State, to test the efficacy of the bivalent SB-1 plus HVT vaccine. The tests were done on a commercial farm that was having disastrous losses due to the presence of a very highly virulent strain of MDV. The result was a resounding success. SB-1 ultimately became widely used throughout the world in multivalent vaccines. Royalties from this patent added significantly to the funds available for additional MD research, and ultimately they supported students in avian medicine through assistantships.

It had been reported that MD tumor cells were of thymic origin, *i.e.*, they were T cells, based in large part on the characterization of a couple of cell lines derived from MD tumors. Unfortunately, the development of cell lines was difficult and attempts generally failed, even by those who reported the first lines. Calnek approached the problem differently by first establishing transplantable MD tumors and then using those as starting material. The effort was successful and provided several new cell lines for study. Improvements in the culture medium, by others, coupled with improved cell culture techniques, subsequently led to the establishment of many MD tumor cell lines at Cornell and elsewhere. We were able to characterize many of these as CD4+ T lymphoblasts, although one line was CD8+.

In addition to the aforementioned graduate students (Smith, Schat, Spencer) who worked on MD projects, several students contributed further studies on immunologic, pathologic and viral aspects of the disease. A number of these ultimately helped in the development of a pathogenesis model. Their contributions included *in vitro* cytotoxicity tests, studies of herpesvirus genome expression, cell surface antigen characterization, cytotoxic *versus* helper activity, molecular studies on genome transcription, and studies of chromosomal aberrations. Graduate students who participated in studies that contributed to our understanding of various aspects of MD included Drs. Hans Adldinger (early pathogenesis), W. W. Fernando (influence of the bursa of Fabricius on infection), David Higgins (relationship of fowl immunoglobulins to genetic resistance), Kenneth McColl (cellular and molecular studies on transformed cells), K. Murthy (immunization against MD with viral antigens and MATSA, a putative tumor antigen), William Pratt (cell-mediated immune responses), Kazuhiko Ohashi (characterization of virus specific transcripts in a MD cell line), Rahman Omar (cytotoxic T cell

responses against MDV), Ariel Rivas (immunodepression with strains of MDV), William Shek (characterization of lymphocytes infected with MDV), Lucy Volpini, Celina Buscaglia, and Daniel Weinstock (all with studies related cytokine control and modulation of MDV genome expression). Dr. Z. Xing worked on the role of cytokines and nitric oxide in Marek's disease.

Dr. Stephen Bloom, a geneticist who transferred into the department from the College of Agriculture, had earlier found a consistent chromosomal aberration in cell lines transformed with Marek's disease herpesvirus, providing evidence of genomic DNA amplification. Further studies on MD cell lines by his graduate student, Franklin Moore, showed that this aberration was not found in other cell lines.

Ultimately, we learned how to infect lymphocytes *in vitro* and at least one such infection resulted in a continuous cell line, although only after results from the infection study were published.

In addition to lymphoblastoid cell lines established from tumors, a totally new approach was developed by Calnek as the result of a "spin-off" from pathogenesis studies. This came about when alloantigens and MD virus were injected intramuscularly at the same site in young chickens to study the possibility of inducing local tumors. The approach was based on our findings (see later) that activation of T-lymphocytes is an important step in the pathogenesis of the disease. The use of alloantigens was expected to stimulate T-cell activation at the site of inoculation. The method worked and tumors did develop at the inoculation sites, but a surprising finding was that cells taken from the inoculation site as early as four days post inoculation could be used to establish continuous lymphoblastoid cell lines following *in vitro* cultivation. Unlike lines from MD tumors, which were almost all of the CD4+ phenotype, cell lines from "local lesions" were found to be of a variety of phenotypes (including many CD8+). Thus they gave us further insight into the pathogenesis of the disease, showing that it is the type of T cell present at the site of an active virus infection that determines the phenotype of the tumor cells. Interestingly, some of the CD8+ cell lines were exceptionally susceptible to the chicken infectious anemia virus (CIAV) and one of these, CU-147, was patented by Calnek and others and has found application in the growth and titration of CIAV vaccine virus.

A novel finding by Dr. Celina Buscaglia, a graduate student working with Dr. Calnek, identified factors involved in the maintenance of latency in Marek's disease. Initially, a soluble factor was discovered which was named "latency maintaining factor." Later work by another student of Calnek's, Dr. Lucy Volpini, implicated interferon as important. For obvious reasons, latency is a pre-requisite to transformation given the dogma stating that replication of a herpesvirus in a cell results in the death of that cell. Thus, factors that are involved in both the induction and maintenance of latency are of critical importance in MD tumor pathogenesis.

Immunological studies included characterization of: humoral and cell-mediated immune responses; the effects of maternal antibodies, interferon and vaccinal immunity on the disease; immunoglobulins; lymphocyte responses; immune deficiencies; natural killer cell activity; induction and maintenance of latency; and immunocompetence *versus* latency.

Immunity studies by several members of the research team centered first on the development and effects of humoral antibody responses and later on the role of macrophages, cell-mediated immunity (CMI), natural killer (NK) cells, *etc*. We were particularly interested in how each of these interacted in both the pathogenesis of the disease and the control of infection. The role of passive antibodies gained by chicks through the egg was investigated and found to be of limited value in preventing the disease, no doubt because they could not prevent infection from occurring. Also, they did not restrain cell-to-cell

spread of virus in chicks that had been infected from a contaminated environment or infected pen mates.

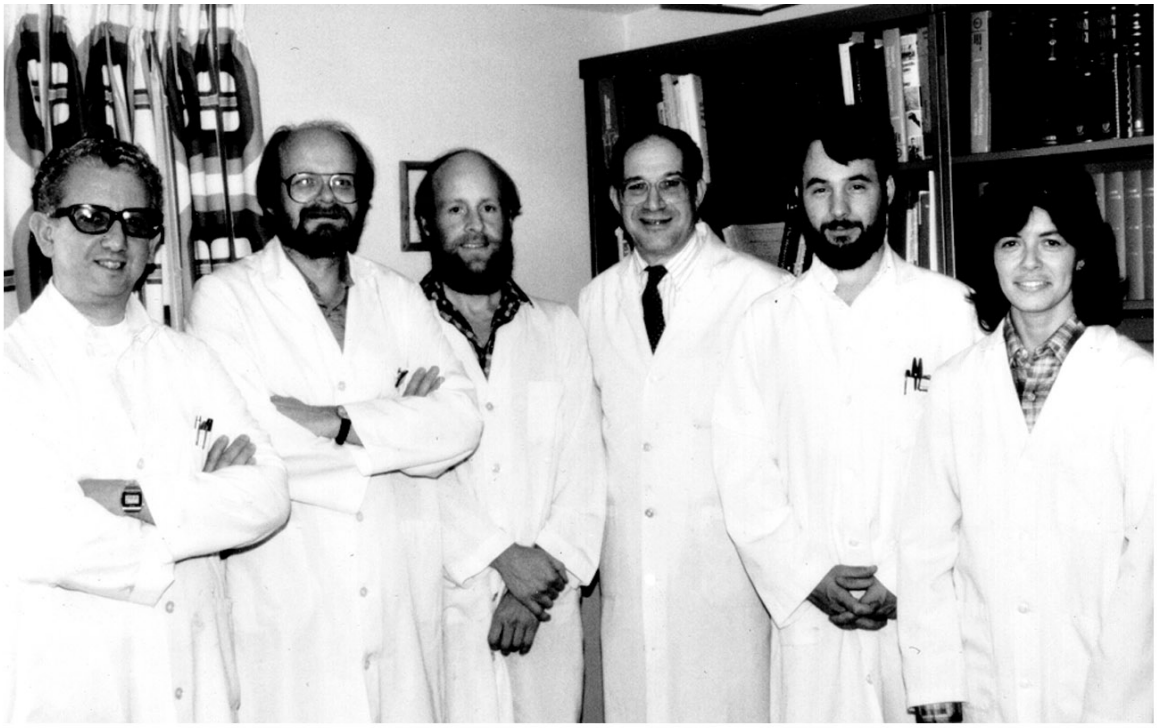
Cell-mediated immune responses and especially cytotoxic T lymphocyte (CTL) responses also received attention. Once MD cell lines with defined MHC antigens were developed by the Cornell group it became clear that CTL responses to tumor cells were mostly directed to alloantigens raising important questions concerning the importance of these responses for protective immunity. Subsequently an approach was developed in which reticuloendotheliosis virus-transformed lymphocyte cell lines with known MHC antigens were stably transfected with individual MDV genes. Using this approach it was learned that syngeneic CTL responses were generated to specific MDV proteins such as glycoprotein B (gB), some other glycoproteins, and ICP4 in the resistant N2a line but not in the susceptible P2a line. This observation was important because it is likely to be a part of the explanation for the MHC-defined genetic resistance of the N2a chickens. The effector cells were characterized as CD8+ CTL. In addition, it was shown that NK cells, nitric oxide, several proinflammatory cytokines and interferons are activated during the early stages of infection.

Because both resistant and susceptible strains of chickens had similar early stages of active infection, but only the susceptible-strain chickens developed a second wave of active infection, it could be deduced that the latter sustained more severe damage to their immune systems. Indeed, as mentioned above, we found that immunocompetence is required for the maintenance of latency. The effect of immunization of chicks with MD vaccines such as turkey herpesvirus or SB-1 was investigated in terms of effect on the pathogenesis of infection and the prevention of immunosuppression following MDV challenge.

The centerpiece of nearly 20 years of study was the development of what became known as the "Cornell Model" for the pathogenesis of Marek's disease. The aim of much of our work was to determine the sequential events and the influential factors that characterized the response to infection with MDV. This involved establishing specific-pathogen-free (SPF) flocks of chickens of different genetic susceptibility to MD (see above), the isolation, purification and characterization of strains of MDV with varying oncogenic potential, the development of *in vitro* and *in vivo* techniques for studying the viruses and the pathological and immunological responses of experimentally infected birds, and the integration of results from all of the above to provide a believable hypothesis of the pathogenesis of this tumorigenic herpesvirus.

SPF flocks of genetically susceptible (S-strain and P-line) and resistant (N-line) chickens (see the section on SPF flocks) were indispensable. Drs. Hutt and Cole had worked for a number of years on the genetic control of susceptibility to neurolymphomatosis (MD) and the S-strain was the result of intensive selection for a high incidence of the disease. Later, Cole used MDV inoculation-challenge of progeny from a random-bred flock of chickens as a means to select both resistant (N-line) and susceptible (P-line) sublines in the matter of a very few generations. These strains, along with our departmental SPF flock called PDRC (which was moderately resistant to MD), were employed for most or our research.

Certain virus strains were obtained from other laboratories for our early studies. Dr. Martin Sevoian, from the University of Massachusetts, provided his JM strain of virus, and the more virulent GA strain was obtained from Drs. Eidson and Schmittle at the University of Georgia. We clone-purified these strains in cell culture and called them JM-10 and GA-5, respectively. The low-virulence virus, isolated by Dr. Maurice Smith from our departmental PDR flock yielded two clones, identified as CU-1 and CU-2. Soon thereafter, Dr. Ton Schat, as part of his PhD studies, isolated and clone-purified the nononcogenic strain of MDV which he called SB-1. Several years later, when some field strains of MDV were overriding



Faculty and graduate students 1987
from left: Drs. Lucio, Schat, Kenneth McColl*, Calnek, Daniel Weinstock*, Celina Buscaglia*
* = graduate students with projects on Marek's disease

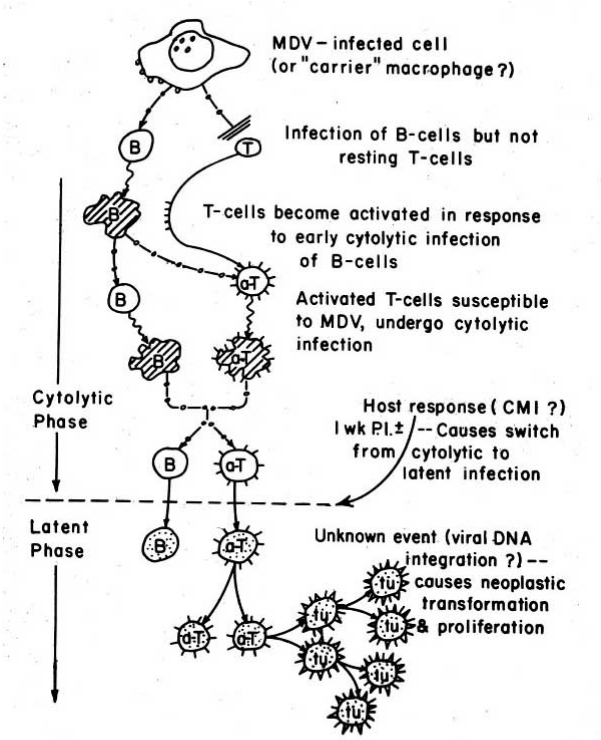
vaccinal immunity in commercial flocks, Dr. Schat isolated and characterized a very highly virulent virus from a New York State commercial breeding flock maintained by Robert Ball. A clone of this strain, called RB1B, provided a powerful tool for comparing the responses of chickens based on virus virulence, and it also was used world-wide as a standard challenge strain for assessing the efficacy of various MD vaccines.

A third tool that contributed to our studies on pathogenesis was related to the ability to control immune competence. Embryonal bursectomy and neonatal thymectomy plus cyclophosphamide treatment were employed to delete humoral and cell-mediated immunity, respectively, and thus helped us to determine the effect of these two arms of the immune system on pathogenesis. This approach was complemented by experiments to determine the effects of maternally derived antibodies, infection during embryonic development (before immune responses are possible) and post-hatch infection at different ages given the age relationship of immune competence. The importance of natural killer cells in altering the outcome of infection was yet another area of study. Although several of these approaches were not unique to our Cornell research efforts, they did contribute significantly to the understanding of immunity in Marek's disease.

Tracking infection in various tissues using Dr. Spencer's immunofluorescence tests was essential to the development of hypotheses regarding the sequential pattern of infection which could be correlated with immune responses and pathological changes, particularly in comparisons of genetic strains, virus strains, age factors, immune competence, *etc*. Dr. Hans Adldinger, another graduate student, made the very significant observation that cytolytic infection with MDV is biphasic in nature with an early involvement of lymphoid organs. Dr. William Shek then identified B cells as the initial target for the virus as part of his PhD program. Studies on cell lines demonstrated that tumor cells were activated T cells. Subsequent experiments by Calnek taught us that T cells, the cell type that is transformable by MDV, are

susceptible to infection only after they become activated in response to the lytic infection of B cells. Identification of target cells for productive infection, latency and transformation was aided by the use of monoclonal antibodies.

When all of the pieces were put together, we came up with the following scheme: MDV infection occurs by inhalation of infectious virus from an environment contaminated with desquamated cells from the feather follicle epithelium of infected chickens. Virus is carried (perhaps by macrophages) to lymphoid organs including the bursa of Fabricius, the thymus and the spleen. Bursa-derived lymphocytes (B cells) in those organs become infected, replicate virus, and undergo cytolysis. The cytolytic infection of B cells causes an intense inflammatory response. This in turn stimulates both humoral and cell-mediated immune responses and spreads infection to other susceptible cells including those of epithelial origin as found in the kidney, adrenal gland, feather follicles, proventriculus, *etc*. The epithelial tissues also develop a cytolytic infection. A cell-mediated immune response to the cytolytic infection results in the activation of T cells which, unlike resting T cells, are susceptible to infection which they acquire by association with cytolytically infected cells. Some of these T cells also replicate virus and die as the result. Immune responses cause a switch from cytolytic infection to latent infection after about 7-8 days and this is particularly important for infected T cells. CD4+ (helper) T cells are the most abundant phenotype at lesion sites because they are the early responders to the cytolytic infection; thus they are the predominant phenotype when latency develops. Occasionally, a latently infected T cell undergoes neoplastic transformation and proliferates to produce a tumor, often at the site where it became infected such as the kidney, proventriculus, skin, *etc*. Thus, MD lesions can be inflammatory, neoplastic, or a mixture of the two. This model of pathogenesis, which was largely established by the mid 1980s, has stood the test of time and has been accepted by other researchers in the field of Marek's disease.



Schematic representation of hypothesized sequential events leading to tumor development in MD virus-infected chickens. Cell designations: B = bursa-derived lymphocyte (B-cell); T = thymus-derived lymphocyte (T-cell); a-T = activated T-cell; tu = tumor cell (transformed T-lymphoblast). Misshapen cells with cross-hatch represent cytolytic infection. Internal stipling represents noncytolytic infection, i.e., latency for B- or a-T-cells, transformation for tu-cells.

From: Calnek, Marek's Disease-
A Model for Herpesvirus Oncology
in CRC Critical Reviews
in Microbiology 12:293, 1986

Molecular studies focused on the role of different virus genes and interactions with the innate immune responses. Early studies by Dr. Schat during his sabbatical year at the Houghton Poultry Research Station in England led to one of the first transcription maps for MDV. Subsequent studies with his graduate students, post docs and visiting scientists identified MDV genes expressed in tumor cells and genes important for the cytolytic infection cycle. The use of bacterial artificial chromosomes (BAC) containing the complete genome of RB-1B led to the finding that deletion of the RLORF4 gene causes attenuation of MDV by reducing the

cytolytic infection. Infection of resistant N2a and susceptible P2a chickens with the very highly virulent RK-1 strain of MDV led to the discovery that the N2a birds had a significantly higher production of proinflammatory cytokines and nitric oxide in the brain than did P2a chickens. The consequence of these high levels of cytokines was the development of early neural lesions in the resistant birds, suggesting that a very strong immune response may not be as beneficial when nonvaccinated chickens become infected with very highly virulent strains of MDV.

Tumors of unknown etiology

Another area of research, carried out by Drs. Fabricant and Calnek, concerned the development of tumors in old birds. The stimulus for this work came from the fact that although our SPF flocks remained tumor-free until the end of their first laying cycle, they had never been held for longer periods.

At the time there were four strains (P-line, N-line, S-strain, and PDRC) of SPF chickens available as flocks maintained on the departmental research farm. Three of these had been selected for susceptibility (P-line, S-strain) or resistance (N-line) to Marek's disease and were used primarily for research programs on this disease. They were free of known oncogenic viruses (MDV, avian leukosis, reticuloendotheliosis) and all other pathogenic viruses and bacteria recognized at that time. At 19 months of age (no tumors observed up to this time) groups of approximately 100 hens of each of the four strains were placed in a house with pens separated only by wire partitions. All dead birds and all of those surviving until 31 months of age were necropsied. There was an astonishing difference in tumor incidence between the four groups. Birds in one group had no tumors. Two groups had a 14 or 20% incidence of adenocarcinomas of the oviduct which resulted in abdominal carcinomatosis. The fourth group had no malignant tumors but did evidence a 50% incidence of leiomyoma of the salpinx. These tumor incidences did not correlate either with the Marek's disease resistance of the genetic strains or with their overall livability patterns. A repeat experiment with two of the strains the next year gave almost identical results, one group free of tumors and the other with a 17% incidence of abdominal carcinomatosis. Representative tumors were used to initiate cell cultures which were tested for the presence of known tumor viruses. All tests were negative.

Atherosclerosis

Catherine Fabricant was a member of the Department of Microbiology and Immunology, but she interacted with the Department of Avian and Aquatic Animal Medicine when she carried out some exceptionally important work on atherosclerosis in chickens. Her interest in atherosclerosis was initiated by an observation from her work on a feline herpesvirus thought to be involved in urolithiasis. Cell cultures infected with this virus were found to contain crystals subsequently identified as cholesterol. This was interesting in its own right, but it became even more so in light of a report by Canadian workers that atherosclerosis in chickens appeared to be more common in those that also had lymphomatosis, *i.e.*, Marek's disease, for which a herpesvirus is the etiology. After a thorough literature search and advice and encouragement from some other research workers, she carefully constructed experiments to test the hypothesis that a herpesvirus could cause atherosclerotic lesions. She prepared an NIH grant proposal and enlisted some aides. Julius Fabricant furnished some of expertise for working with Marek's disease virus and Dr. Richard Minick, a professor of pathology at Cornell's Medical College in New York City, served to authenticate the similarity of the lesions produced to those seen in human atherosclerosis.

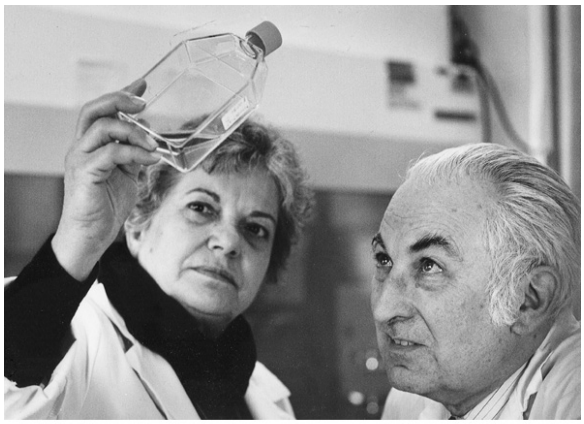
For her experiments she chose to use a chicken strain that had been bred for high susceptibility to MD, the P-line developed by Dr. Cole in the College of Agriculture at Cornell. This strain was so susceptible to MD that infected chickens

would generally succumb to the disease long before there would be an opportunity for atherosclerotic lesions to develop. So, to address this problem, she selected the CU2 strain of MDV that had been isolated and characterized by Maurice Smith and Bruce Calnek as part of their studies on MDV virulence. That virus induced only a low incidence of tumors in susceptible chickens and virtually none in more resistant strains.

Because of the general belief that high blood cholesterol levels could be involved in the development of atherosclerosis, she divided the groups of infected and noninfected chickens into two subgroups, with and without supplemental cholesterol in their diets. The results of her experiments were an unqualified success, proving that Marek's disease virus was able to produce atherosclerotic lesions in the coronary arteries, aorta and large abdominal arteries. These lesions, grossly and microscopically, were essentially identical to the lesions of human atherosclerosis. High cholesterol levels alone were without effect, but MDV infection, with or without a high cholesterol intake, caused gross and microscopic lesions remarkably similar to those seen in the human disease. Thus, viral infection could produce these lesions in chickens with normal levels of cholesterol in the blood.

Later, with the collaboration of Dr. David Hajjar at the Cornell Medical School, it was found in both birds and tissue cultures that infected arterial smooth muscle cells produced more cholesterol and cholesteryl esters and excreted less of these products than was seen in uninfected tissues and cell cultures. This resulted in an accumulation of lipids and deterioration in these cells, and suggested that virus-transformed cells and the lipid could be produced *in situ* and was not dependent on lipid absorption through the intima as the current dogma insists.

The work in chickens has been confirmed by others and it has attracted a good deal of attention among groups who are involved in studies of the disease in humans. It appears probable that there are some human herpesviruses that could constitute at least part of the



Catherine and Julius Fabricant
circa 1988

etiology of the human disease. This study is a good example of the enormous value of having specific-pathogen-free chickens of defined genetic character, clone-purified virus strains of known pathogenic potential, and secure isolation facilities to prevent adventitious exposure to other agents.

Miscellaneous Viral Diseases

Chicken infectious anemia

Chicken infectious anemia (CIA) and the causative virus (CIAV) were the subject of a number of studies at Cornell beginning about 1990 when Drs. Lucio, Schat and Shivaprasad isolated a strain of the virus, reproduced the disease, and did a serological survey of its incidence in the United States. This virus is extremely widespread and, because of its very hardy nature, it is extremely difficult to eradicate from contaminated premises. It is associated with an aplastic anemia-hemorrhagic syndrome and atrophy of lymphoid organs. The resultant immunosuppression, in turn, causes an exacerbation of many other disease syndromes.

Soon after the virus was isolated, a graduate student (Liangbiao Hu) working with Drs. Lucio and Schat found that embryonal bursectomy

abrogated age-related resistance to the virus. This was an important discovery because others had suggested that the age-related resistance was based in thymus maturation with only the first waves of thymocytes being susceptible to infection. They also described the depletion of T-cell subpopulations by the virus. The latter is of special significance regarding the immunosuppression associated with CIAV infection. It was subsequently shown by another graduate student (Carrie Markowski-Grimsrud) that cytotoxic T lymphocyte responses to reticuloendotheliosis virus were strongly impaired by CIAV. Detection techniques for CIAV are extremely important to ensure that vaccines are free of this pathogen. Monoclonal antibodies to viral protein 3 of CIAV and a nested PCR assay were developed along with a quantitative (q)PCR and qRT-PCR assay which can differentiate between two different strains of CIAV. This allowed a study of protection by experimental vaccines against superinfection with a second strain. One of the many puzzling aspects of CIAV was the apparent inability to isolate certain strains of CIAV in the departmental subline of the MD cell line, MSB-1 which had been the standard *in vitro* substrate for growing CIAV. Randy Renshaw, a postdoctoral associate in Dr. Schat's lab, generated a number of chimeras using the CIAV isolate Cux-1 (which replicates in MSB-1) and CIA-1 (which does not replicate in the MSB-1 cells). He showed that a small highly variable region in viral protein 1 was responsible for the difference in infecting MSB-1 cells. Later work by Calnek's group found that several CD8+ MD cell lines were especially susceptible to CIAV, including the CIA-1 strain. Moreover, all CIAV strains tested replicated to much higher titers in several of these lines than in any of the MD-derived CD4+ cell lines. This has recently been confirmed by other groups. As a consequence, one of the lines, CU147, has been patented and is currently used by some commercial groups to test inactivation processes for the related human TT viruses.

Commercial and research SPF flocks often experience problems with CIAV infection based on seroconversion during the laying period. Drs. Carol Cardona (a postdoctoral associate) and Schat examined this problem in some detail when our SPF flocks broke with CIAV. It was found that CIAV DNA could be detected in gonadal tissues of both sexes by nested PCR independent of the presence of antibodies, suggesting the presence of latent virus in these tissues. Interestingly, sero-conversion in the SPF flocks occurred mostly after sexual maturity. By 60 weeks, 100% of the P2a and N2a birds were positive but that was not true for the S13 strain. Continued monitoring the N2a and P2a closed flocks for seroconversion during an eight-year period showed that there are flocks that remain essentially antibody-negative even though a previous flock may have had a 50-60% seroconversion rate.

Dr. Myrna Miller, a graduate student with Dr. Schat, studied possible mechanisms explaining Dr. Cardona's observations. It was learned that CIAV DNA can be transferred through the embryo without causing clinical infection after hatch. Viral DNA was detected by nested PCR in the blastoderm at day 0 of incubation and later in different organs, and virus transcripts were found about the time of gonadal development between 4 and 6 days of incubation and later. It was also learned that hens produced CIAV-positive embryos intermittently, thus making eradication possible by testing egg-shell membranes of embryos for viral DNA. Dr. Miller also found that there are hormone-response elements that control messenger RNA transcription. Estrogen enhances the expression while COUP-TF1 represses the transcription. A second repressor was found at the transcription initiation site. These findings led us to the following model for the maintenance of latent viral DNA and limited horizontal transmission: 1) viral DNA can be present as double-stranded episomal DNA in gonadal cells and be transferred to the blastoderm; 2) low-level viral DNA occurs during gonadal development when estrogen is actually produced leading to spread into the different organs as latent DNA; 3) virus remains latent until sexual maturity when estrogen production leads to viral replication and

viral antigen production causing seroconversion but only limited potential for horizontal spread. Dr. Cardona had earlier shown that there is limited horizontal spread if a positive bird is kept in a cage surrounded by negative birds in other cages.

Rotavirus infection

Rotaviruses became of interest in the 1980s when the first reports on rotavirus infections in chickens and turkeys were published by other groups. It was also the time that our flocks were to be moved into new high-security SPF housing. The flocks were found to be free of this agent and this allowed studies on the pathogenesis of rotavirus infection. Support was provided by a USDA grant. Several rotavirus isolates were obtained from turkey and chicken flocks and used to infect one-day-old chickens and turkeys. Dr. Schat's graduate student, Dr. Carmencita Yason, undertook a project with rotavirus and, surprisingly, she found that turkeys became infected but chickens kept in the same isolation room and given the same inoculum did not. Because infection in 6-week-old chickens was known to result in seroconversion, an experiment was designed to examine the age susceptibility in adult SPF chickens, broiler chickens, and turkeys. Whereas rotavirus infection in mammals causes disease of young animals, it was found that the older the birds were, the more severe the disease became, especially in turkeys, which developed bloody diarrhea. Apparently, the epithelial cells of the intestinal villi are not susceptible in young chickens but become susceptible in older birds. The most likely explanation is that the putative receptor for rotavirus is not expressed (or fully expressed) in less mature epithelial cells. Dr. T.J Myers, another graduate student, studied the potential importance of immunossuppression for rotavirus infection in 6-week-old birds. Intact and embryonally bursectomized chickens lacking antibody responses to two antigens (BSA and SRBC) were infected with rotavirus and examined for virus replication. The bursectomized chickens failed to produce anti-rotavirus IgM, IgY and IgA but had only a minimal delay in virus clearance compared to the intact hatchmates, suggesting that antibody responses, especially IgA, were not the main mechanism involved in virus clearance. Subsequenly, Dr. Myers demonstrated that natural killer cells were able to recognize rotavirus infected chick kidney cells, indicating that these cells may be important in rotavirus clearance in chickens.

Drs. "Ton" Schat and
T. J. Myers 1987

Adenoviruses

Adenoviruses were the subject of several studies at Cornell. One of the first projects was aimed at classification of a number of serotypes that had been isolated elsewhere (many by Patricia Taylor, Dr. Calnek's graduate assistant when he was at UMass). Calnek was joined by Dr. Barrett Cowen in this project and Dr. Cowen then undertook a series of additional experiments and field studies that examined the broad antigenicity of some strains, characterized the effect of adenovirus infections on egg production, shell quality and feed consumption, and surveyed the incidence of infection in growing and laying flocks of chickens.

One of the problems in working with avian adenoviruses is the fact that most cultures are contaminated with a small so-called adeno-associated-virus (AAV). This virus depends on the replication of an adenovirus for its own

replication. When we wanted to determine serological cross reactivity of avian adenovirus serotypes in an enzyme-linked immunosorbent assay, it was necessary to work with AAV-free stocks of virus. With help from two visiting scientists, Nestor Menendez from Argentina, and Peter Stiube from Romania, all adenovirus stocks were "cleaned" up by treating individual serotypes with antiserum from a different serotype which had antibodies against AAV as well as the virus against which it had been prepared.

The other adenovirus work that was done by Dr. Calnek involved the isolation of a duck adenovirus (named K11) from fecal samples supplied by the Duck Research Laboratory. This hemagglutinating adenovirus was shown to be related to Adenovirus 127, the prototype virus that causes the so-called "egg-drop syndrome" in chickens. The K11 strain was the first such isolate in the United States and was subsequently supplied to other investigators who wished to work on that disease (importation of Virus 127 into this country was not permitted).

Infectious bursal disease

Infectious bursal disease (IBD) is important because it can cause clinical disease and mortality in chicks infected when they are more than 3 weeks of age, and it can induce a severe and prolonged immunosuppression when they are infected while very young. The latter makes them more susceptible to a variety of other infections and thus it is a very serious cause of economic loss in the poultry industry. Various features of IBD, particularly those related to immunity, immunization, and host responses were the subject of a number of studies, mostly by Drs. Hitchner and Lucio. Hitchner carried out experiments on the immunization of adult hens, with the aim of providing maternal antibodies to protect chicks for the first few weeks. He also studied the persistence of maternal antibodies and their effect on the susceptibility of young chickens. This was shown by Drs. Lucio and Hitchner to be an important factor related to the incidence of disease in exposed chicks and also to the ability to immunize chicks at a young age. An interesting finding by Drs. Lucio and Ronald Schultz (Department of Microbiology) was that feeding chicks colostrum from cows that had been immunized against IBD virus protected them against the disease, although this was never put to practical use.

Immunity studies included work comparing the response of susceptible *versus* immune chicks to killed, live-modified, and wild infectious bursal disease virus vaccines. When Dr. Joram Weisman was a visiting scientist from Israel, he worked with Dr. Hitchner comparing virus-neutralization and agar-gel precipitin tests for detecting serological responses to infectious bursal disease virus. They also attempted to infect Coturnix quail and turkeys with IBD virus. Turkeys became infected but only subclinically, with no damage to the bursa of Fabricius. The quail were refractory to infection.

A particularly important study by Drs. Lucio and Hitchner dealt with the use of emulsified IBD vaccines. They showed that such vaccines markedly improve neutralizing-antibody levels in the dam which, in turn, improves the protection of the progeny. This approach was found to be very beneficial and has been adopted by the poultry breeding industry not only with IBD killed vaccines but others as well.

The pathogenesis of IBD in chicks that were embryonally bursectomized (and thus lacked the primary target organ for infection) was the subject of experiments conducted by Drs. Schat, Lucio and Carlisle. Immunofluorescence tests showed that thymocytes were positive for antigen. However, when we learned about the existence of CIAV, Dr. Lucio reexamined this issue and the most likely explanation for the positive staining of thymocytes was that the IBDV strain used in the earlier study was contaminated with CIAV. Thus, the antiserum produced against it and used in the fluorescent antibody test also contained CIAV antibodies.

Part II

Other Programs

The Farmingdale Laboratory

Beginning in the mid 1920s, personnel in the Department of Pathology and Bacteriology staffed a laboratory at Farmingdale, Long Island. The lab was established by the College in cooperation with the New York State Institute of Applied Agriculture to provide diagnostic service, assist with eradication and vaccination programs, and conduct research on existing and newly discovered diseases of chickens, turkeys, ducks and assorted other avian species. Also, as was occurring in Ithaca, a special school was conducted at Farmingdale in the effort to engage practicing veterinarians in the field of poultry diseases. The program was headed by Dr. John M. Hendrickson who, as noted above, had been pleading for more involvement of the general veterinary profession. Beginning in 1926, separate diagnostic reports on poultry diseases at Ithaca (prepared by E. L. Brunett and W. E. Brandner) and Farmingdale, (prepared by Hendrickson and H. M. DeVolt) were recorded in the annual report. The two laboratories examined 2,329 and 1,535 specimens, respectively. Hendrickson, who started out as an Assistant in Poultry Diseases, was promoted to Instructor in 1926 and to Assistant Professor in 1927. He was in charge of the Farmingdale laboratory until 1931.

In 1928, Dr. Kenneth F. Hilbert joined the faculty as an Instructor to assist Hendrickson. It is not clear regarding his status after Hendrickson left in 1931, but in 1945, he was promoted to Assistant Professor and given the title of Director of the Laboratory. He retained this position until his retirement in 1963 when the laboratory was closed. All poultry diagnostic work on Long Island was then conducted by Dr. Louis Leibovitz, who replaced Dr. Hilbert but was located at the Duck Research Laboratory in Eastport. Various short-term appointments (one or two years) with the title of Research Instructor were made at the Farmingdale laboratory between 1927 and 1947, apparently to assist Hilbert with the diagnostic work and testing/eradication programs. These included Arthur Trayford, Hendrick Versluis, Herman Tax, M. B. Spiegel, A. S. Charles, John C. Stevenson, and David E. Laurence.

Beginning in the late 1920's, a test project for the eradication of bacillary white diarrhea constituted a major activity at both Ithaca and Farmingdale, largely because there was a lack of experimental data on which to evaluate the usefulness of testing programs. Testing for carriers was done by, or supervised by, the two laboratories and totaled nearly 29,000 birds in 1926 and nearly 36,000 birds in 1927.

Dr. Kenneth Hilbert

Research projects carried out at the Farmingdale facility covered a variety of subjects. The first published report, by Hendrickson and Hilbert in 1931, was related to the persistence of *Pasteurella avicida* in fowl with spontaneous fowl cholera. Perhaps the most important publication from Farmingdale was a paper published by the same authors in the 1931-32 Annual Report entitled “A new and serious septicemic disease of young ducks with a description of the causative organism, *Pfeiff-*

erella anatipestifer, N.S." It described the signs, lesions, etiology, pathogenicity, and experimental protocols from their studies on this previously undescribed disease (currently known as *Riemerella anatipestifer* infection). The infection was the cause of continuing heavy losses in the duck industry and was still the subject of considerable research after the Duck Research Laboratory opened at Eastport many years later (see below).

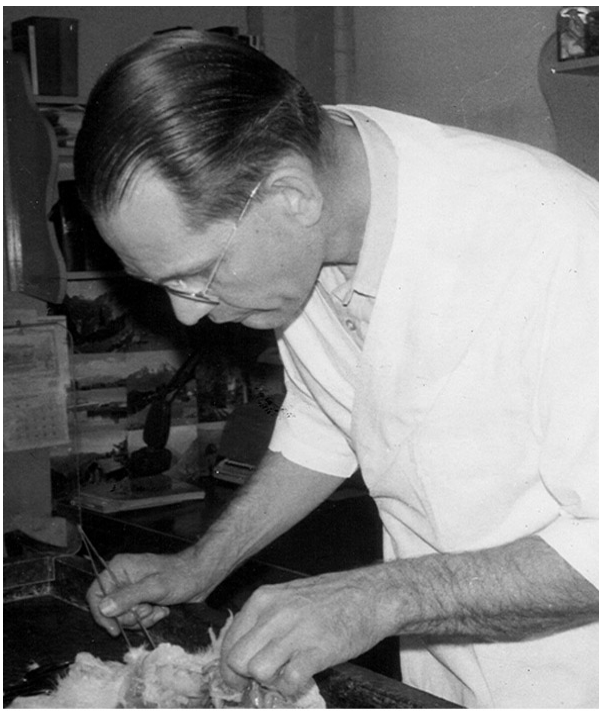
It should be noted that Dr. Hilbert's interaction with other avian disease programs in the College was essentially aborted following Dr. Brunett's retirement, when Dr. P. P. Levine was given responsibility for overseeing poultry disease work in New York State. The story that has been circulated suggests that Hilbert believed he should have been given that job, and refused to work with Levine. In any case, he answered only and directly to Dr. Peter Olafson the Chairman of the Department of Pathology and Bacteriology.

Little research was published by Hilbert in the remaining years of his stewardship at Farmingdale. In the 1943-44 Report, he summarized results of a 5-year study on important diseases of ducks. He noted that sulfathiazole was useful in the temporary control of duck cholera, and might be useful in conjunction with the administration of a duck cholera bacterin. Also, although he refused any direct connection with Levine, he did collaborate with Dr. Earl N. Moore, the turkey pathologist at Cornell, on a project related to transmission and treatment of a disease then referred to as "blue comb" or "Washington mud disease" in turkeys (now known as coronaviral enteritis). Transmission to poults on contaminated litter occurred with trials at Farmingdale but not at Ithaca. The author of this review was thrilled to accompany Dr. Moore (for whom he was working as a student helper) on a trip to Farmingdale in 1950 (+/-), to compare results of research on this disease.

Thus, Dr. Hilbert concentrated mostly on diagnostic work. He provided the first diagnosis of Newcastle disease in New York State in 1945 (abstract in the 1944-45 Report), and in 1951 he published a paper on renal coccidiosis in a goose. Other brief notes that appeared in the College's annual report concerned broiler mortality studies (1956-57), visceral gout and omphalitis (1957-58), and a mortality study of floor layers (1959-60).

The Regional Poultry Laboratories

Because most veterinary practitioners were not interested in working with poultry, it was necessary to have sick or dead birds brought to the Farmingdale or Ithaca laboratories for diagnosis and advice regarding treatment. The poultry industries in western and southeastern counties in New York State needed more convenient diagnostic and extension service. Dr. P. P. Levine, as the *de facto* head of poultry disease work in the State, therefore executed a plan to correct the problem. Regional laboratories were opened in both East Aurora and Kingston in 1946 with Drs. Grayson Mitchell and Clement Angstrom as the Laboratory Directors. Dr. Angstrom had returned to Cornell to resume his graduate studies but was influenced by Dr. Levine to take on the challenge of heading a branch laboratory instead. Dr. Mitchell joined him for a two-month "training period" in the poultry diagnostic laboratory before they took responsibility for the branch labs. There was the question of which one would go where. Apparently lacking agreement, the issue was ultimately decided by a flip of a coin with Mitchell going to East Aurora and Angstrom to Kingston. Later, in 1949, a third regional laboratory was opened in Oneonta with Dr. Anthony Sylstra as the Director.



Dr. Grayson Mitchell *ca.* 1948

East Aurora Laboratory

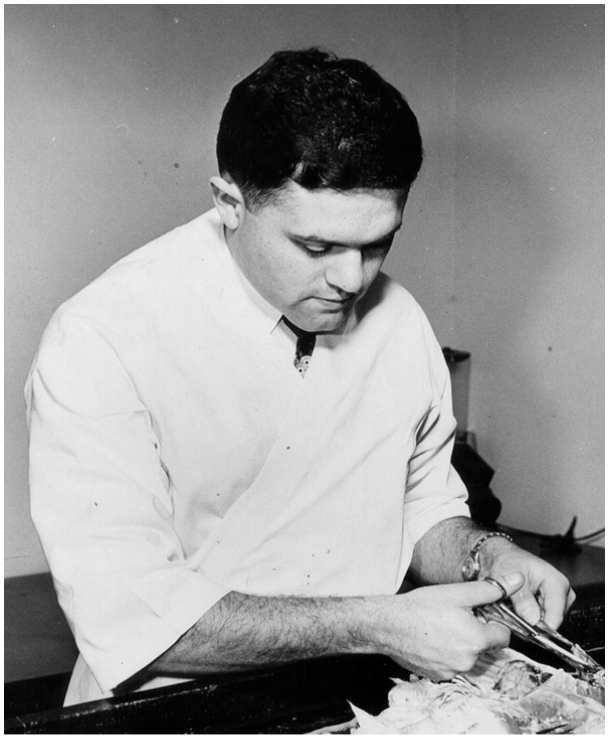
The facility that housed the Regional Poultry Laboratory in East Aurora, dedicated in 1947, was shared with Cornell's mastitis control program headed by Dr. Francis Reed. Interestingly, it had been one of the buildings (a carriage house?) belonging to the Roycrofters, a group associated with the arts & craft movement at an earlier time.

Dr. Grayson Mitchell (part 1, 1946-48). As a student in Cornell's College of Agriculture, Grayson Mitchell had assisted Dr. Randall Cole, a geneticist in the Poultry Science Department, by helping him with poultry necropsies. Randy told him that he should go to veterinary college if he was truly interested in poultry pathology. He did so. While in the Veterinary College at Cornell, he worked part time as a Student Assistant in Veterinary Bacteriology. He was a natural for the job that Levine offered him in 1946. Unfortunately, as much as he enjoyed his position at the East Aurora laboratory, he was forced to leave the veterinary profession after only a couple of years to help run the family feed store in King Ferry, NY. There is little record of any work he did other than that associated with his diagnostic and extension service. However, he apparently helped with a study on Newcastle disease (tests for the spread of infection by recovered chickens) that was published by Levine *et al.*

Dr. Saul Narotsky (1948-71). Dr. Mitchell was quickly replaced by Dr. Saul Narotsky, a graduate of the veterinary college at Michigan

E. Aurora Laboratory for Mastitis and Poultry Disease Control dedicated 1947
Rear: Drs. Murphy, Reed, Olafson, Levine, Fincher, ??
Front: Dr. Mitchell, Dean Hagan, ??

State University. Saul remained in charge of the laboratory for 23 years, conducting necropsies, doing associated bacteriology and serology, and performing whatever tests were needed in the diagnostic field. He also conducted weekly "infectious bronchitis clinics" similar to those offered at Ithaca and Kingston. In these, poultrymen would bring about one percent of their young chickens to the laboratory premises where Dr. Narotsky would place a small sample of live vaccine virus into the trachea. The inoculated chickens were then returned to the flock to spread infection to the other 99 percent of the birds. The vaccine was administered when the birds were old enough to survive and develop a good immunity but before they became mature when the infection could affect egg production and egg quality. In an interesting side to this story, Dr. Narotsky suggested to Dr. Levine that probably the vaccine could be given by "eye-drop" administration to birds held by the owner, thus avoiding having to actually touch the birds and risk carrying other disease agents from one flock to another. Dr. Levine told him that he must continue to give the vaccine by opening the mouth and placing the drop directly into the trachea since that was the only tried and true method. Dr. Narotsky quietly disobeyed his orders and tested his idea on a number of flocks. He then showed Dr. Levine



Dr. Saul Narotsky *ca.* 1950

the results of tests for immunity following the eye-drop method. Dr. Levine had no choice but to accept the new method and all labs then adopted this procedure.

In addition to his work associated with providing diagnoses and recommendations to poultrymen in Western New York, Dr. Narotsky did extension work to educate poultry producers and offer suggestions useful in avoiding disease problems. Also, he participated in some research programs with faculty at Ithaca and carried out some projects independently. In 1954, he published a paper in the *Cornell Veterinarian* describing field cases of erysipelas in chickens and, in 1958, he authored one on suspected egg-transmission of infectious avian hepatitis. Other subjects which resulted in publications that he coauthored included one on feed as a source of salmonellosis in poultry and one on *E. coli* serotypes from salpingitis and chronic respiratory disease. He also collaborated with Dr. Calnek for some unpublished studies on Rous sarcoma virus, with Dr. Boyer *et al.* on "pseudo-botulism," now known to be a manifestation of Marek's disease virus infection, and with Dr. J. R. E. Taylor on antibiotic therapy in chronic respiratory disease.

Over the years, the number of accessions at the East Aurora laboratory dropped, reflecting the changes in the industry wherein poultry farms became fewer but larger. Ultimately, when New York State mandated budget reductions, Dr. Hitchner was forced to close the laboratory, effective May 15, 1971. As a consequence, Dr. Narotsky resigned; he then entered private practice and offered his services privately to interested poultry farmers as well as to pet owners.

Saul Narotsky was one of the founding members of the American Association of Avian Pathologists and he remains a member to this day. In recognition, he was among a handful of persons honored at the 50th anniversary of the organization which was celebrated in Washington, DC in 2007.

Kingston Laboratory

Dr. Clement I. Angstrom (1946-65). As noted in an earlier section, Dr. Angstrom, a graduate of Iowa State University, had begun an

Regional Poultry Laboratory
Kingston, NY

advanced degree program at Cornell but gave it up when he entered the armed services during World War II. He was involved with carrier pigeons while in the Army. In 1946, he accepted the position of Laboratory Directory in Kingston. The laboratory was in a brick building which housed a large necropsy room, a small bird-holding room, an office for poultry

Dr. Clement Angstrom *ca.* 1950

disease work and also laboratory and office space for the mastitis program. A large "kitchen" for cleaning, sterilizing, media preparation, *etc.* was shared by both groups.

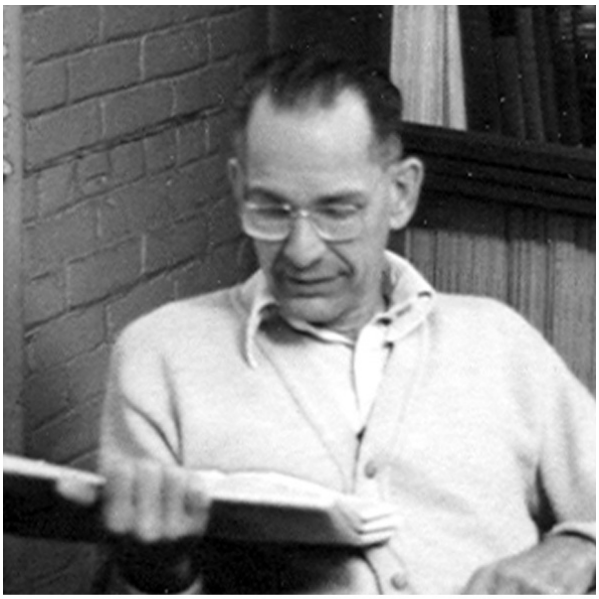
Dr. Angstrom soon developed a fine rapport with a large number of poultrymen, particularly those in the Catskill area who had moved to that region after World War II. Many of them were Jewish businessmen from New York City, and "Clem," as he was known, predicted that they would fail since they knew virtually nothing about raising chickens. He later professed that he was dead wrong and declared that it seemed that it was easier to teach a businessman how to raise poultry that it was to teach some poultrymen how to run a profitable business. Dr. Angstrom was truly a "people person" who was liked and admired by all who knew him. Also, he was a particularly astute diagnostician who gained the trust of his clients when it became obvious that he was right far more often than he was wrong. Sometimes he went head to head with the "experts" and often got them to admit in the end that he was right. This no doubt contributed to his reputation as one of the "best" in the East.

Dr. Angstrom did not publish much. He authored a paper in 1950, in the Proceedings of the American Veterinary Medical Association, on poultry disease diagnosis in the laboratory. Also, he had articles on poultry diseases in trade magazines and papers such as *The Turkey World* and *Poultry Tribune* and he was coauthor for a couple of scientific journal publications. One was the same 1958 Levine paper (contact exposure to chickens recovered from Newcastle disease) for which Dr. Mitchell was also a coauthor. The other was one by Heddleston *et al.* on characteristics of *Pasteurella multocida* isolated from free flying birds and poultry which was published in *Avian Diseases* in 1972. Like Dr. Narotsky, he conducted, or participated in, a number of unpublished studies by colleagues at Cornell (*e.g.*, control of cholera in chickens, effect of fat in the ration on avian hepatitis, control of cannibalism with chemical repellants, treatment of *Syngamus trachea* in pheasants with thiabendazole, and histopathology in the differential diagnosis of infectious avian hepatitis).

For many years, Dr. Angstrom headed a committee of the Northeastern Conference on Avian Diseases (NECAD) charged with establishing nomenclature and recording the incidence of poultry diseases. These were generally published annually, along with reports from other regions of the United States, in the journal *Avian Diseases*.

Clem Angstrom remained the director of the Kingston Regional Poultry Laboratory until his retirement in 1973. He was to be replaced by Dr. William Urban who was being transferred from the Duck Research Laboratory. Sadly, Dr. Urban died the very day he was to have begun at Kingston, and Dr. Angstrom quickly "unretired" and remained in place until a replacement could be found.

Dr. Grayson Mitchell (part 2, 1975-88). The story of the Kingston laboratory took a strange twist when Dr. Angstrom retired. It seems that in the preceding year Dr. Mitchell decided that the family business had demanded his time long



Dr. Grayson Mitchell at the Kingston laboratory, mid 1980s

enough and he was anxious to return to poultry pathology. He had asked his old colleague, Clem Angstrom, to let him come to the Kingston laboratory to "brush up" since he had been away from diagnostic work for many years. Clem happily helped him with his "refresher" and when Dr. Urban died, Dr. Mitchell applied for the job and was enthusiastically reinstated as a Director of the Laboratory. Dr. Hitchner was going on sabbatic leave at that time and Dr. Calnek "covered" for him during his absence. Before he left, Hitchner gave Calnek a strong order: "Hire Grayson Mitchell!" One wonders if Kingston was the location that Mitchell had wanted in the first place (there is no record of who wanted which location when the decision was made by a coin toss).

Dr. Mitchell spent the next 15 years (1973-88) as the Director, largely carrying out diagnostic and extension activities that had been in place since the laboratory was first opened. However, like elsewhere in New York State, the number of clients dropped over the years. This laboratory was busier than either E. Aurora or Oneonta and so was left open when the others were closed, but it became increasingly clear that there was barely enough activity to justify its existence. Taking advantage of this fact, the production and distribution of a low virulence strain of *Mycoplasma gallisepticum* used to immunize young stock that would go to multi-age poultry farms was moved from the Ithaca laboratory to Kingston and Dr. Mitchell was put in charge of the program. For a number of years, this activity kept him sufficiently busy to justify the existence of the laboratory. However, a similar product eventually became commercially available and so production at Kingston ceased. Further budget cuts in the late 1980s dictated program reductions and the Kingston Laboratory was necessarily a target. Dr. Calnek, the Department Chairman at that time, traveled to Kingston to relate the "bad news" to members of the poultry industry. At a meeting with poultrymen he revealed the number of accessions from the previous few years showing the severe erosion of the laboratory usage. An expected critic of the closure then got up and declared that as much as he wanted the laboratory to stay, he, too, was a taxpayer and agreed that the laboratory could not be justified. Thus, Dr. Mitchell retired and his position was reoriented to provide an extension specialist based in Ithaca who would travel throughout New York State to visit poultry farms on a routine schedule or in response to problems.

Oneonta Laboratory

The 1948-49 Annual Report of the College stated that "Another branch lab scheduled for Oneonta has been provided for in the 1949-50 budget and will be established as soon as facilities can be established; Dr. Anthony Sylstra will be the director." In the Fall of 1949 the plan was put into effect. The laboratory

Regional Poultry Laboratory
Oneonta, New York

consisted of a one-story brick building designed specifically for its purpose with a necropsy laboratory and associated laboratory space for bacteriology, serology and virology work associated with the diagnostic mission of the lab. Additionally, there were 4 small semi-isolated buildings in which experimental chickens could be housed. Unlike the laboratories in E. Aurora and Kingston, the laboratory was not shared with the Mastitis Control Program.

Dr. Anthony Sylstra (1949-51). Dr. Sylstra was the first Director at the Oneonta Laboratory. Annual Reports from the College make

Dr. Anthony Sylstra 1950

no mention of Dr. Sylstra's contributions, only that he was replaced in 1951 by Dr. Walter Packer. There is no apparent reason for his short tenure.

Dr. Walter Packer (1951-55). Walter Packer was the director from 1951 to 1955. As with Dr. Sylstra, there is no mention in available reports

Dr. Walter Packer 1953

as to his contributions. It seems likely that he may have conducted some research since there were four bird-holding pens on the premises. Sadly, in 1955, Dr. Packer and his entire family succumbed to carbon monoxide poisoning and it was once again necessary to restaff the laboratory.

Dr. Jean Hagan (1955-71). Jean Hagan was hired in 1955 as Dr. Packer's replacement. She soon developed a special interest in avian vibrionic hepatitis, surveying the incidence of the infection and carrying out a series of studies on the possibility of egg transmission of the organism. Along with Drs. Angstrom and Narotsky, she participated in a project headed by Dr. J.R.E. Taylor on the use of histo-pathology in the differential diagnosis of infectious avian hepatitis and, in 1964, she published a paper in *Avian Diseases* on diagnostic techniques for the disease. Certainly, the availability of the pens for housing experimental chickens at the Oneonta laboratory was useful for her research.

Dr. Jean Hagan administering infectious bronchitis vaccine

Ultimately, the fate of the Oneonta laboratory was the same as that of the East Aurora program. Budget restrictions prompted its closure by Dr. Hitchner on May 15, 1971.

When she joined the Cornell staff, Jean Hagan was one of very few women in the field of veterinary medicine, not to mention the much

narrower specialty of avian medicine. She was probably the first female member of the American Association of Avian Pathologists.

Summary

These regional poultry laboratories, like the Farmingdale laboratory, filled a critical need during the period of their existence. Dr. Levine provided help for the poultry industry across the State, but ultimately, changes in the number, type (small-flock operations) and distribution of poultry farms, coupled with the need to reduce budget, dictated their closure.

The Cornell University Duck Research Laboratory

Cornell University Duck Research Laboratory - Main Building

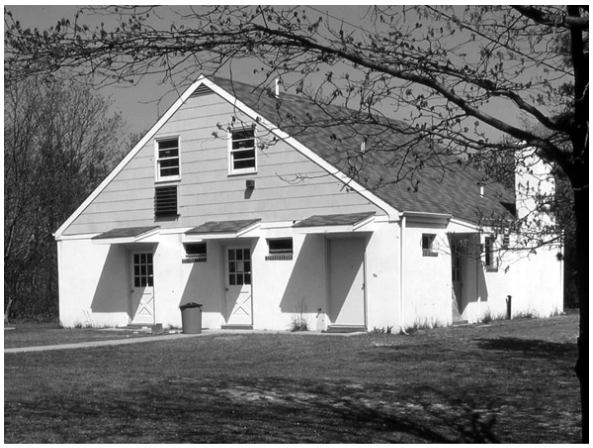
Dr. Levine played an important role in the establishment of a research laboratory to serve the duck industry on Long Island (LI). In the late 1940s, the appearance of a new and deadly disease affecting young ducklings on LI was posing a serious threat to the duck industry. Drs. Levine and Fabricant had isolated and identified the virus which is the etiology of duck virus hepatitis (DVH) and they soon learned that injection of serum from recovered birds into young ducklings provided them with a protective passive immunity. This lasted for their first few weeks when they were particularly vulnerable. The major problem posed by DVH no doubt prompted the series of events which led to the creation of a new laboratory to help the duck industry. In April, 1950, Dr. Levine transferred Dr. Ellsworth Dougherty from Ithaca to Eastport to serve as the Director of the new lab (initially called the Duck Disease Laboratory) where he conducted a diagnostic service and prepared DVH-immune duck serum. Shortly after Dougherty's arrival, the production of duck-origin cholera bacterin was moved from the Farmingdale laboratory to the Eastport facility. Initially, these activities were carried out in a building housing the offices of the Long Island Duck Growers Marketing Cooperative. Dr. Dougherty found that the duck industry consisted of 69 farms and that one of the major problems at that time was "new duck disease," now known as *Reimerella anatipestifer* (RA) infection. Condemnations at the Eastport processing plant were very high (up to 9%) due to extensive air sac infections and peritonitis. Also, DVH was killing about 20% of the 4 million market ducks being produced on Long Island at that time. It was abundantly clear that the special duck disease laboratory was needed by the industry.

In January, 1951, the Cooperative purchased an 80-acre tract of land on Old Country Road in Eastport and soon thereafter they constructed a building with isolation pens for virus research. This was followed by a main laboratory building, a feed house and two chicken houses, funded primarily by another appropriation from the Cooperative but supplemented with grants from the Massachusetts Duck Growers Cooperative and producers in Wisconsin, Illinois and New Jersey. Additional buildings

DRL Buildings
In order from left: Main building, isolation pens, research building, and biologics production facility

that followed in the next few years to make the laboratory fully functional for research purposes included growing facilities, a breeder house, and an incubator house. The development of these facilities by the Cooperative and the provision of staff to run the laboratory by Cornell constituted a collaboration which was later formalized after the College of Agriculture entered the picture. In the mid 1950s, Dr. J. H. Bruckner, the Head of the Poultry Science Department, along with other faculty from that department, established research programs at the laboratory that were related to nutrition, management and breeding. This added to the scope of the duck research program and it heralded a long-term agreement in which the two colleges would provide the personnel and jointly administer the laboratory, and the Duck Growers Cooperative would provide the facilities and financial support for running the program. This probably was the stimulus for the formation of the Long Island Duck Research Cooperative (LIDRC) which was incorporated on January 1, 1956. Shortly thereafter, the Marketing Cooperative transferred the real estate and all other appropriate assets to the LIDRC and, in February of that year, Drs. Levine, Bruckner and Milton Scott met with the LIDRC Board of Directors (Lloyd Robinson, Harold Hubbard, John Leary, Stanley Chornoma and Howard Phillips) to discuss plans for the Cornell programs at the laboratory. By that time, the lab was annually producing over 4 million ml of fowl cholera vaccine and bacterin and nearly 2 million ml of duck virus hepatitis antiserum in addition to carrying out diagnostic work in 556 accessions. Research during the 1955-56 years concentrated on anatipestifer infection and control, an egg embryo vaccine for the control of cholera, fly spray toxicity, and nutrition of ducks. Clearly, the laboratory was filling a need.

In 1958, the LIDRC met in Ithaca with Cornell administrators (deans, department heads, and financial officers) and selected faculty from the Veterinary and Agriculture colleges. The Long Island representatives appealed to the University for additional professional personnel to be assigned to the Eastport laboratory. They also requested that the positions there be given academic standing and salaries that recognized the higher cost of living on Long Island. In consequence, a "Memorandum of Agreement between Cornell University and the Long Island Duck Research Cooperative" was developed and signed by the appropriate officers from the LIDRC and the University in 1959. This established the working arrangement between the University and the Cooperative and set forth the responsibilities and the prerogatives of each party.



DRL Biologics Facility 1975

The value of having a special laboratory devoted to diseases important to the duck industry was very clear. Of course, the appearance of the devastating disease named duck virus hepatitis in 1949 was a strong

stimulus for its "birth," and the continuing problems with bacterial diseases such as anatipestifer infection strongly supported the development of the laboratory. None the less, the importance of having a dedicated laboratory functioning in the midst of the duck producing area of Long Island was brought home emphatically when, in 1967, an outbreak of duck virus enteritis (DVE) occurred. Dr. Leibovitz, with assistance from Dr. Hwang, made the first diagnosis in ducks submitted to the laboratory on January 3rd, and Suffolk County was soon put under quarantine. A total of at least 13 farms had infected birds. A chicken-embryo-adapted DVE modified-live-virus vaccine (DVEMLV), developed in Holland, was quickly imported to the USDA Plum Island laboratory where the virus was screened and tested in ducks for serological and immunological responses. The vaccine was then released to the DRL where several lots were produced and tested both in the laboratory and in field studies. Once the USDA was satisfied with the results, all breeder ducks on Long Island were vaccinated with DVEMLV. By 1968, 14 lots of MLV chicken embryo adapted DVE vaccine had been produced. The federal quarantine of Suffolk County was lifted in June of 1969. This is but one example of the benefits derived from the establishment of the DRL.

There were several significant changes over the years that bear special mention. One was the move to produce the biologics (antisera, vaccines, bacterins) under federal licensure. For a number of years, these were made for local distribution to Long Island members of the Cooperative, presumably with approval by New York State. Members from outside of New York State needed the same biologics but there was no legal way to accommodate this need. It seems that extra doses were being obtained by Long Island members, who had unrestricted access to the vaccines stored at the laboratory, and these found their way to out-of-state members. Dr. Stephen Hitchner, the Chairman of the Department at that time, had been involved in the production and sale of federally licensed poultry biologics prior to his coming to Cornell. Thus, he knew the "ropes," and he hired Dr. Sajjad Haider based on his experience in vaccine production and licensure programs of the USDA. The LIDRC borrowed money to construct and equip a special building that would meet all of the specifications laid out by the USDA, and Dr. Haider proceeded to establish, and gain approval for, protocols required to obtain licenses for the desired products. It was no small accomplishment for an organization like the LIDRC to pass the stringent requirements that are imposed by the USDA. Dr. Calnek approached a USDA official with whom he was acquainted to see if a bit of latitude could be afforded to the DRL since the products would all be used "in house, " *i.e.* by members only. He was told in no uncertain terms that absolutely no shortcuts or special dispensations were allowed. Dr. Haider and his colleagues were to be commended for the job they did and, most certainly, Dr. Hitchner deserved a good deal of credit for his foresight and honesty in making the biologics program respectable.

A second significant change was based on the scope and value of the program on a world-wide basis. The laboratory had no peers; it was "one of a kind" in the world. One member of the cooperative was in Canada and a large duck breeding organization in England (Cherry Valley) helped to support the laboratory for a period. Equally important, staff members (Dean, Haider, Sandhu) were sought after to visit countries as far away as southeast Asia to serve as consultants to duck producers. To recognize the global importance of the laboratory, the name was later changed to The International Duck Research Laboratory.

Toward the end of the 1980s and into the 1990s, New York State was facing severe budgetary constraints. Dr. Calnek was Chair of the department at that time and had to make some difficult decisions. A couple of decades earlier, similar problems had forced Dr. Stephen Hitchner to close two of the Regional Poultry Laboratories. By the same token, Dr. Calnek was faced with a decision as to where to make

cuts that were required during his period of leadership. The DRL was vulnerable because it was not part of the academic programs of the Department and College. Dr. Calnek did warn members of the DRL staff of possible fiscal problems and one of them (Dr. Price) found employment elsewhere "just in case." As it turned out, that position survived, but ultimately, it was necessary to eliminate the position held by Dr. Woolcock. Fortunately, he found an attractive alternative in California. In spite of serious budget constraints in the Department, Dr. Calnek did not want to be responsible for closing the DRL and so, by working with the laboratory's Board of Directors, a new funding formula was developed in which the Cooperative began contributing more by assisting in personnel support. This trend has continued as funding from Cornell has gradually diminished over the years. In the early 1990s, the Department of Poultry and Avian Sciences was eliminated by the Dean of the College of Agriculture, and in 1995, the Department of Avian and Aquatic Animal Medicine merged with the Department of Microbiology and Immunology. These events further eroded the close relationship that had been fostered over the many years. Finally, administrative responsibility for the DRL was handed over to the Diagnostic Laboratory at the Veterinary College, a unit that had a long-time commitment to service and diagnostic programs. This relationship continues to this date, but the LIDRC has been forced to assume more and more of the financial burden of keeping the laboratory functioning. By the end of 2008, although sufficient support staff remained to carry on the biologics production and to provide the laboratory support necessary for diagnostic work, only a single professional staff member (Dr. Ruiz) remained.

Personnel at the Duck Research Laboratory

The first tangible result of the meetings between the LIDRC and Cornell University was the addition of two new positions in 1959 and one more in 1960. In the fall of 1959, Drs. Jessie Price and Bill Ash, both with PhDs from Cornell, joined the staff. During the previous summer, Dr. Price had conducted a research project on anatipestifer infection while she was still a graduate student at Cornell. She was expected to continue investigating that disease and also to take charge of the production of cholera biologics. Dr. Ash was given responsibility for research on duck breeding and reproductive physiology of ducks. In January of 1960, Dr. Jen Hwang joined the staff as a virologist to work on duck virus hepatitis and other virus diseases. He was a veterinarian with a PhD from the University of Connecticut. These appointments provided a good spectrum of disciplines to compliment the diagnostic service and biologics production that were already in place. In March 1960, additional facilities were completed, including a "Laboratory Annex" for bacteriologic and virologic research.

The next several years brought in additional personnel. In 1963, Dr. Louis Leibovitz was added to the staff as a Field Veterinarian with a primary responsibility for diagnostic work. That same year, William Ash was transferred back to the Ithaca campus and he was quickly replaced by Dr. William Dean who was to deal mainly with nutrition and management. A year later, Dr. Dougherty transferred to the Ithaca campus and he ultimately took a position at the Plum Island National Laboratory. Dr. William Urban was hired in 1964 to replace Dr. Dougherty as Director of the laboratory.

In 1973, there were two significant changes. Dr. Leibovitz was transferred to Ithaca where he was given the responsibility of heading up the new aquatic animal disease program in the Department. He was immediately replaced by Dr. Tirath Sandhu. At about the same time, Dr. Urban was transferred to the Kingston Regional Poultry Laboratory where he was to serve as a replacement for Dr. Angstrom. Dr. Dean was appointed to head the laboratory as the new Director, a position he held until his retirement in 1991. After his "official" retirement, he

continued to work part time for another four years.

Over the years, there was a succession of virologists at the lab. Dr. Jen Hwang, who first covered this specialty, resigned in 1967 and was replaced that same year by Dr. Thomas Toth, a veterinarian who came by way of Germany after escaping from the communist takeover of Hungary. Dr. Toth transferred to the Ithaca campus in 1971 to pursue a PhD program with Dr. Hitchner, and Dr. Sajjad Haider was appointed in 1973 as the new virologist. When Haider left in 1985, Dr. Jack Carlson covered the virology program for the next two years. He was followed by Drs. Peter Woolcock (1986-91), Samia Shawky (1993-2000), Betty Miguel (2000-03) and Alejandro Banda (2004-08). Each of these individuals conducted research on various viral diseases of ducks and also were involved in the production of viral biologics.

Dr. Price, who covered the field of bacteriology (1959-77) was replaced by Dr. Herbert Layton, who served from 1978 until 1985 when he suffered a stroke. Dr. Sandhu essentially assumed responsibility for this specialty from that point on.

As noted above, the College of Agriculture initiated a program in nutrition, breeding and management with the appointment of Dr. Ash in 1959. Although he and a succession of persons who embraced these fields did not specifically address disease problems, several of them interacted with those who did. Persons who worked under the supervision of the Department of Poultry and Avian Sciences were as follows: William Ash (1959-63), William Dean (1963-73), Leslie L. Ortman (1964-66), David Thomason (1974-76), Joseph Veltmann (1976-77), and Doris King Hayden (1978-79). Because the position of Director was an appointment of the Veterinary College, when Dr. Dean became Director in 1973 his appointment was switched from the College of Agriculture to the College of Veterinary Medicine.

Following Dr. Dean's retirement in 1991, Dr. Sandhu served as Director and he continued in that capacity until his own retirement in 2007 when Dr. Alejandro Banda was named Director. After only a year in that position, Dr. Banda left and was replaced by Dr. Jaime Ruiz.

Details of each of the professional staff follow, in chronological order.

Ellsworth Dougherty III (1950-63). Dr. Ellsworth Dougherty received his veterinary degree from the University of Pennsylvania. He joined the Cornell staff in 1948 as an Assistant Professor and transferred to the Duck Research Laboratory as its first Director in 1950. He was responsible for diagnostic work and extension and he prepared cholera bacterin, a cholera egg embryo vaccine, and duck virus hepatitis immune serum. In addition to these duties, he most certainly was involved in the design and development of facilities at the laboratory as it evolved.

Dr. Dougherty also carried a heavy commitment to research. He conducted a large variety of

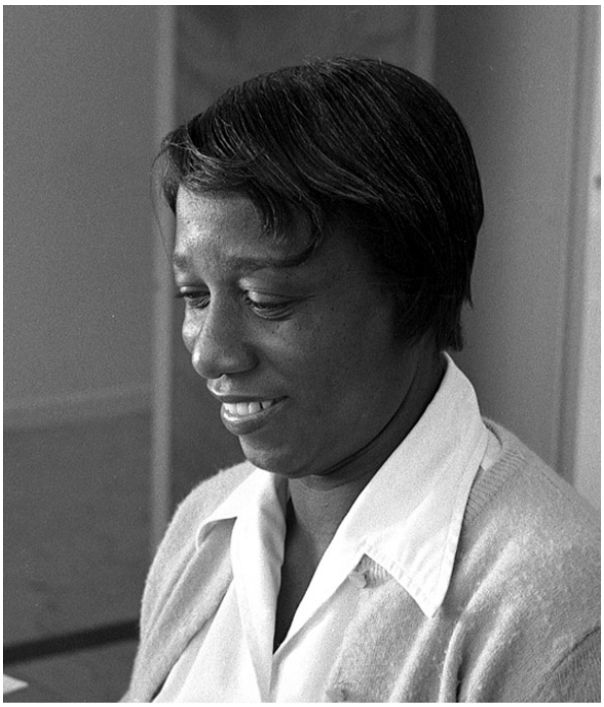
Dr. Ellsworth Dougherty, III

projects related to the disease problems he encountered. These included studies on coccidiosis, fowl cholera, paratyphoid infections, erysipelas, drug toxicities, duck virus hepatitis, Eastern encephalitis (EE), bacterial infections causing arthritis and synovitis, meningoencephalitis, and a number of pathologic conditions of unknown etiology. Because of the seriousness of the problem with "new duck disease," many of his studies were related to *R. anatipestifer* infection and he collaborated with Dr. Jessie Price on vaccination strategies and antibiotic treatments after she joined the staff. He described the first case of EE in White Pekin ducks and followed up by helping Dr. Price with research on this disease. Duck virus hepatitis (DVH) control was another area that commanded his attention. Initially, he tested various vaccines and vaccination strategies. Later, in collaboration with Dr. Jen Hwang, he helped develop the breeder vaccination scheme which provided protective maternal antibodies to progeny and which still constitutes the primary approach to the control of this disease. With a special interest in pathology, he worked on hepatic cirrhosis and an artifact resembling focal necrosis in livers of slaughtered ducks. These studies were done with collaborative input from Dr. Charles Rickard, his friend and colleague in the Department of Pathology at Cornell. In addition to his interest in diseases, he participated in studies on nutritional and management problems and miscellaneous conditions associated with processing when ducklings were slaughtered. His research led to a total of 17 publications in refereed journals; with ten of these he was either the sole or senior author.

Clearly, Dr. Dougherty was a man of many talents who contributed in a very large way to the establishment and maturation of the DRL as a world resource for studies of duck diseases and conditions.

Jessie I. Price (1959-77). Dr. Jessie Price, an Ithaca High School and Cornell University classmate of Bruce Calnek, completed a PhD degree under the tutelage of Dr. Dorsey Bruner in the Department of Pathology and Microbiology. Part of her graduate study on anatipestifer infection in ducks was conducted at the Duck Research Laboratory, and in August of 1959 she began her employment as a Research Support Specialist.

Initially, she worked with Dr. Dougherty on a



Dr. Jessie Price 1960s

fowl cholera bacterin, and was placed in charge of the production of cholera biologics. Jessie and her staff produced a number of broth-grown bacterins containing isolates of *Riemerella anatipestifer* from local farms that were sometimes marginally effective in controlling outbreaks. She soon turned to studies on RA infection itself, embracing many facets of the infection but with particular attention given to methods of control. She tested a variety of immunization approaches including vaccination with inactivated and live organisms. Her work with bacterins was especially prominent and was conducted over a period of several years. Also, she assessed antibiotic treatments and carried out serological subtyping of isolates. Collaborative studies with Dr. Urban and others looked at the pathogenesis of the infection.

Other areas that commanded her attention included salmonella, coliform and cholera infections in ducks. She described salmonella infections in Pekin ducks, listing the major species found and the typical lesions they caused in ducks. Dr. Price, along with Dr. Dougherty, described the first case of Eastern encephalomyelitis (EE) infection in Pekin ducks on Long Island. She tested the virulence of the virus for breeder ducks (antibodies but no disease), reported on the neutralization of duck-origin EE virus with guinea pig serum, and conducted mosquito surveillance for the virus on Long Island. In another collaboration (also including Drs. Dougherty and Leibovitz), she assisted Dr. Dean in testing the efficacy of feed-administered medications used in controlling bacterial diseases in ducks.

In 1973, Dr. Price left the Duck Research Laboratory for a position at the National Wildlife Research Center of the U.S. Fish and Wildlife Service in Wisconsin where she continued studies on diseases of wild animals including ducks.

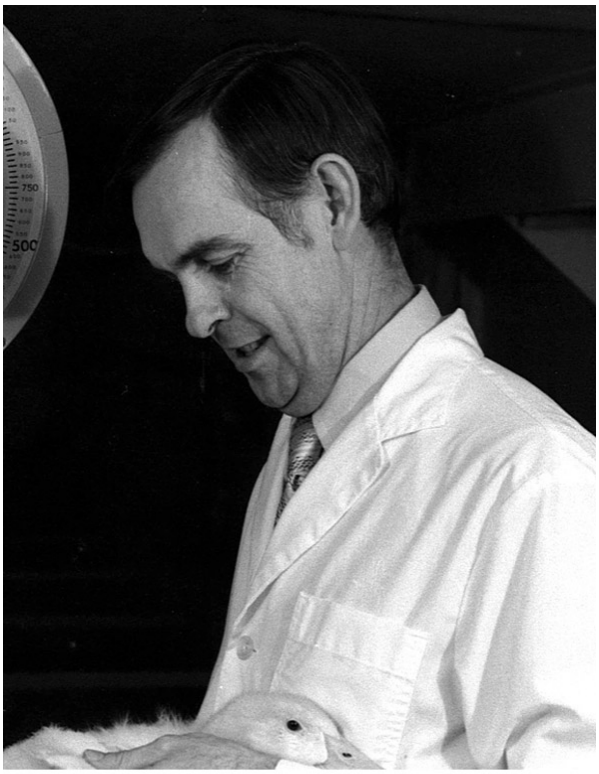
Jen Hwang (1960-67). Dr. Jen Hwang, a veterinarian who was originally from Taiwan, held a PhD from the University of Connecticut. He had worked on avian encephalomyelitis for his thesis study and thus had experience in the field of virology. He joined the duck laboratory in January of 1960 to tackle the problem of duck virus hepatitis (DVH) and other virus diseases in ducks. This was no small undertaking considering the fact that most farms were located close together along creeks, and isolation of flocks and age groups was almost impossible under the existing management system. Virulent DVH virus was present on most farms and depopulation, clean-up and biosecurity were unknown concepts to duck growers in those days. Dr. Hwang, in collaboration with Dr. Dougherty and, most likely, Drs. Levine and Fabricant at Ithaca, came up with the concept of protecting young ducklings by vaccinating breeder ducks with the duck hepatitis virus, thus providing passive immunity to the offspring (it had been observed that ducklings hatched from breeders that had been exposed to the virulent virus were immune to DVH). Dr. Hwang developed a live attenuated DVH vaccine by serial passage of the virus in chicken embryos and, with the help of the Suffolk County Cooperative Extension Agent (Mr. Devenpeck), field tested the vaccine. Generally, results were very good and soon regular vaccination of all breeder ducks with DVHMLV vaccine became standard practice. In the 1960s, Dr. Hwang improved the VN test in chicken embryos that Dr. Fabricant had used in the initial DVH studies, and it was used on a regular basis for decades afterward. Dr. Hwang also demonstrated that vaccination of DVH-susceptible newly hatched ducklings with the DVHMLV vaccine induced a long-lasting high level of active immunity in the ducklings.

Another of Dr. Hwang's contributions involved the first North American isolation and identification of duck virus enteritis (DVE), popularly known as duck plague, in a collaborative study with Dr. Leibovitz. He also worked on Eastern equine encephalomyelitis virus with Dr. Dougherty and carried out some cell culture studies with the virus.

Dr. Hwang resigned in 1967 to accept a position at the University of Pennsylvania and was replaced by Dr. Thomas Toth. Sadly (and ironically), he later succumbed to the human variety of viral hepatitis, presumably from eating raw oysters.

William F. Dean (1963-91; part time to 1995). Prior to his position being transferred to the College of Veterinary Medicine in 1973 when he was appointed Director of the Duck Laboratory, Dr. William Dean had been a member of the Department of Poultry Science in the College of Agriculture at Cornell for ten years. Having just completed his PhD in 1963 at the University of Illinois, he was hired by J. H.

Bruckner, then the Chairman of the Poultry Science Department, to carry out research on the nutrition and management of ducks at the Long Island Laboratory. His training at Illinois, and earlier at the University of Arkansas where he completed his MS, gave him a well-rounded background which, in addition to nutrition, included training in poultry physiology, genetics, husbandry and diseases. This allowed him to tackle many of the varied problems facing the duck industry.



Dr. William Dean 1970s

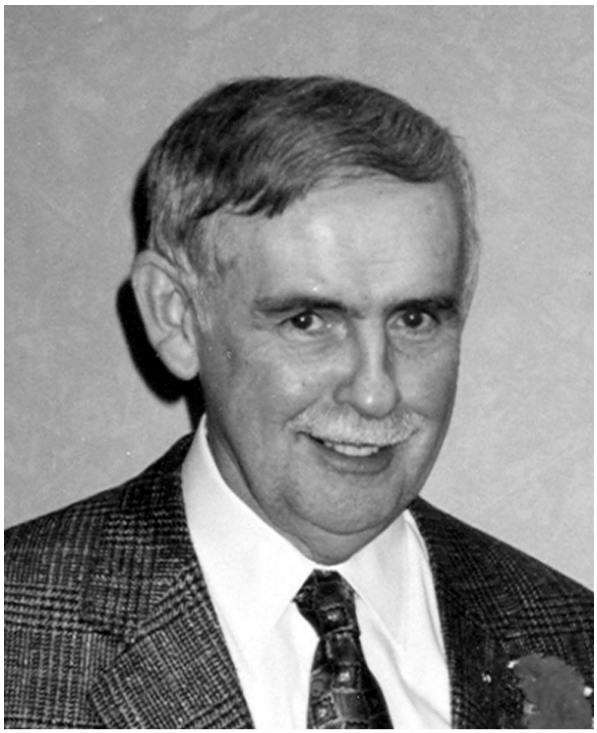
Quantitative nutrient requirements of ducks became the focus of a good deal of Dr. Dean's work during his early years at the DRL. His nutrition studies were often done in collaboration with others in the Poultry Department, including Milton Scott, Bob Young, Malden Nesheim and Gerry Combs. These studies established, or further clarified, the growing Pekin duck's requirement for energy, protein, methionine, cystine, lysine, calcium, phosphorus, sodium, chlorine, selenium, Vitamin K, niacin and choline. Much of this work, as well as management research mentioned below, appear in the book Nutrition and Management of Ducks authored by Drs. Scott and Dean and published in 1991.

Finding ways of improving the carcass composition of Pekin ducks was another of Dr. Dean's areas of interest which he approached both from a nutritional and a genetic point of view. His nutrition studies helped establish the limits of improvement that could be accomplished by dietary manipulations, but he found that genetic selection offered the most promise for improving carcass composition of this duck breed. With the help of Professor J. R. Stouffer in the Animal Science department at Cornell, Dr. Dean perfected the use of ultrasound scanning as a means of accurately measuring the thickness of the breast muscle on the live duck. This proved to be well correlated with breast muscle mass. Working in collaboration with Professor Dan Cunningham in the Poultry and Avian Science Department at Cornell, Dr. Dean and staff carried out a small-scale duck selection project in which breeders were selected for increased breast muscle thickness (measured with ultrasound) over 6 generations. This selection technique is currently used by large commercial duck breeders in several countries around the world.

At the time Dr. Dean joined the DRL, most ducks on Long Island were raised outdoors, except for a brief confinement during their early brooding period. This practice left ducks vulnerable to the adverse effects of extremes in weather and allowed easy introduction of duck diseases via wild waterfowl and other carriers. In collaboration with Professor Hollis Davis in the Department of Agricultural Engineering at Cornell, and after renovating some of the buildings at the Duck Laboratory to emulate modern environment-controlled housing, they demonstrated improved performance of ducks raised in total confinement compared to ducks raised in the conventional manner.

Dr. Dean was appointed to the directorship of the duck laboratory in 1973. This departed from

precedent in that Dr. Dean was not a veterinarian, as had been the first two directors, Drs. Dougherty and Urban. At the time, a number of changes in DRL staff were taking place as explained elsewhere. One of the reasons for choosing Dr. Dean was that he had been at the laboratory for ten years and represented a familiar face to both the DRL staff and the duck growers. Also, he had

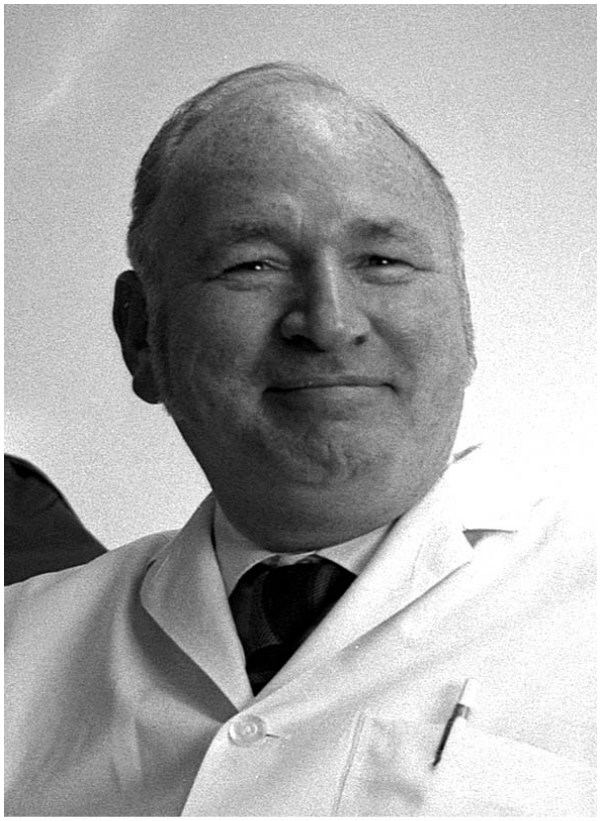


Dr. William Dean 1991

worked cooperatively with the veterinary staff at the DRL on several projects. While serving as Director, he continued his research in the areas of duck nutrition, management and breeding. However, prior to the time that Dr. Sandhu was able to develop more efficacious biologics to control the high mortality due to *R. anatipestifer* and other bacterial infections on duck farms, there was great pressure from the duck industry to find more effective anti-bacterial drugs that could be administered in feed. Furthermore, once efficacious drugs were identified it was necessary for the DRL to assist drug manufacturers in getting each drug approved for ducks. Using the facilities that he had developed for nutrition work, Dr. Dean collaborated with the DRL veterinary staff and drug companies to generate the safety and efficacy data needed to get efficacious drugs approved for ducks.

Dr. Dean retired in 1991, but generously continued to work part time for the next four years to help with the administration of the laboratory. He continues to maintain an interest in the activities of the DRL to the present (2008) and he is also updating his book on duck nutrition.

Louis Leibovitz (1963-73). Dr. Louis Leibovitz, who received his veterinary degree from the University of Pennsylvania, joined the staff in 1963 as a Field Veterinarian with a primary responsibility for diagnostic work. He



Dr. Louis Leibovitz 1960s

previously had been on the faculty at Delaware Valley College in Pennsylvania, where he taught a course in veterinary science. Lou was a person with an insatiable curiosity and appetite for learning. He was especially interested in exploring areas that were not being

addressed by many others, and that no doubt contributed to his interest in duck diseases and the exploration of the many disease conditions that affected them.

At the time, there were over forty duck farms operating on Long Island that were experiencing significant mortality from most of the common duck diseases. Dr. Leibovitz routinely examined a large number of ducks weekly and found them to be infected with a variety of pathogens. His skills in identifying the causative agent and making appropriate recommendations for prevention and treatment were much appreciated by both duck growers and fellow scientists at the lab.

Of course, as was true of others when they joined the staff at the DRL, he initially concerned himself with perhaps the most important disease, *i.e.*, anatipestifer infection. He undertook a study of the diagnostic and microbiological features of the disease by conducting a bacteriological survey of field accessions which pointed out the distinctive roles of *Riemerella anatipestifer* and *E. coli* in this syndrome. He subsequently collaborated in studies on the infection with Drs. Jessie Price and William Urban.

As noted above, in January 1967 Dr. Leibovitz and Dr. Hwang detected duck plague (a highly virulent herpesvirus) in White Pekin ducks on Long Island, constituting the first observation of this disease in North America. They published a number of papers describing details of the initial outbreak as well as the pathology of this disease in ducks and other anseriformes. Leibovitz subsequently conducted a survey of wild birds and found evidence of the infection in a variety of species of wild free-flying Anseriformes at different locations on Long Island. Other work on this disease included a report on the gross and histologic pathology.

On another front, Dr. Leibovitz published one of the few papers available describing necrotic enteritis, an important disease of breeder ducks. Coccidiosis was yet another area of interest. He described a new species from ducks which he named *Wenyonella philiplevinei* in honor of Dr. P. Philip Levine, and later he reported on a new species of the coccidial genus *Cyclospora*, which he found in ducks and geese. The latter had previously been observed only in snakes and lizards.

His wide interests resulted in reports of a fatal Puffinosis-like disease in a Sooty Shearwater (the first diagnosis of such on the American continent), a cytomegalic-like disease in squabs, *Haemaproteus* infections, necrotic enteritis, cholera, streptococcal infections associated with endocarditis, and (as a portent of his future as an aquatic animal pathologist) the causes of mortality in larval shellfish.

In short, Dr. Leibovitz offered an important and interesting approach to his work as a diagnostician and he developed a fine reputation as a specialist in the field of anatine pathology. The breadth of his interests was further manifested when, in 1973, he transferred from the DRL to the Ithaca campus to head up a new program in aquatic animal medicine that was added to the responsibilities of the Department of Avian Diseases.

William Urban (1964-73). Dr. William Urban, a veterinarian from California, was hired to replace Dr. Dougherty in 1964. Thus, he was the Laboratory Director during the DVE crisis of 1967-69 when he worked closely with USDA officials, DRL scientists, and duck producers. He played an important role in maintaining communications between the parties and advising farmers as to what action should be taken.

Dr. Urban's research, with assistance from Dr. Price, included studies on anatipestifer infection (pathogenesis, drug therapy), experimental coliform infections in ducklings, and toxicity of insecticides for ducks. He also assisted others (Drs. Leibovitz, Hwang, Toth, Price) in various projects dealing with anatipestifer infection, DVE and DVH.

In 1973, Dr. Urban was transferred to Kingston where he was to serve as Director of the Regional Poultry Laboratory following Dr. Angstrom's retirement. Sadly, he died of a heart attack on the very day he was to have started.

Dr. William Urban

Thomas Toth (1967-71). Dr. Thomas Toth, a Hungarian veterinarian, was hired by Dr. Stephen Hitchner in November 1967 as a Duck Research Specialist to replace Dr. Hwang. He arrived in time to participate in solving the DVE crisis that had begun in January of that year. Dr. Toth and his staff produced the initial serials of the modified live-virus, chicken-embryo-adapted DVE vaccine (DVEMLV) that had been released to the DRL from the USDA's Plum Island Disease Laboratory. They conducted both laboratory and field trials establishing the safety and efficacy of the vaccine. Once USDA officials were satisfied with the results, all breeder ducks in Suffolk County were vaccinated with the DVEMLV vaccine.

In addition to overseeing the production of viral biologics, his work included studies on the growth curve of DVH in embryonating eggs and on the serologic and immunologic response of ducklings to inoculations with single and combined DVH and DVE vaccines. He carried out experiments to compare live DVH vaccines with alum-precipitated and sodium-hydroxide-conjugated inactivated vaccines (the latter were ineffective).

Dr. Toth also is credited with the discovery of a second type of duck virus hepatitis. First isolated in 1968, the virus was characterized as a DVH virus which was antigenically distinct from the classical DVH virus. It caused significant, but relatively low mortality on some of the Long Island farms. He named it "Variant DVH" but later it was called DVH Type III to distinguish it from the classical virus (DVH Type I) and a second serotype described by English workers (Type II).

In 1971, Dr. Toth resigned from his position and moved to Ithaca to undertake graduate studies leading to a PhD under the guidance of Dr. Hitchner.

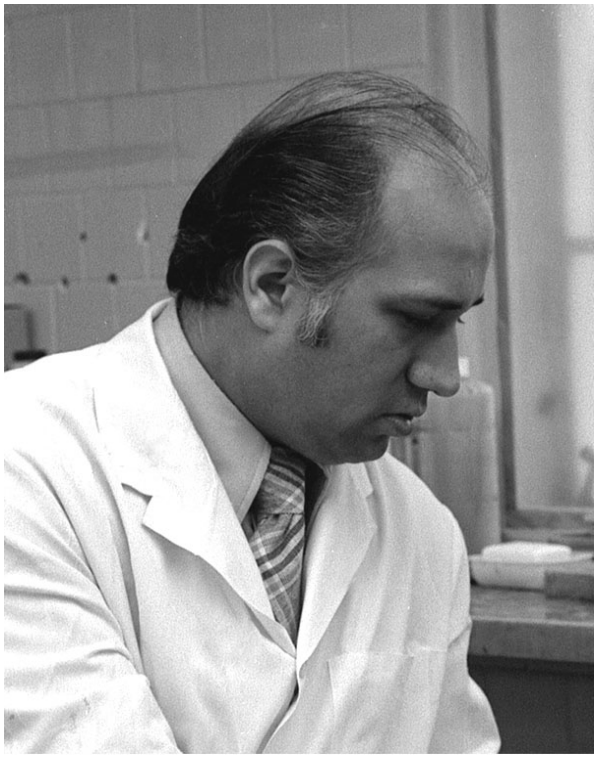
Sajjad A. Haider (1973-85). Recognizing the need for a person who could not only cover the field of virology at the DRL (replacing Dr. Toth) but also oversee the development and licensing of a federally accredited biologics, Dr. Hitchner hired Dr. Sajjad Haider, a DVM with a PhD. Dr. Haider had previously worked for two commercial poultry biologics laboratories in the US and was thoroughly familiar with federal licensing requirements since he had been active in obtaining a number of product licenses for his previous employers. He assisted Dr. Dean in drawing up plans for a new biologics production laboratory at the DRL. The new facility was completed in 1975. Requirements for a federal "establishment license" and one "product license" (DVH yolk antibody) were met in 1976 and approved by the Biologics Division of the USDA. This was no small accomplishment for a small organization and it was critical to the goals of the DRL.

Dr. Sajjad Haider

Much of Dr. Haider's research during his early years at the DRL was devoted to developing a better product to replace the anti-DVH antiserum which had been regularly produced at the laboratory. He demonstrated that a highly efficacious anti-DVH antibody product could be made with the yolks of chicken eggs from hens that had been hyper-immunized against the duck hepatitis virus. He and his staff conducted all the necessary work demonstrating the safety, efficacy and shelf-life of this new product. Federal product licenses were soon obtained for the anti-DVH yolk, as well as licenses for duck virus hepatitis modified-live-virus vaccine (DVHMLV) and duck virus enteritis modified-live-virus vaccine (DVEMLV) which had been previously developed at the DRL. Dr. Haider and his staff worked diligently at refining production techniques and field vaccination programs for all virus products. He also carried out a research project with Dr. Calnek in which the *in vitro* isolation, propagation and characterization of duck hepatitis virus type III was reported. This virus was the one that had been isolated and described by Dr. Toth, but it had not been fully characterized.

Dr. Haider left the DRL in 1985 to accept a Cornell University Veterinary College assignment as part of an assistance program in Saudi Arabia.

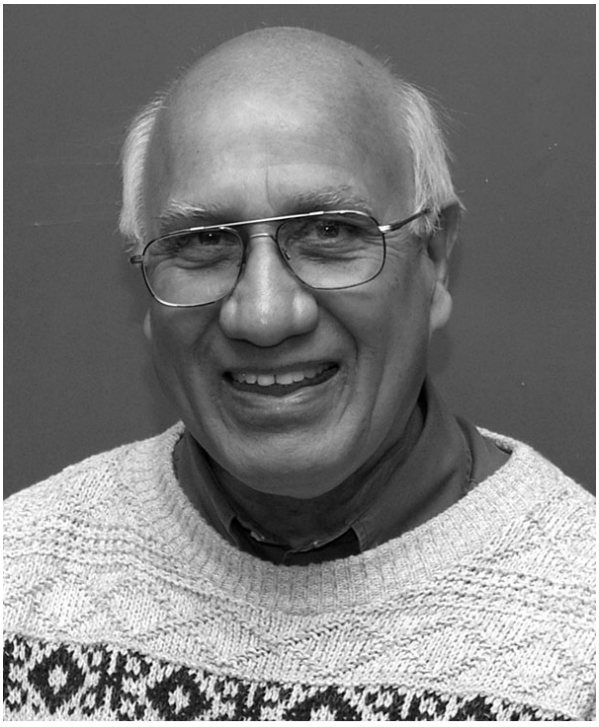
Tirath Sandhu (1973-2007). Dr. Tirath Sandhu earned his veterinary degree (BVSc) and a Master's degree in Microbiology in Bikaner, India and then came to the United States where he received an MS degree and a PhD in microbiology from the University of Florida in 1970 and 1972, respectively. In 1973, he joined the staff at the Duck Research Laboratory as a Field Veterinarian, filling the position vacated when Dr. Leibovitz was transferred to Ithaca to head up the aquatic animal disease program in the Department. As was true for Leibovitz, he had responsibility for the diagnostic laboratory, extension service and research on disease problems important to the duck industry. He remained in this position until 1991 when he was promoted to the position of Senior Research Associate and was named Director of the Duck Research Laboratory following Dr. Dean's retirement. He also assumed responsibility for supervising the veterinary biologics program at the same time.



Dr. Tirath Sandhu 1970s

Dr. Sandhu's research interests were related to the diagnosis, pathogenesis and epizootiology of diseases of ducks and other waterfowl. He studied various types and subtypes of duck hepatitis virus and the efficacy of modified-live-virus vaccines for their control. He described a variant of DVH type I in a study with Drs. Calnek and Leslie Zeman (a graduate assistant at Cornell). Duck virus enteritis, *E. coli*, salmonellae, and streptococci also were subjects of his varied research program, and he contributed significantly with his studies on influenza virus in ducks on Long Island.

Of all of his contributions, the ones that were arguably the most significant were those directed at the infection that was first identified at the Farmingdale laboratory by Dr. Hilbert, *i.e.*, the condition variously named "new duck disease," infectious serositis," *Pasteurella anatipestifer*, and finally, *Reimerella anatipestifer* (RA) infection. After duck virus hepatitis was largely under control, this disease constituted one of the most serious conditions affecting the duck industry. Dr. Dougherty, and particularly Dr. Price, had carried out a great deal of research on RA bacterins and their administration and found some combinations to be somewhat efficacious but only able to keep the infection partially in check. Dr. Sandhu undertook a systematic approach in which he first identified the three most prevalent serotypes of the organism affecting Long Island flocks. Then he searched for isolates of those serotypes that were relatively avirulent. Those were then grown in the laboratory and administered as a live *R. anatipestifer* "vaccine" in the drinking water or as an aerosol to 1-day-old ducklings. Dr. Sandhu later found that an easy method of administration was as an aerosol administered in the hatcher before the ducklings were removed. This control method was used very successfully as an alternative to killed bacterins. A federal license for this product was added to those he had helped develop for other biologics such as inactivated *Reimerella* plus *E. coli*, cholera, and autogenous bacterins. Dr. Sandhu's systematic approach to the control of



Dr. Tirath Sandhu 1996

RA typified his quiet and effective research efforts during the 34 years he worked at the Duck Research Laboratory.

In addition to a number of scientific publications detailing his research, Dr. Sandhu was the author of several book chapters, including ones covering duck virus enteritis, and *Reimerella anatipestifer* in the major reference book *Diseases of Poultry*.

Herbert Layton (1978-85). Dr. Herbert Layton, a PhD bacteriologist, filled the position vacated by Jessie Price when she left to join the US Fish and Wildlife Service in Madison Wisconsin in 1977. Dr. Layton had previously worked in a microbiology laboratory at the American Cyanamid Company in Princeton, NJ and was well grounded in the skills necessary to take on the challenges of improving techniques for the production of bacterial biological products at the DRL. Prior to his arrival, Dr. Sandhu had been successful in developing a much improved *Riemerella anatipestifer* (RA) bacterin which was proving to be highly successful in the field. The organisms for this

bacterin were initially grown on solid media (agar) to produce the desired concentration of antigenic material in the bacterin. Dr. Layton and his staff carried out the tests necessary to obtain a federal product license for this agar-grown bacterin. However, the increased

Dr. Herbert Layton

demand for this product created the need for improved techniques for producing large quantities. Although broth bacterins had been only marginally efficacious in earlier studies by Jessie Price, Dr. Layton and his staff found that continuous aeration of the broth, along with other refinements in technique, enabled them to grow the organism in broth media in sufficient concentrations to produce a product that was as efficacious as the agar-grown product. This development greatly improved the efficiency of producing RA bacterin. Dr. Layton and staff then completed the work required to license the broth-grown product. Later, he and Dr. Sandhu collaborated to develop and eventually obtain a license for a formalin-inactivated *E. coli*/RA bacterin. He also applied techniques similar to those used in producing RA bacterin to the production of *Pasteurella multocida* bacterin, which his team produced occasionally based on demand, under the DRL's autogenous bacterin license.

Another phase of Dr. Layton's work was examining the antigenic properties of different fractions of the RA bacterin. He found that an acetone precipitate, which contained a high level of carbohydrate, contained a high concentration of antigenic material. He was still pursuing this promising line of inquiry in March of 1985 when, tragically, he suffered a massive stroke and was severely debilitated. On the brighter side, Herb has since made amazing progress toward recovery. He and his wife Jackie presently live in New Jersey.

Jack Carlson (1985-87). Dr. Jack Carlson replaced Dr. Haider to oversee the biologics production, particularly the viral biologics. He remained for only a brief time. Medical problems and having a large family facing a shortage of potential housing in the Eastport area were factors in his short tenure.

Peter Woolcock (1986-91). Dr. Peter Woolcock, who had a PhD in microbiology from Leeds University in the United Kingdom, accepted the position of Senior Research Associate at the DRL in April, 1986. He had worked for a duck industry foundation in England where he participated in the production of a modified-live-virus DVH vaccine for use in susceptible day-old ducklings. While at the DRL, he pursued the feasibility of vaccinating breeder ducks with a killed duck virus hepatitis vaccine following an initial vaccination with the modified-live-virus DVH vaccine already in use. This procedure proved to be successful if the killed vaccine was prepared with an adjuvant containing a salmonella typhimurium mitogen (Ribi adjuvant). Dr. Woolcock was also successful in perfecting the use of tissue culture for measuring DVH serum neutralization titers in ducks.

Unfortunately, in 1991, severe budgetary constraints required downsizing and his position was eliminated. He moved to the University of California's Fresno Laboratory

where he has established a fine reputation as an avian virologist.

Dr. Peter Woolcock

Samia A. Shawky (1993-2000). Dr. Samia Shawky came to the DRL as a Senior Research Associate II in 1993. She had earned her DVM from the University of Cairo and her PhD from Ohio State University under the tutelage of Dr. Mo Saif. Her main concentration in research was in virology.

Dr. Samia Shawky

In addition to normal virological diagnostic work and biologics production, she studied the pathogenesis of duck virus enteritis with emphasis on latency. DVE had been considered primarily a disease of mature breeder ducks. This had been the case since the initial introduction of DVE on Long Island in 1967. However, in 1997, Drs. Shawky and Sandhu isolated a virus that was causing problems in relatively young market ducks on a Long Island Farm. Dr. Shawky's studies on this DVE isolate revealed that although it exhibited low virulence, it caused significant immuno-suppression, including atrophy of lymphoid organs (thymus gland and bursa of Fabricius). She then investigated the efficacy of the DVE vaccine in current use in preventing mortality and immunosuppression and found it to be effective on both counts. Dr. Shawky also explored the use of a tissue-culture-derived inactivated DVE vaccine as a means of providing protection against the 1967 DVE isolate. In 1985, Dr. Shawky resigned to accept a position at the USDA's Plum Island Laboratory.

Betty Miguel (2000-2003). Dr. Betty Miguel held a DVM and a PhD from Mississippi State University with training in avian pathology and molecular virology. She was appointed to the position of Senior Research Associate in November, 2000. During the relatively short time she was at the DRL, she concentrated on perfecting better techniques for detecting duck disease agents. She worked toward developing an ELISA test for measuring *Reimerella anatipestifer* (RA) antibody and had some success in identifying specific protein bands corresponding to RA serotypes 1,2 and 5. She also attempted to perfect a polymerase chain reaction (PCR) test for detecting DVE, but successful application was not achieved until

later when Dr. Banda made some modifications to the test. Dr. Miguel conducted an interesting experiment on the effects of the concentrations of the amino acids arginine and lysine on the replication of the DVE *in vitro*. Her study was based on the established fact that, *in vitro*, L-arginine is required for the successful replication of herpes simplex virus-1 and it conveys a substantial growth promoting effect. Conversely, L-lysine, an analog of arginine, antagonizes the growth promoting effect of arginine and therefore reduces viral replication. Dr. Miguel found that replication of DVE was highly dependent upon the arginine concentration of her culture media. Media depleted of arginine almost totally inhibited viral replication of the duck enteritis virus. The addition of lysine to the media, as anticipated, had an inhibitory effect on viral replication.

Dr. Miguel resigned in September 2003 to take a position as Director of the Kissimmee Animal Diagnostic Laboratory.

Alejandro Banda (2004-2008). Dr. Alejandro Banda received his DVM and an MS degree at the National University in Mexico. He was awarded his PhD from the University of Georgia where he also did some post-doctorate work. In 2004, he joined the staff at the DRL as a Senior Extension Associate. He helped in the diagnostic laboratory and carried out a research program in which he was the first to identify the presence of a circovirus in ducks in the United States. Also, he followed up on Dr. Miguel's work and adapted the PCR test for the detection of DVE and duck circovirus. In his investigations on the duck circovirus he isolated from White Pekin ducks on Long Island, he conducted a genetic analysis to compare that virus with similar viruses isolated in Germany and Hungary. In 2007, following Dr. Sandhu's retirement, Dr. Banda assumed the position of Director at the laboratory but remained in that position only until March, 2008, when he resigned to accept a position at Mississippi State University.

Jaime Ruiz (2008-). Dr. Jaime Ruiz received his DVM degree from the Universidad de Los Llanos, Colombia, South America. He also earned a Master of Avian Medicine and a Master of Science in Immunology at the University of Georgia in the US. Before coming to the DRL, he had worked as a Poultry Technical Consultant for Elanco Animal Health for the Carribean in San Juan, Puerto Rico. In 2007, Dr Ruiz joined the DRL staff to assist Dr. Banda. Four months later, when Dr. Banda resigned to move to Mississippi State, Dr. Ruiz was named Director.

Part III: Summation

Summation

The foregoing account attests to a history of modest beginnings in the early 1900s, followed by a gradual and then more intense evolution into a well functioning and highly productive program encompassing many facets of the field of avian diseases. The fact that the New York State Legislature recognized the importance and economic ramifications of poultry production in the first three decades of the 20th century was particularly important. They provided the financial support and encouragement for the College's fledgling program in poultry disease control by funding new positions and facilities.

Poultry diseases are not "different" from those of other animals. Birds have various bacterial, viral, parasitic, neoplastic, *etc.* conditions, but approaches to control had to be devised that were quite different from those generally used by veterinary practitioners in the early years. This is in large part because of the low economic value of individual birds and, thus, the need to control diseases on a flock basis. Diagnosis of poultry diseases involved the examination of dead individuals in a flock, and the sacrifice (for examination) of sick birds, as well. The latter was obviously not an option with most farm or pet animals. Furthermore, treatments had to be devised that could be applied to large numbers of animals. Group chemotherapy, eradication, vaccination, genetic selection for disease resistance, and other similar approaches were required for poultry disease control and thus avian medicine led the way in the field of population medicine. It is not surprising that the early work at Cornell was aimed first at understanding a disease like pullorum, and then working toward its eradication. Diseases such as fowl pox, which were not easily eradicated, were the target of vaccination programs. Yet others, like coccidiosis, demanded attention through chemotherapy. Some were simply unknown entities for which research aimed at characterizing the disease was the focal point. Neoplastic diseases fell into this category. During the first three decades of the 1900s, all of these approaches and others were the province of faculty such as Jones, Pickens, Fuller, and Brunett.

The late 1920s and the early 1930s saw a significant increase in commitment on the part of the State and College. New positions to address problems in the fields of parasitology and neoplastic diseases were added through a special appropriation by the State Legislature. These new additions to the faculty (filled by Drs. Levine and Goss) signaled an appreciation of the need for fundamental research on selected disease problems. A new laboratory to provide diagnostic and extension services to the Long Island poultry industry was established at Farmingdale, another indication that poultry were viewed as an important part of New York State agriculture. Very significantly, in the early 1930s a research farm was established on Snyder Hill with pens to hold experimental groups of poultry and a sizeable building dedicated to poultry disease research. This was done with another special appropriation from the State.

The program got a tremendous boost when, following Dr. Brunett's retirement, Dr. Levine was given considerable authority to oversee the continued development of the poultry disease program at Cornell. Research had already received a good deal of attention, but he nurtured and expanded research programs, adding new faculty whose responsibilities were primarily in that arena. He established new programs *(e.g.*, the network of branch laboratories, a turkey disease program, the special duck research laboratory), added new very significant facilities such as the poultry virus isolation building and enhanced others, and fostered programs of basic and applied research that addressed the most significant poultry disease problems of the time. Without question, Dr. Levine provided the leadership that made Cornell one of the World's most productive and

influential centers dealing with avian diseases.

Areas of research that helped build Cornell's reputation as a leader were varied and reflected the interests and expertise of the faculty as well as the importance of the diseases prevalent at a given time. Pullorum disease and coccidiosis commanded a great deal of attention in the earlier years. Later, respiratory diseases took center stage and later yet, tumor virus research predominated. Intermixed was attention to a wide assortment of viral, bacterial, and other diseases of chickens, turkeys, and other species. Staff at the Long Island Duck Research Laboratory had their own agenda with a great need for research on serious bacterial and viral diseases. Additionally, they first developed and then produced federally licensed biologics for use by the duck industry.

Some diseases were studied by individuals, but much research was done by teamwork. The latter was especially true for respiratory and neoplastic diseases. Particularly after the early 1960s, many graduate students participated in the various research projects and there were a number of visiting scientists who also contributed. Postdoctoral associates became part of the scientific staff in later years. All in all, it is very significant to note that over the years, research evolved from "one-person" shows to highly interactive ones; collaboration between individuals who were both in-house and at other institutions became the norm and the benefits of such were reflected in the rate of progress.

Although teaching (other than mentoring of graduate students) was an important contribution by the avian disease group, it commanded a relatively small amount of faculty time. Service work, both diagnostic and extension, was the province of some of the faculty, but others were largely free to focus on research. It is fair to say that Cornell's reputation was founded more on research than on other activities.

Some of the "firsts" and other significant research for which Cornell can be justifiably proud include:

- Established the efficacy of sulfonamides as coccidiostats
- Identified several new coccidial species in chickens, turkeys and ducks
- First diagnosis of highly pathogenic avian influenza in the United States
- Developed and applied the procedure of antibiotic "egg-dipping" to prevent egg transmission of mycoplasmas
- Showed the interaction between infectious bronchitis, *Mycoplasma gallisepticum*, and *E. coli* in causing complicated chronic respiratory disease in chickens
- Discovered the bi-phasic nature of the cytolytic infection in Marek's disease (independently from similar work reported by English workers)
- Discovered the source of cell-free Marek's disease virus responsible for spread of the infection (the feather follicle epithelium)
- Developed extraction and lyophilization methods useful with cell-associated herpesviruses
- Provided the first unequivocal evidence that a herpesvirus can be oncogenic by using cell-free Marek's disease virus
- Isolated and characterized a serotype-2 Marek's disease virus (SB-1) as truly nononcogenic
- Reported the first field trial showing the efficacy of a bi-valent Marek's disease vaccine (HVT + SB-1) in controlling losses due to high pathogenicity MD viruses
- Discovered that cytokines are involved in the induction and maintenance of latency

with Marek's disease virus

- Discovered that B cells are the primary early target in Marek's disease and that T cells are susceptible to Marek's disease virus only after they are "activated"
- Developed the widely accepted model for the pathogenesis of Marek's disease
- Developed several immunization strategies for *R. anatipestifer* in ducks
- Isolated the causative virus and described duck virus hepatitis as a serious disease for ducks
- Provided the first isolation of duck virus enteritis virus in the United States
- Discovered the role of a herpesvirus (Marek's disease virus) in atherosclerosis
- Determined that *Clostridium colinum* is the causative agent of ulcerative enteritis in chickens
- Recognized a relationship between lens opacities and prior infection with avian encephalomyelitis virus
- Identified and characterized several viral pathogens (paramyxoviruses, orbiviruses and herpesviruses) of pet and wild bird species
- Established the benefits of oil adjuvant vaccines for use in breeder hens against infectious bursal disease and other pathogens
- Provided the first report of experimental egg transmission of avian reovirus
- Developed vaccines against Pacheco's disease (parrots) and canary pox
- Developed and deployed monoclonal antibodies useful for identification of the prevalent strains of infectious bronchitis virus causing field outbreaks of the disease.
- Established the "local-lesion" model for Marek's disease which led to the development of MD lymphoblastoid cell lines of a variety of phenotypes
- Showed that some strains of chickens can develop abdominal carcinomas or leiomyomas in the absence of all known oncogenic viruses
- Identified a latent state for infection with chicken infectious anemia virus and described a model for its maintenance and limited horizontal spread
- Determined a role for natural killer cells in Marek's disease and rotavirus infections
- Discovered that differences in age susceptibility to rotaviruses between chickens and turkeys is based on maturation of intestinal villi
- Provided the first evidence of the presence of the EDS76 agent in the United States
- Provided experimental evidence of transovarian transmission of *S. enteritidis*
- The first identification and molecular cloning of a duck circovirus
- Propated chicken NK cells *in vitro* for the first time
- Discovered that nitric oxide can inhibit virus replication *in vitro* and *in vivo*

It is often said that all good things come to an end. That is not necessarily the case with *all* good things, but it is certainly true for the avian medicine program at Cornell. Factors that spelled the doom of the vibrant program that flourished for decades include a gradual but marked reduction in the number of poultry industry operations in New York State, fiscal

constraints that dictated the loss of personnel, and lessened interest on the part of some administrators to support a species-oriented program in a discipline-oriented college. But perhaps the most credit (or blame) should be given to the success of the program. We and others had solved many of the disease threats that commanded attention. Some were eradicated (examples: pullorum disease, mycoplasmas, lymphoid leukosis). Others were well controlled by effective vaccines (examples: Newcastle disease, infectious bronchitis, laryngotracheitis, infectious bursal disease, fowl pox, avian encephalomyelitis, Marek's disease, duck virus hepatitis, duck virus enteritis, anatipestifer infection, cholera). Yet others are problems that were of less importance in New York State because broiler production is not part of the poultry industry here. In any case, it became difficult for the College to commit major resources to this field.

It was predictable that when avian medicine did not have administrative control over its own programs, competing areas would dominate. Indeed, that has been the case. So, when Dr. Schat retires in the not too distant future, Cornell's commitment to avian medicine research will be narrowed to the position held by Dr. Lucio in the diagnostic laboratory and a greatly diminished level of activity (essentially without a research component) at the Duck Research Laboratory. None-the-less, Cornell can be justifiably proud of its many achievements.

Part IV:Faculty, Graduate Students,Visiting Scientists, Postdoctoral Associates and Publications

Professional Staff in Avian Medicine

Name	Title	Tenure
Ithaca		
Angstrom, Clement I.	Instructor in Poultry Diseases	1938-41
Barber, Clifford	Instructor; Res Asst Prof	1937-45
Benson, J.P.	(Dept Pathol & Bact)	1919-..?..
Bloom, Stephen	Prof (Transfer from Poultry & Avian Sci)	1990-
Boyer, Clyde	Asst Prof; Assoc Prof	1952-65
Brandner, W.E.	Instructor in Poultry Diseases	1926-27
Brunett, Earl L.	Assist in Diagnosis	1919-22
	Instructor	1922-23
	Assist Prof	1923-42
Calnek, Bruce	Acting Asst Prof	1956-57
	Assoc Prof	1961-68
	Prof	1968-95
	Acting Dept Chair	1975-76
	Dept Chair,	1976-95
	Prof Emer	1995-
Carlisle, James	Assist Prof	1976-82
Caslick, W.C.	Instructor	1926–28
Cole, Randall	Prof Emer (from Poultry & Avian Sci)	1990-2006
Cowen, Barrett	Res Specialist, Research Associate	1968-78
Delaney, Mary	Res Associate	1990-95
DeVolt, H.M.	Instructor in Poultry Diseases	1926-27
Dougherty, Ellsworth	Asst Prof	1948-49
Ellis, Carlton, C.	Instructor	1931-36
Fabricant, Julius	Acting Asst Prof	1948-49
	Asst Prof,	1949-53
	Assoc Prof	1953-60
	Prof	1960-85
	Prof Emer	1985-
Fish, Pierre A.	Prof Physiology	1914-..?..
Fuller, J.W.	(Dept of Materia Medica)	1920-22
Gillespie, James H.	Asst Prof	1945-47
Gilman, H.L.	(Veterinary Exper. Station)	1929-30
Goldberg, S.A.	Assist in Pathol, Asst Prof	1914-20
Goss, Leonard J.	Instructor	1935
Graham, David	Prof	1981-87
Hayden, C.W.	Asst Prof, Physiol Dept	1917-28
Hitchner, Stephen	Prof, Dept Chair	1966-75
	Prof	1976-81
	Prof Emer	1981-
Hofstad, Mel	Instructor	1941-44
	Asst Prof	1944-45
Jones, F.S.	Instructor in Research Work in Poultry Diseases	1909-11

Levine, Philip P.	Research Instructor,	1935-42
	Asst Prof	1942-43
	Assoc Prof	1943-44
	Prof	1944-73
	Dept Chair	1961-66
	Prof Emer	1973-79
Lucio, Benjamin	Sr Res Associate	1987-89
	Assoc Prof	1989-93
	Sr Extension Associate	1993-
Mathey, William	Asst Prof	1958-60
Monlux, William	Res Instructor	1937-39
Moore, Earl N.	Assoc Prof	1946-52
Muscarella, Donna	Sr Res Associate	1990-
Mutalib, Ahmed	Sr Extension Associate	1989-93
Naqi, Syed	Prof	1987-2002
Olson, Carl	Res Asst Prof	1935-36
Peckham, Malcolm	Asst Prof	1949-53
	Assoc Prof	1953-60
	Prof	1960-84
Pickens, Earl M.	Assist Prof in Diagnosis	1914-18
Renshaw, Randall	Res Assoc	1993-95
Ross, Gary	Res Assoc	1985-87
Schat, Karel A.	Sr Res Assoc	1978-80
	Asst Prof	1980-82
	Assoc Prof	1982-89
	Prof	1989-
Sevoian, Martin	Asst Prof	1954-55
Shivaprasad, H.L.	Asst Prof	1985-89
Sickles, John	Asst Prof	1952-54
Sneath, Barbara	Res Assoc	1990-92
Taylor, John R.E.	Asst Prof	1956-58
East Aurora		
Mitchell, Grayson	Director of Laboratory	1946-48
Narotsky, Saul	Director of Laboratory	1948-71
Kingston		
Angstrom, Clem	Director of Laboratory	1946-65
Mitchell, Grayson	Director of Laboratory	1975-88
Oneonta		
Packer, Walter	Director of Laboratory	1951-55
Hagan, Jean	Director of Laboratory	1955-71
Sylstra, Anthony	Director of Laboratory	1949-51
Farmingdale		
Hendrickson, John	Asst in Poultry Diseases, Instructor, Asst Prof	1924-31
Hilbert, Kenneth	Instructor, Assist Prof, Dir of Laboratory	1928-62
Tax, Herman	Res Instructor	1937-40

Trayford, Arthur	Res Instructor	1927-..?..
Versluis, Hendrick	Res Instructor	1935-..?..
Spiegel, M.B.	Res Instructor	1939-40
Charles, A.S.	Res Instructor	1941-42
Stevenson, John C.	Res Instructor	1944
Laurence, David E.	Res Instructor	1945
Boerer, Maurice H.	Res Instructor	1946
Eisenberg, David	Res Instructor	1947

Duck Research Laboratory

Banda, Alejandro	Sr Extension Associate	2004-07
	Dir of Laboratory	2007-08
Carlson, J. H.	Senior Research Associate	1985-87
Dean, William	Poultry Nutritionist	1963-66
	Director of Laboratory	1966-91
	Part-time Administrator	1991-95
Dougherty, Ellsworth	Director of Laboratory	1949-64
Haider, Sajjad	Senior Research Associate	1973-85
Hwang, Jen	Duck Disease Specialist	1960-67
Layton, Herbert	Research Support Specialist	1978-85
Leibovitz, Louis	Field Veterinarian	1963-73
Miguel, Betty	Senior Research Associate	2000-03
Price, Jesse	Research Support Specialist	1959-77
Ruiz, Jaime	Senior Extension Associate	2007-08
	Director of Laboratory	2008-
Sandhu, Tirath	Field Vet, Sr Res Assoc	1973-91
	Director of Laboratory	1991-2007
Shawky, Samia	Senior Research Assoc	1993-2000
Toth, Thomas	Duck Research Specialist	1967-71
Urban, William	Director of Laboratory	1964-66
Woolcock, Peter	Senior Research Associate	1986-91

Graduate degrees awarded for studies on avian diseases at Cornell University

Adldinger, Hans Karl. Studies on the cell-association of Marek's disease virus and on the pathogenesis of the disease. PhD 1971. [Mentor: Calnek]

Aycardi, Eduardo. Studies with the toxins of *Clostridium botulinum* in domestic poultry. MS 1965. [Mentor: Boyer]

Barber, Thomas Lynwood. Procedures for the characterization of mycoplasmas, with special reference to culture purification and classification. PhD 1969. [Mentor: Fabricant]

Barber, Clifford Warren. A study of fowl paralysis. PhD 1935. [Mentor: Olafson]

Berkhoff, German Adolfo. The etiology and pathogenesis of ulcerative enteritis ("quail disease"). PhD 1973. [Mentor: Bruner]

Buscaglia, Celina, The relationship between immune competence and latency with Marek's disease herpesvirus. PhD 1988. [Mentor: Calnek]

Calnek, Bruce W. Studies on experimental egg transmission of pleuropneumonia-like organisms in chickens. MS 1956. [Mentor: Levine]

Chalquest, Richard Ross. Studies on the survival of pleuropneumonia like organisms (PPLO) in experimentally infected hatching eggs that were dipped in antibiotic solutions. MS 1959. [Mentor: Fabricant]

Chalquest, Richard Ross. A study of pleuropneumonialike organisms (PPLO) associated with synovitis in turkeys and chickens. PhD 1960. [Mentor: Fabricant]

Chandratilleke, Dhammapali. Characterization of proteins of chicken anemia virus. MS 1991. [Mentor: Schat]

Cowen, Barrett Stickney. Classification studies of avian infectious bronchitis virus strains. PhD 1973. [Mentor: Hitchner]

El-Attar, Abdallah Farid. Procedures for the elimination of Salmonella typhimurium from chicken hatching eggs by dipping. MS 1973. [Mentor: Fabricant]

Ellis, Carlton Case. Avian coccidiosis, studies of the viability of coccidial oocysts (E. tenella). PhD 1936. [Mentor: Brunett]

Fabricant, Catherine Grenci. Studies on blood levels of penicillin in domestic fowls and the effect of penicillin on poultry pathogens in vitro. MS 1948. [Mentor: Levine]

Fabricant, Julius. Studies on the diagnosis of Newcastle disease and infectious bronchitis of fowls. PhD 1949. [Mentor: Levine]

Fasina, Solomon Olubamji. Studies of the pathogenesis of avian hemorrhagic enteritis virus with fluorescent antibody technique. MS 1981. [Mentor: Fabricant]

Fernando, Warunakula Weerasuriya Dennis. The Influence of the bursa of Fabricus on the infection and pathological response of chickens exposed to Marek's disease herpesvirus. MS 1970. [Mentor: Calnek]

Gay, Kathryn. Infectious bronchitis virus detection and persistence in experimentally infected chickens. MS 2000. [Mentor: Naqi]

Gewirtz, Myrna. Elucidation of glycolytic and pentose phosphate enzyme patterns for characterization of the mycoplasma. PhD 1973. [Mentor: Fabricant]

Giordano, Anthony Robert. Attempts to substitute cytopathogenic viruses for Rous Sarcoma virus in the resistance inducing factor(RIF) test. MS 1963. [Mentor: Calnek]

Goss, Leonard J. A survey of the mortality in farm poultry flocks with special reference to the incidence of tumors. PhD 1938. [Mentor: Olafson]

Higgins, David Anthony. Fowl immunoglobulins : quantitative and functional relationship to genetic resistance to Marek's diseases. PhD 1974. [Mentor: Calnek]

Hofstad, Melvin Sidney. A study of infectious bronchitis in chickens. PhD 1944. [Mentor: Levine]

Hu, Liangbiao. Role of humoral immunity and T cell subpopulations in the pathogenesis of chicken infectious anemia. MS 1992. [Mentor: Lucio]

Jensen, Wayne Ivan. A study of Histomonas meleagridis in culture and in the tissues of the host. MS 1951. [Mentor: Levine]

Jia, Wei. Genetic mechanisms of variation in avian infectious bronchitis virus and localization of the coding regions of the serotype-specific epitopes of the strains ARK99 and MASS41. PhD 1995. [Mentor: Naqi]

Karaca, Kemal. Development of molecular probes for diagnosis and epidemiology of avian infectious bronchitis virus. PhD 1992. [Mentor: Naqi]

Karpas, Dov. Mycoplasma from ducks: isolation characterization and classification. MS 1969. [Mentor: Fabricant]

Levine, Pincus Philip. Observations on the biology and control of the poultry cestode Davainea proglottina (Dav.). PhD 1937. [Mentor: Hagan]

Li, Xinhui. Characterization of Marek’s disease virus serotype 1 phosphorylated polypeptide pp38 gene product and quail cell lines supporting replication of Marek’s disease virus serotype 1 and 2 and herpesvirus of turkeys. PhD 2004. [Mentor: Schat]

Lucio-Martinez, Benjamin. Differentiation and detection of infectious bronchitis virus subtypes

by immunofluorescence. MS 1969. [Mentor: Hitchner]

Lucio-Martinez, Benjamin. Effects of maternal antibodies on infectious bursal disease and active immunization. PhD 1979. [Mentor: Hitchner]

Machado, Antonio Vieire. The effect of infectious bronchitis and Newcastle disease on the blood cells of chickens. MS 1951. [Mentor: Levine]

Markowski Grimsrud, Carrie Justine. Cytotoxic T lymphocyte responses to Marek's disease herpesvirus-encoded glycoproteins and their impairment by chicken infectious anemia virus. PhD 2002. [Mentor: Schat]

McColl, Kenneth Alexander. Cellular and molecular studies on transformed cells in Marek's disease. PhD 1988. [Mentor: Calnek]

Miller, Myrna. Positive and negative regulation of transcription from the chicken infectious anemia virus promoter-enhancer and implications for latency and activation. PhD 2005. [Mentor: Schat]

Miller, Timothy K. Cellular immunity to Eimeria tenella in chickens. MS 1994. [Mentors: Bowman, Schat]

Moore, Franklin Robert. Cytogenetic and molecular studies of cell lines transformed with Marek's disease herpesvirus. PhD 1993. [Mentor: Bloom]

Murthy, Krishna Kesava. Immunization against Marek's disease with virus-versus tumor-associated antigens and studies on the characterization of a tumor-associated surface antigen. PhD 1979. [Mentor: Calnek]

Myers, Thomas Jeffrey. Immune responses of chickens to rotavirus infection. PhD 1990. [Mentor: Schat]

Ohashi, Kazuhiko. Characterization of Marek's disease virus-specific transcripts expressed in a Marek's disease lymphoblastoid cell line. PhD 1993. [Mentor: Schat]

Omar, Abdul Rahman. Cytotoxic T lymphocyte responses against Marek's disease herpesvirus. PhD 1997. [Mentor: Schat]

Patterson, F. D. Avian coccidiosis; a study of some of the factors concerned in its control. PhD 1932 [Mentor: Hagan/Brunett]

Pratt, William Donald. Cell-mediated immune responses of chickens to Marek's disease virus. PhD 1992. [Mentor: Schat]

Price, Jessie Isabel. Studies on Pasteurella anatipestifer infection in white Pekin ducks. PhD 1959. [Mentor: Bruner]

Rivas, Ariel Luis. Indications of immunodepression in chickens infected with various strains of Marek's disease virus. MS 1986. [Mentor: Fabricant]

Sabry, Mohamed Mohy El-Dine Zaki. Characterization and classification of avian mycoplasma. PhD 1968. [Mentor: Fabricant]

Schat, Karel Antoni. Cell-mediated immune responses induced by SB-1, an apparently non-oncogenic Marek's disease herpesvirus. PhD 1978. [Mentor: Calnek]

Sevoian, Martin. The effect of infectious bronchitis on the oviducts, egg production, and egg quality of laying chickens. MS 1954. [Mentor: Levine]

Shek, William Robert. Characterization of chicken lymphocytes infected with Marek's disease virus or turkey herpesvirus. PhD 1982. [Mentor: Calnek]

Smith, Maurice Wayne. Comparison of single and combined infections with low-virulence and high-virulence Marek's disease virus. PhD 1974. [Mentor: Calnek]

Spencer, James Lloyd. Studies on the survival of avian lymphomatosis virus – JM strain (non-RIF) following various storage conditions and treatments. MS 1966. [Mentor: Calnek]

Spencer, James Lloyd. Cultivation of Marek's disease virus in cell culture and the application of immunoflourescence for virus detection. PhD 1969. [Mentor: Calnek]

Taylor, John Ronald Eric. Studies on the isolation of the pleuropneumonia-like organism of chronic respiratory disease of fowl. MS 1956. [Mentor: Fabricant]

Thompson, Gertrude Averil Baker. Immune responses to IBV in the respiratory tract of chickens. PhD 1995. [Mentor: Naqi]

Toth, Thomas Elemer. Immune response of the White Pekin duck to viral, soluble protein and red blood cell antigens. PhD 1975. [Mentors: Hitchner, Norcross]

Volpini, Lucia M. Cytokine modulation of Marek’s disease virus genome expression. PhD 1993. [Mentor: Calnek]

Weinstock, Daniel. Cytotoxic T cells in reticuloendotheliosis virus and Marek’s disease virus-infected chickens. PhD 1989. [Mentor: Schat]

Witter, Richard Lawrence. The agar gel precipitin test in the diagnosis of infectious bronchitis of chickens, with notes on Newcastle disease. MS 1962 [Mentor: Fabricant]

Witter, Richard Lawrence. Influence of naturally occurring parental antibody on the epizootiology of infection of chickens with a resistance-inducing factor (RIF) type of visceral lymphomatosis virus. PhD 1964. [Mentor: Levine]

Xing, Zheng. Effect of cytokine expression and nitric oxide production on the pathogenesis of Marek’s disease. PhD 1999. [Mentor: Schat]

Yason, Carmencita Villar. Pathogenesis of experimental rotavirus infection in turkeys and chickens. PhD 1986. [Mentor: Schat]

Zecha, Bernard Clarence. A comparison of four techniques for measuring serologic response of chickens to Mycoplasma gallisepticum infections. MS 1970. [Mentor: Fabricant]

Visiting Scientists

Name	From	Year
Adene, Daniel	Nigeria	1986
Buscaglia, Celina	Argentina	Various times 1990s
Dren, Csaba	Hungary	2000
Garrido, Celedonio	Mexico	1969
Gaudry, Daniel	France	1977
Guo, Yu Pu	China	1984
Harrigan, Karl	Australia	1969
Heller, Daniel	Israel	1983-84
Hernandez, Eliseo	Mexico	1987
Hirai, Katsuya	Japan	1977
Ianconescu, Marius	Israel	1974
Li, Jinsong	China	1982
Linblad, Johan	Sweden	1972
Long, Peter	England	1968
Lorr, Nancy	USA	1993
Lucio, Benjamin	Mexico	1986
Machado, Antonio V.	Brazil	1949
Martins, Nelson Rodriguez	Brazil	2004
Menendez, Nestor	Argentina	1973, 1981
Patrascu, Ionel	Romania	1970
Rosenwald, A.S.	Univ Calif, Davis	1966
Samberg, Yehuda	Israel	*ca.* 1970
Shafqat, Shela	Pakistan	1976
Shimi, Ahmed	Iran	1955
Sohrab, V	Iran	1950s
Stiube, Peter	Romania	1980
Trenchi, Herbert	Uruguay	1940s
Wakenell, Patricia	Univ Calif, Davis	1999
Weisman, Joram	Israel	1976
Wightman, Charles	Univ Calif, Davis	1967
Yamaguchi, Yoshi	Japan	1999
Zhou, Wenping	China	1993

Postdoctoral Associates

Name	From	Faculty sponsor	Years at Cornell
Cardona, Carol	USA	Schat	1998-2000
Delany, Mary	USA	Bloom	1992-95
Dhondt, Keila	USA	Schat	2007
Duan, Yuyou	China	Schat	2000
Hemendinger, Richelle	USA	Bloom	1993-95
Jia, Wei	USA	Schat	1997-99
Poonia, Bhawna	India	Schat	2001-03
Jarosinski, Keith	USA	Schat	1999-2003
Piepenbrink, Mike	USA	Schat	2007
Renshaw, Randall	USA	Schat	1985-87
Ross, Gary	USA	Schat	1994-96
Uni, Zehava	Israel	Schat	1991-92
Yunis, Reem	Israel	Schat	2001-03

Publications

Abplanalp, H., K.A. Schat, and B.W. Calnek. Genetic resistance to Marek's disease in congenic strains of chickens. In: Proc. International Symposium on Marek's disease (Calnek, B.W., and Spencer, J.L. eds.). Amer. Assoc. Avian Pathol., Kennett Square, PA. pp.347-358, 1985.

Adldinger, H.K. and B.W. Calnek. Effect of chelators on in vitro infection with Marek's disease virus. In: Oncogenesis and Herpesviruses (Biggs, P.M., de-The, G. and Payne, L.N., eds.). IARC, Lyon. pp. 99-105, 1972.

Adldinger, H.K. and B.W. Calnek. Pathogenesis of Marek's disease: early distribution of virus and viral antigens in chickens. J. Natl. Cancer Inst. 50:1287-1289, 1973.

Adldinger, H.K. and B.W. Calnek. An improved in vitro assay for cell-free Marek's disease virus. Arch. ges. Virusforsch. 34:391-395, 1971.

Adler, H.E., J. Fabricant et al. Isolation and identification of pleuropneumonia-like organisms of avian origin. Am. J. Vet. Res, 19:440-447, 1958.

Al Aubaidi, J.M. and J. Fabricant. The practical application of immunofluorescence (agar block technic) for the identification of mycoplasma. Cornell Vet. 61:519-542, 1971.

Andreasen, Jr., J. R. and T. Sandhu. Pasteurella anatipestifer-like bacteria associated with respiratory disease in pigeons. Avian Dis. 37: 908-911, 1993.

Angstrom, C. I. Poultry disease diagnosis in the laboratory. Proc. Amer. Vet. Med. Assoc, 1950

Angstrom, C. I. Diseases don't cause all the losses. The Turkey World 30:16, 1955.

Angstrom, C. I. Summer health program for layers. Poultry Tribune 61:9, 1955.

Angstrom, C. I., E. S. Bryant, W. Gerencer, and G Stein. Report of the committee on nomenclature and reporting of diseases. Avian Dis. 13:925-931, 1969.

Angstrom, C. I., E. S. Bryant, W. Gerencer, and George Stein. Report of the committee on nomenclature and reporting of diseases. Avian Dis. 14:815, 1970.

Angstrom, C. I., E. S. Bryant, W. Gerencer, and G. Stein. Report of the committee on nomenclature and reporting of diseases. Avian Dis. 15:959, 1971.

Angstrom, C. I., H. L. Chute, M. S. Cover, and G. H. Snoeyenbos. Report of the committee on nomenclature and reporting of diseases. Avian Dis. 3:488-493, 1959.

Angstrom, C. I., H. L. Chute, M. S. Cover, and G. H. Snoeyenbos. Report of Committee on Nomenclature and Reporting of Diseases. Avian Dis. 4:549, 1960.

Angstrom, C. I., H. L. Chute, M. S. Cover, and G. H. Snoeyenbos. Report of committee on nomenclature and reporting of diseases. Avian Dis. 5:463, 1961.

Angstrom, C. I., H. L. Chute, M. S. Cover, and G. H. Snoeyenbos. Report of the committee on nomenclature and reporting of diseases. Avian Dis. 6:516, 1962.

Angstrom, C. I., H. L. Chute, M. S. Cover, and G. H. Snoeyenbos. Report of the committee on nomenclature and reporting of diseases. Avian Dis. 7:509, 1963.

Angstrom, C. I., H. L. Chute, M. S. Cover, and G. H. Snoeyenbos. Report of the committee on nomenclature and reporting of diseases. Avian Dis. 8:687, 1964.

Angstrom, C. I., H. L. Chute, M. S. Cover, and G. H. Snoeyenbos Report of the committee on nomenclature and reporting of diseases. Avian Dis. 9:687, 1965.

Angstrom, C. I., H. L. Chute, M. S. Cover, and G. H. Snoeyenbos. Report of the committee on nomenclature and reporting of diseases. Avian Dis. 10:535, 1966.

Angstrom, C. I., H. L. Chute, M. S. Cover, and G. H. Snoeyenbos. Report of the committee on nomenclature and reporting of diseases. Avian Dis. 11:727, 1967.

Angstrom, C. I., F. R. Craig, and D. D. Payne. Report of the committee on nomenclature and reporting of diseases. Avian Dis. 12:730, 1968.

Ardia, D.R., and Schat, K.A. Ecoimmunology. In: Avian Immunology (Davison, F., Kaspers, B., and Schat, K.A., eds.). Elsevier, London, San Diego, CA. pp. 421-442, 2008.

Ardia, D.R, K.A. Schat, and D.W. Winkler. Reproductive effort reduces long-term immune function in breeding tree swallows (Tachycineta bicolor). Proc. Royal. Soc. Lond. B 270:1679-1683, 2003.

Ash, W. and J. Hwang. Evidence for genetic differences in resistance of ducklings to virus hepatitis. Proc. W. Virginia Academy of Science 38:79-83, 1966.

Ash, W. J. and P. Nothers. Sex differences in economic traits of Long Island White Pekin market ducklings. Nature 201:571-572, 1964.

Ash, W. J. Studies of reproduction in ducks. 1. The duration of fertility and hatchability of White Pekin duck eggs. Poult. Sci. 41:1123-1126, 1962.

Ash, W. J. and L. L. Hulbert. Einfluss der photoperiode auf weibliche Pekingenten. Arch. Geflugel Kleintierkd 19:169-172, 1970.

Asif, M., J.W. Lowenthal, M.E. Ford, K.A. Schat, W.G. Kimpton, and A.G.D. Bean. IL-6 expression following IBV infection in chickens. Viral Immunol. 20:479-486. 2007.

Bagust, T.J., B.W. Calnek, and K.J. Fahey. Gallid-herpesvirus infection in the chicken. 3. Reinvestigation of the pathogenesis of infectious laryngotracheitis in acute and early post-acute respiratory disease. Avian Dis. 30:179-190, 1986.

Baker, R. C., R. C. Qureshi, T. S. Sandhu and J. F. Timoney. The frequency of salmonellae on duck eggs. Poult. Sci. 64:646-652, 1985.

Banda, A., R.I. Galloway-Haskins, T.S. Sandhu, and K.A. Schat. Genetic analysis of a duck circovirus (DuCV) detected in commercial Pekin ducks in New York. Avian Dis. 51:90-95. 2007.

Bankowski, R.A., R. Corstvet, and J. Fabricant. A tissue culture-modified Newcastle disease virus. II. Immunogenicity of the live culture-modified Newcastle disease virus in chickens. Avian Dis. 2:227-240, 1958.

Bankowski, R.A., R. Corstvet, and J. Fabricant. A tissue culture-modified Newcastle disease virus. III. The immunity induced by the modified virus and crystal-violet inactivated vaccines in laying birds. Avian Dis. 2:466-493, 1958.

Barber, C. W. A study of fowl paralysis. Cornell Vet. 29:41, 1939.

Barber, C. W. Studies on the avian leukosis complex. Cornell Veterinarian. 37:349-351, 1947.

Barber, C. W. Transmission experiments on the avian leucosis complex. Cornell Vet. 38: 130-134, 1948.

Barber, C. W. The effect of the rearing environment upon the incidence of the avian leukosis complex (pp73-79). Report of NYS Veterinary College for 1941-42. pp. 73-79, 1942

Barber, T. L. and J. Fabricant. Identification of Mycoplasmatales. 2. Procedures for both characterization and purification. Appl. Microbiol. 21:600-605, 1971.

Barber, T. L. and J. Fabricant. Identification of Mycoplasmatales. I. Characterization procedures. Appl. Microbiol 21:594-599, 1971.

Barber, T. L. and J. Fabricant. A suggested reclassification of avian mycoplasma serotypes. Avian Dis. 15:125-138, 1971.

Boyer, C. I., Jr. Better keep after blackhead. Turkey World. p. 17, 1954.

Boyer, C. I., Jr. Salmonellosis: Source of paratyphoid infections in turkeys. Cornell Poultry Pointers 13:6, 1961.

Boyer, C. I., Jr. Turkeys vaccinated against fowl cholera and erysipelas. Farm Research, Cornell Agric. Exp. Sta. January-February, 1964.

Boyer, C. I., Jr. and J. A. Brown. The comparative coccidiostatic activity of some drugs against turkey coccidia. Proc. 90th Ann. Meeting, AVMA. p. 328, 1953.

Boyer, C. I., Jr. and J. A. Brown. Turkey disease research at Cornell. Turkey News, N. Y. State Turkey Breeders Assoc. 10:1, 1955

Boyer, C. I., Jr. and J. A. Brown. Oral therapy for erysipelas in turkeys. Avian Dis. 1:275-290, 1957.

Boyer, C.I., Jr. and J. A. Brown. Protection of turkeys vaccinated with fowl cholera bacterins. Avian Dis. 7:165-167, 1963.

Boyer, C.I., Jr. and J. A. Brown. Protection of turkeys vaccinated with fowl cholera bacterins. Avian Dis. 7:165, 1963.

Boyer, C. I., Jr., J. Fabricant, and J. A. Brown. Non-specific plate agglutination reactions with PPLO antigen (abstract). Avian Dis. 4:546, 1960.

Boyer, C. I., Jr., S. Narotsky, D. W. Bruner and J. A. Brown. Salmonellosis in turkeys and chickens associated with contaminated feed. Avian Dis. 6:43, 1962.

Brentano, L., S. Lazzarin, T.A.P. Klein, and K.A. Schat. Detection of chicken anemia virus in the gonads and in the progeny of broiler breeder hens with high neutralizing antibody titer. Vet. Microbiol. 105:65-72, 2005.

Brentano, L., N. Mores, I. Wentz, D. Chandratilleke, and K.A. Schat. Isolation and identification of chicken infectious anemia virus in Brazil. Avian Dis. 35:793-800, 1991.

Bruner, D.W., and J. Fabricant. A strain of Moraxella anatipestifer (Pfeifferella anatapestifer) isolated from ducks. Cornell Vet. 44:461-464, 1954.

Brunett, E.L. Bacillary white diarrhea. Report of NYS Veterinary College for 1925-26. pp. 131-145, 1926.

Brunett, E.L. Bacillary white diarrhea control project.1926-27. Report of NYS Veterinary College for 1927-28. pp. 228-238, 1928.

Brunett, E.L. Transmission of bacterium pullorum infection among mature chickens. Cornell Vet. 18: 135, 1928.

Brunett, E.L. Transmission of bacterium pullorum infection among mature chickens. Report of NYS Veterinary College for 1928-29. pp. 98-206, 1929.

Brunett, E.L. Transmission of Bacterium pullorum infection among mature chickens - II. Report of NYS Veterinary College for 1929-30. pp. 114-116, 1930.

Brunett, E.L. Pullorum disease in the mature turkey. Report of NYS Veterinary College for 1929-30. pp. 105-108, 1930.

Brunett, E.L. Paratyphoid infection of pigeons. Report of NYS Veterinary College for 1929-30. pp. 89-93, 1930.

Brunett, E.L. Studies on fowl pox vaccination. J. Amer. Vet. Med. Assoc. 83:774, 1933.

Brunett, E.L. Some observations on pox virus obtained from a turkey. Report of NYS Veterinary College for 1932-33. pp. 69-70, 1933.

Brunett, E. L. and M. S. Hofstad. Erysipelas in turkeys in New York State. Cornell Vet. 33:105, 1943.

Brunett, E.L. and S. Kondo. Fowl Plague. Report of NYS Veterinary College for 1924-25. pp. 209-224, 1925.

Bülow V. Von, and K.A. Schat. Chicken infectious anemia virus. In: Diseases of Poultry (B.W. Calnek, H.J. Barnes, C.W. Beard, L.R. McDougald, and Y.M. Saif, eds.) 10th Ed., Iowa State Univ Press, Ames, Iowa. pp.739-756, 1997.

Buscaglia, C., and B.W. Calnek. Maintenance of Marek's disease herpesvirus latency in vitro by a factor found in conditioned medium. J. Gen. Virol. 69:2809-2818, 1988.

Buscaglia, C., B.W. Calnek and K.A. Schat. Effect of immunocompetence on the establishment and maintenance of latency with Marek's disease herpesvirus. J. Gen. Virology 69:1067-1077, 1988.

Buscaglia, C., B.W. Calnek and K.A. Schat. Effect of reticuloendotheliosis virus and infectious bursal disease virus on Marek's disease herpesvirus latency. Avian Pathol. 18:265-281, 1989.

Calnek, B.W. and others. Report of the AAAP-sponsored Leukosis Workshop. Avian Dis. 11:694-702, 1967.

Calnek, B.W. Established cell lines of avian lymphocytes and their use. In: Avian Immunology - Basis and Practice (Toivanen, A., and Toivanen, P., eds.). Vol. II. CRC Press, Boca Raton, FL pp. 57-70. l987.

Calnek, B.W. Immunologically rational vaccination programs. Proc. Aust. Vet. Poultry Assoc. Conf. on Disease Prevention and Control in Poultry Production. Sydney, Australia. pp. 177-180, 1983.

Calnek, B.W. Marek's disease - a model for herpesvirus oncology. CRC Critical Reviews in Microbiology 12:293-320, 1986.

Calnek, B.W. An antigen in normal avian cells which confuses virological and serological tests. Avian Pathol. 4:255-269, 1975.

Calnek, B.W. Discussion summary. In: Oncogenesis and Herpesviruses II (G. de-The, M.A. Epstein, and H. zur Hausen, eds.). IARC Scientific Publications, Lyon. pp. 505-506, 1975.

Calnek, B.W. Pathogenesis of Marek's disease - A review. In: Proc. International Symposium on Marek's disease (Calnek, B.W., and J. L.Spencer, eds.). Amer. Assoc. Avian Pathol., Kennett Square, PA. pp. 374-390, 1985.

Calnek, B.W. Research Note. Precipitin in chicken sera reactive against tryptose phosphate broth. Avian Dis. 18:627-630, 1974.

Calnek, B.W. Immunity and Marek's disease. In: Unifying Concepts of Leukemia Bibl. Haemat. No. 39, (R.M. Dutcher and L. Chieco-Bianchi, eds.). Karger, Basel. pp. 389-394, 1973.

Calnek, B.W. Influence of age at exposure on the pathogenicity on antibody production in Marek's disease. J. Natl. Cancer Inst. 51:929-939, 1973.

Calnek, B.W. Chicken neoplasia - A model for cancer research. Br. Poult. Sci. 33:3-16, 1992.

Calnek, B.W. Marek's disease virus and lymphoma. In: Oncogenic Herpesviruses (F. Rapp, ed). CRC Press, Boca Raton. pp. 103-144, 1980.

Calnek, B.W. Effects of passive antibody on early pathogenesis of Marek's disease. Infect. and Immun. 6:193-198, 1972.

Calnek, B.W. Neoplastic Diseases. Introduction. In: Diseases of Poultry, 6th Ed. (M.S. Hofstad, B.W. Calnek, C.F. Helmboldt, W.M. Reid, and H. W. Yoder, Jr., eds.). Iowa State University Press, Ames. 467-470, 1971

Calnek, B.W. Neoplastic Diseases. Introduction. In: Diseases of Poultry, 7th Ed. (M.S. Hofstad, B.W. Calnek, C.F. Helmboldt, W.M. Reid, and H. W. Yoder, Jr., eds.) Iowa State University Press, Ames. 383-385, 1978.

Calnek, B.W. Neoplastic Diseases. Introduction. In: Diseases of Poultry, 8th Ed. (M.S. Hofstad, B.W. Calnek, H. John Barnes, W.M. Reid, and H. W. Yoder, Jr., eds.). Iowa State University Press, Ames. 323-325, 1984.

Calnek, B.W. Neoplastic Diseases. Introduction. In: Diseases of Poultry, 9th Ed. (B.W. Calnek, H. John Barnes, C.W. Beard, W.M. Reid, and L.R. McDougald, eds.). Iowa State University Press, Ames. 340-342, 1991

Calnek, B.W. Neoplastic Diseases. Introduction. In: Diseases of Poultry, 10th Ed. (B.W. Calnek, H. John Barnes, C.W. Beard, L.R. McDougald, and Y.M. Saif, eds.). Iowa State University Press, Ames.367-368, 1997.

Calnek, B.W. Reticulotheliosis. In: Diseases of Poultry, 6th Ed. (M.S. Hofstad, B.W. Calnek, C.F. Helmboldt, W.M. Reid, and H. W. Yoder, Jr., eds.). Iowa State University Press, Ames. 568-385, 1978.

Calnek, B.W. Antibody development in chickens exposed to Marek's disease virus. In: Oncogenesis and Herpesviruses (Biggs, P.M. de-The, G. and Payne, L.N., eds.), Lyon, IARC. pp. 129-136, 1972.

Calnek, B.W. Control of avian encephalomyelitis: A historical account. Avian Dis. 42:632-647,1998.

Calnek, B.W. Duck virus hepatitis. In: Virus Infections of Vertebrates, (M.C. Horzinek, Series ed.), Vol. 4, Virus Infections of Birds (J.B. McFerran and M.S. McNulty, eds.). Elsevier, The Netherlands. pp. 485-495, 1993.

Calnek, B.W. Marek's disease: Contributions to comparative herpes virology and oncology. Proc. XIX Worlds Poult. Congr., Amsterdam, The Netherlands. pp. 220-232,1992.

Calnek, B.W. Lesions in young chickens induced by lymphoid leukosis virus. Avian Dis. 12:111-129, 1968.

Calnek, B.W. Lymphoid leukosis virus: A survey of commercial breeding flocks for genetic resistance and

incidence of embryo infection. Avian Dis. 21:104-111, 1968.

Calnek, B.W. Studies on the RIF test for the detection of an avian leukosis virus. Avian Dis. 9:545-559, 1965.

Calnek, B.W. A simplified tissue-culture technique to detect Rous sarcoma virus and its antibody. Avian Dis. 8:163-172, 1964.

Calnek, B.W. Morphological alteration of RIF-infected chick embryo fibroblasts. National Cancer Institute Monograph No. 17:425-447, 1964.

Calnek, B.W. Lymphomagenesis in Marek's disease. Avian Pathol. 27:S54-S64, 1998.

Calnek, B.W. Leukosis in chickens is more than one disease. Farm Research Reprint No. 311, Cornell Univ. Agric. Exper. Sta. Jan-Mar, 1966.

Calnek, B.W. Genetic Resistance. Chapter 11, in: Marek's Disease Scientific Basis and Methods of Control (Payne, L.N., ed.), Martinus Nijhoff Publishing, -Boston/Dordrecht/Lancaster. pp. 293-328, 1985.

Calnek, B.W. Introduction - Miscellaneous Viral Infections, Chapter 29. In: Diseases of Poultry (B. W. Calnek, Barnes, J.H., Beard, C.W., Reid, W.M., and Yoder, H.W., Jr., eds.). 9th Ed., Iowa State University Press, Ames, Iowa. p. 664, 1991.

Calnek, B.W. Marek's disease vaccines. Proc. Symp. Int. Assoc. Biol. Stand., Lyon, France. Dec. 6-8, 1981.

Calnek, B.W. Avian encephalomyelitis virus. In: Virus Infections of Vertebrates (M.C. Horzinek, Series ed.), Vol. 4, Virus Infections of Birds (J.B. McFerran and M.S. McNulty, eds.). Elsevier, The Netherlands. pp.469-478, 1993.

Calnek, B.W. Research Note--Hemagglutination-inhibition antibodies against an adenovirus (virus 127) in white pekin ducks in the United States. Avian Dis. 22:693-697, 1978.

Calnek, B.W., D.F. Adene, K.A. Schat and H. Abplanalp. Immune responsiveness versus susceptibility to Marek's disease. Poultry Sci. 68:17-26.

Calnek, B.W. and H.K. Adldinger. Some characteristics of cell-free preparations of Marek's disease virus. Avian Dis. 15:508-517, 1971.

Calnek, B.W., H.K. Adldinger, and D.E. Kahn. Feather follicle epithelium: a source of enveloped and infectious cell-free herpesvirus from Marek's disease. Avian Dis. 14:219-233, 1970.

Calnek, B.W., J.C. Carlisle, J. Fabricant, K.K. Murthy and K.A. Schat. Comparative pathogenesis studies with oncogenic and nononcogenic Marek's disease viruses and turkey herpesvirus. Proc. Symp. Resistance and Immunity to Marek's disease, W. Berlin, Oct. 31-Nov. 2, 1978. pp. 168-178.

Calnek, B.W., J.C. Carlisle, J. Fabricant, K.K. Murthy and K.A. Schat. Comparative pathogenesis studies with oncogenic and nononcogenic Marek's disease viruses and turkey herpesvirus. Am. J. Vet. Res. 40:541-548, 1979.

Calnek, B.W. and B.S. Cowen. Adenoviruses of chickens: Serologic groups. Avian Dis, 19:91-103, 1975.

Calnek, B.W. and J. Fabricant. Immunity to infectious avian encephalomyelitis. In: Avian Immunology (M.E. Rose, L.N. Payne and B.M. Freeman, eds.) British Poultry Sci. Ltd., Edinburgh, 1981. pp. 235-244.

Calnek, B.W., J. Fabricant, K.A. Schat and K.K. Murthy. Pathogenicity of low-virulence Marek's disease viruses in normal versus immunologically compromised chickens. Avian Dis. 21:346-358, 1977.

Calnek, B.W., J. Fabricant, K.A. Schat and K.K. Murthy. Rejection of a transplantable Marek's disease lymphoma in normal versus immunologically deficient chickens. J. Natl. Cancer Inst. 60:623-631, 1978.

Calnek, B.W., K.J. Fahey, and T.J. Bagust. In vitro infection studies with infectious laryngotracheitis virus. Avian Dis. 30:327-336, 1986.

Calnek, B.W., C. Garrido, W. Okazaki, and I.V. Patrascu. In vitro methods for assay of turkey herpesvirus (a report by a subcommittee of the Leukosis Committee of the American Association of Avian Pathologists). Avian Dis. 16:52-56, 1972.

Calnek, B.W., R.W. Harris, C. Buscaglia, K.A. Schat, and B. Lucio. Relationship between the immunosuppressive potential and the pathotype of Marek's disease virus isolates. Avian Diseases 42:124-132, 1998.

Calnek, B.W., D.A. Higgins and J. Fabricant. Rous sarcoma regression in chickens resistant or susceptible to Marek's disease. Avian Dis, 19:473-482, 1975.

Calnek, B.W. and S.B. Hitchner. Localization of viral antigen in chickens infected with Marek's disease herpesvirus. J. Nat. Cancer Inst. 43:935-949, 1969.

Calnek, B.W. and S.B. Hitchner. Localization of viral antigen in chickens infected with Marek's disease herpesvirus. Proc. IVth Congress of the World Veterinary Poultry Assoc., Belgrade, Yugoslavia, September 15-17, 1969. pp. 277-283.

Calnek, B.W., S.B. Hitchner, and H.K. Adldinger. Lyophilization of cell-free Marek's disease herpesvirus and a herpesvirus from turkeys. Applied Microbiol. 20:723-726, 1970.

Calnek, B.W. and S.B. Hitchner. Survival and disinfection of Marek's disease virus and the effectiveness of filters in preventing airborne dissemination. Poultry Sci. 53:35-43, 1973.

Calnek, B.W. and H. Jehnich. Studies on avian encephalomyelitis. I. The use of a serum-neutralization test in the detection of immunity levels. Avian Dis. 3:96-104, 1959.

Calnek, B.W. and H. Jehnich. Studies on avian encephalomyelitis. II. Immune responses to vaccination

procedures. Avian Dis. 3:226-239, 1959.

Calnek, B.W. and P.P. Levine. Studies on experimental egg transmission of pleuropneumonia-like organisms in chickens. Avian Dis. 1:208-222, 1957.

Calnek, B.W., B. Lucio-Martinez, C. Cardona, R.W. Harris, K.A. Schat, and C. Buscaglia. Comparative susceptibility of Marek's disease cell lines to chicken infectious anemia virus. Avian Diseases 44: 114-124, 2000.

Calnek, B.W., B. Lucio and K.A. Schat. Pathogenesis of Marek's disease virus-induced local lesions. 2. Influence of virus strain and host genotype. In: Advances in Marek's Disease Research (S. Kato, T. Horiuchi, T. Mikami, and K. Hirai, eds.). Proc. 3rd Intl. Symp. on Marek's disease. Sept. 12-16, 1988, Osaka, Japan.

Calnek, B.W., B. Lucio, K.A. Schat and H. Lillehoj. Pathogensis of Marek's disease virus-induced local lesions. 1. Lesion characterization and cell line establishment. Avian Dis. 33:291-302, 1989.

Calnek, B.W., R.E. Luginbuhl, and C.F. Helmboldt. Avian encephalomyelitis. Chapter 20, In: Diseases of Poultry, 9th Ed. (B. W. Calnek, Barnes, J.H., Beard, C.W., Reid, W.M., and Yoder, H.W., Jr., eds.)., Iowa State University Press, Ames, Iowa. pp. 520-531, 1991.

Calnek, B.W., R.E. Luginbuhl, and C.F. Helmboldt. Avian encephalomyelitis. Chapter 21, In: Diseases of Poultry, 10th Ed. (B. W. Calnek, Barnes, J.H., Beard, C.W.,McDougald, L.R., and Saif, Y.M., eds.). Iowa State University Press, Ames, Iowa. pp. 520-531, 1997.

Calnek, B.W. and S.H. Madin. Characteristics of in vitro infection of chicken kidney cell cultures with a herpesvirus from Marek's disease. Amer. J. Vet. Res. 30:1389-1402, 1969.

Calnek, B.W., S.H. Madin, and A.J. Kniazeff. Susceptibility of cultured mammalian cells to infection with a herpesvirus from Marek's disease and T-virus from reticuloendotheliosis of chickens. Am. J. Vet. Res. 30:1403-1412, 1969.

Calnek, B.W., K.K. Murthy and K.A. Schat. Establishment of Marek's disease lymphoblastoid cell lines from transplantable versus primary lymphomas. Int. J. Cancer 21:100-107, 1978.

Calnek, B.W. and L.N. Payne. Lack of correlation between Marek's disease tumor induction and expression of endogenous RNA tumor virus genome. Int. J. Cancer 17:235-244, 1976.

Calnek, B.W. and K.A. Schat. Proliferation of chicken lymphoblastoid cells after in vitro infection with Marek's disease virus. Avian Dis. 35:728-737, 1991.

Calnek, B.W., K.A. Schat and J. Fabricant. Modification of Marek's disease pathogenesis by in ovo infection or prior vaccination. Cold Spring Harbor Conferences on Cell Proliferation, Vol. 7. pp. 185-197, 1980.

Calnek, B.W., K.A. Schat, E.D. Heller, and C. Buscaglia. In vitro infection of T-lymphoblasts with Marek's disease virus. In: Proc. International Symposium on Marek's disease. (Calnek, B.W. and Spencer, J.L., eds.). Amer. Assoc. Avian Pathol., Kennett Square, PA. pp. 173-187, 1985.

Calnek, B.W., K.A. Schat, M.C. Peckham, and J. Fabricant. Field trials with a bivalent vaccine (HVT and SB-1) against Marek's disease. Avian Dis. 27:844-849, 1983.

Calnek, B.W., K.A. Schat, L.J.N. Ross and C-L.H. Chen. Further characterization of Marek's disease virus-infected lymphocytes. II. In vitro infection. Int. J. Cancer 33:399-406, 1984.

Calnek, B.W., K.A. Schat, L.J.N. Ross, W.R. Shek and C.-L.H. Chen. Further characterization of Marek's disease virus-infected lymphocytes. I. in vivo infection. Int. J. Cancer 33:389-398, 1984.

Calnek, B.W., K.A. Schat, W.R. Shek, and J. Fabricant. Marek's disease studies. Proc. Aust. Vet. Poultry Assoc. Conf. on Disease Prevention and Control in Poultry Production. Sydney, Australia. pp.163-176, 1983.

Calnek, B.W., W.R. Shek, N.A. Menendez, and P. Stiube. Serological cross reactivity of avian adenovirus serotypes in an enzyme-linked immunosorbent assay. Avian Dis. 26:897-906, 1982.

Calnek, B.W., W.R. Shek and K.A. Schat. Spontaneous and induced herpesvirus genome expression in Marek's disease tumor cell lines. Infect. Immun. 34:483-491, 1981.

Calnek, B.W., W.R. Shek and K.A. Schat. Latent infections with Marek's disease virus and turkey herpesvirus. J. Natl. Cancer Inst. 66:585-590, 1981.

Calnek, B.W., Shek, W.R., Schat, K.A., and J. Fabricant. Dose-dependent inhibition of virus rescue from lymphocytes latently infected with turkey herpesvirus or Marek's disease virus. Avian Dis. 26:321-331, 1982.

Calnek, B.W. and M.W. Smith. Vaccination against Marek's disease with cell-free turkey herpesvirus: Interference by maternal antibody (Research Note). Avian Dis. 16(4):945-957, 1972.

Calnek, B.W. and Patricia J. Taylor. Studies on avian encephalomyelitis. III. Immune response to beta-propiolactone inactivated virus. Avian Dis. 4:116-122, 1960.

Calnek, B.W., Patricia J. Taylor and Martin Sevoian. Studies on avian encephalomyelitis. IV. Epizootiology. Avian Dis. 4:325-347, 1960.

Calnek, B.W., Patricia J. Taylor and Martin Sevoian. Studies on avian encephalomyelitis. V. Development and application of an oral vaccine. Avian Dis. 5:297-312, 1961.

Calnek, B.W., Tito Ubertini, and H.K. Adldinger. Viral antigen, virus particles, and infectivity of tissues from chickens with Marek's disease. J. Nat. Cancer Inst. 45:341-351, 1970.

Calnek, B.W. and R.L. Witter. Marek's disease. In: Diseases of Poultry 6th Ed. (M.S. Hofstad, B.W. Calnek,

C.F. Helmboldt, W.M. Reid, and H. W. Yoder, Jr., eds.). Iowa State University Press, Ames. pp. 385-418, 1971;

Calnek, B.W. and R.L. Witter. Marek's disease. In: Diseases of Poultry 7th Ed.(M.S. Hofstad, B.W. Calnek, C.F. Helmboldt, W.M. Reid, and H. W. Yoder, Jr., eds.). Iowa State University Press, Ames. pp. 470-507, 1978.

Calnek, B.W. and R.L. Witter. Marek's Disease. In:Diseases of Poultry 8th Ed.(M.S. Hofstad, B.W. Calnek, H. John Barnes, W.M. Reid, and H. W. Yoder, Jr., eds.). Iowa State University Press, Ames. pp. 325-360, 1984.

Calnek, B.W. and R.L. Witter. Marek's Disease. In:Diseases of Poultry 9th Ed.(B.W. Calnek, H. John Barnes, C.W. Beard, W.M. Reid, and L.R. McDougald, eds.). Iowa State University Press, Ames. pp. 342-385, 1991.

Calnek, B.W. and R.L. Witter. Marek's Disease. In:Diseases of Poultry, 10th Ed.(B.W. Calnek, H. John Barnes, C.W. Beard, L.R. McDougald, and Y.M. Saif, eds.). Iowa State University Press, Ames. pp. 369-413, 1997.

Cardona C., B. Lucio, P. O'Connell, J. Jagne, and K.A. Schat. Humoral immune responses to chicken infectious anemia virus in three strains of chickens. Avian Dis 44:661-667, 2000.

Cardona C, W.B. Oswald, and K.A. Schat. Distribution of chicken infectious anemia virus in the reproductive tissues of specific-pathogen-free chickens. J Gen Virol. 81:2067-2075, 2000.

Cavanagh, D., and S.A. Naqi. Infectious bronchitis. In: Diseases of Poultry 11th Ed. (Y.M. Saif, H.J. Barnes, A.M. Fadly, J. R. Glisson, L.R. McDougald, and D.E. Swayne, eds). Iowa State University Press, Ames. pp. 511-526 2001.

Chalquest, R.R., and J. Fabricant. Survival of PPLO injected into eggs previously dipped in antibiotic solutions. Avian Dis. 3:257-271, 1959.

Chalquest, R. R., and J. Fabricant. Pleuropneumonia-like organisms associated with synovitis in fowls. Avian Dis. 4:515, 1960.

Chandratilleke, D., P. O'Connell, and K.A. Schat. Characterization of proteins of chicken infectious anemia virus with monoclonal antibodies. Avian Dis. 35:854-862, 1991.

Cowen, B., B.W. Calnek, and S.B. Hitchner. Broad antigenicity exhibited by some isolates of avian adenovirus. Am. J. Vet. Res. 38:959-962, 1977.

Cowen, B.W., B.W. Calnek, N.A. Menendez and R.F. Ball. Avian adenoviruses: effect on egg production, shell quality and feed consumption. Avian Dis. 22:459-470, 1978.

Cowen, B.S. and S.B. Hitchner. Serotyping of avian infectious bronchitis viruses by the virus-neutralization test. Avian Dis, 19:583-595, 1975.

Cowen, B.S. and S.B. Hitchner. pH stability with avian infectious bronchitis (coronavirus) strains. J. of Virol. 15:430-432, 1975.

Cowen, B. S., S. B. Hitchner, and Benjamin Lucio. Characterization of a new infectious bronchitis isolate. I. Serological and pathogenicity studies of Clark 333. Avian Dis. 15:518-526, 1971.

Cowen, B. S., S. B. Hitchner and Tito Ubertini. Characterizations of a new infectious bronchitis isolate. II. Some chemical and physical properties of Clark 333. Avian Dis. 15:527-532, 1971.

Cowen, B.S., G.B. Mitchell, and B.W. Calnek. An adenovirus survey of poultry flocks during the growing and laying periods. Avian Dis. 2:459-470, 1978.

Cowen, B. S. and S. C. Smith. Nuclease activities of Mycoplasma gallisepticum as a function of culture age in different media. J. Bact. 109:21-24, 1972.

Davidson, I., N. Artzi, I. Shkoda, A. Lublin, E. Loeb, and K.A. Schat. The contribution of feathers in the spread of chicken anemia virus. Virus Res. 132:152-159. 2008.

Davidson, I., E. Loeb, A. Lublin, I. Shkoda, and K.A. Schat. Assessment of various criteria to determine the chicken anemia virus pathogenicity in embryonated eggs and in day-old chicks. Current Topics in Virology. 6:95-111, 2007.

Davis, H. R., and W. F. Dean. Environmental control of ducklings. Transactions of the American Association of Agricultural Engineers 11:736-738, 1968.

Dean, W. F. Feeding and producing ducks commercially. Feeds Illustrated, December. pp. 9-14, 1966.

Dean, W. F. Nutritional and management factors affecting growth and body composition of ducklings. Proceedings of the 1967 Cornell Nutrition Conference for Feed Manufacturers. pp. 74-82, 1967.

Dean, W. F. Effect of energy protein-balance, energy intake and methionine on growth and body composition of ducklings. Poult. Sci. 47:1665-1666 (Abstract), 1968.

Dean, W. F. Vitamin K requirement of ducklings in the presence and absence of sulfaquinoxaline. Poult. Sci. 51:1800 (Abstract), 1972.

Dean, W. F. Phosphorus requirement of ducklings at different calcium levels. Poult. Sci. 51:1799 (Abstract), 1972.

Dean, W.F. Recent findings in duck nutrition. Proceedings of the 1972 Cornell Nutrition Conference for Feed Manufacturers. pp.77-85, 1972.

Dean, W.F. Duck research on Long Island. Food and Life Sciences Quarterly (New York State Agricultural Experiment Station, Cornell University, Ithaca, New York). 7:16-19, 1974.

Dean, W.F. Nutrient requirements of ducks. Proc, 1978 Cornell Nutrition Conference for Feed Manufacturers.

pp. 132-140, 1978.

Dean, W.F. Poultry Production in China. In: Animal Agriculture in China - A report of the CSCPRC Animal Sciences Delegation, Chapter 5. National Academy Press, Washington, DC. pp. 52-64, 1980.

Dean, W. F. Nutrient requirements of meat-type ducks. Duck Production Science and World Practice, University of New England, Armidale. pp.31-57, 1986.

Dean, W. F. Duck Production and Management in the United States. Duck Production Science and World Practice, University of New England, Armidale. pp. 258-266, 1986.

Dean, W.F. Nutrition of the Pekin Duck in North America. Proceedings of the Cornell Nutrition Conference. pp.44-51, 1986.

Dean, W. F. 2005. Use of ultrasound scanning as a tool in selecting for increased breast muscle mass in Pekin ducks. Proceedings of the 3rd World Waterfowl Conference, Guangzhou, China. World's Poultry Science Association, China Branch and South China Agricultural University. pp. 45-52, 2005.

Dean, W.F. and G.F. Combs, Jr. Influence of selenium on performance, tissue selenium content, and plasma concentrations of selenium-dependent glutathione peroxidase, vitamin E, and ascorbic acid in ducklings. Poult. Sci. 60:2655-2663, 1981.

Dean, W. F., and R. H. Dalrymple. Improved carcass composition in ducks fed the beta-adrenergic agonist cimaterol. Poult. Sci.67:73 (Abstract), 1988.

Dean, W. F., J. I. Price and L. Leibovitz, 1973. Effect of feed medicaments on bacterial infections in ducklings. Poult. Sci. 52:549-558, 1973.

Dean, W. F. and M. L. Scott. Nutrient requirements of ducks. Cornell Feed Service No. 60. pp. l-5, 1965.

Dean, W. F., M. L. Scott and R. J. Young. Protein requirements of ducklings at different stages of growth. Poult. Sci. 44:1363 (Abstract), 1965.

Dean, W. F., M. L. Scott, R. J. Young, and W. J. Ash. Calcium requirement of ducklings. Poult. Sci. 56:1496-1499, 1967.

Dean, W.F. and T.F. Shen. Effect of methionine on the choline requirement of ducklings. Poult. Sci. 61:1447-1448 (Abstract), 1982.

Dean, W. F., J. R. Stouffer and D. L. Cunningham. Estimation of breast muscle mass in ducks with ultrasound. Poult. Sci. 66:90 (Abstract), 1987.

Del Priore, L.V., A. Lewis, and K.A. Schat. Membrane structural alterations in malignant and normal avian lymphocytes: A Raman investigation. Membrane Biochem. 5:97-108, 1984.

Dilmanian, F. A., G. M. Morris, G. Le Due, X. Huang, B. Ren, T. Bacarian, J. C. Alien, J. Kalef-Ezra, I. Orion, E. M. Rosen, T. Sandhu, P. Sathe, X. Y. Wu, Z. Zhong and H. L. Shivaprasad. Response of avian embryonic brain to spatially segmented x-ray microbeams. Cell. Mol. Biol. 47:485-493, 2001.

Dougherty, E., III. The efficacy of several immunizing agents for the control of fowl cholera in the White Pekin duck. Cornell Vet 43:421-27, 1953.

Dougherty, E. Disease problems confronting the duck industry. Proc. 90th Ann. Meeting, AVMA. p. 359, 1953.

Dougherty, E. Diseases of ducks. In: Animal Diseases, The Yearbook of the USDA, 1956.

Dougherty, E. III. Thiophosphate poisoning in White Pekin ducks. Avian Dis. 1:127, 1957.

Dougherty, E., III. The pathology of paratyphoid infection of the White Pekin duck, particularly the lesions of the central nervous system. Avian Dis. 5:415, 1961.

Dougherty, E., III. Fly sprays can poison ducks. Farm Research 28:14, 1962.

Dougherty, E. and D. W. Bruner. Two cases of erysipelas in the White Pekin duck. Cornell Vet. 43:481, 1953.

Dougherty, E., 3rd, and J. I. Price. Eastern encephalitis in White Pekin ducklings. Avian Dis. 4:274, 1960.

Dougherty, E., III and C. G. Rickard. An artifact resembling focal necrosis in the livers of slaughtered White Pekin ducks. Avian Dis. 1:130, 1957.

Dougherty, E. III and L. Z. Saunders. Meningoencephalitis in pigeons. J. Pathol. 29:1165-73, 1953.

Dougherty, E., III, C. G. Rickard, and M. L. Scott. Subacute and chronic liver diseases in the White Pekin ducklings. Avian Dis. 7:217-234, 1963.

Dougherty, E. 3rd., L. Z. Saunders, and E. H. Parsons. The pathology of infectious serositis of ducks. Amer. J. Pathol. 31:475, 1955.

Ellis, C. C. Studies of the viability of the oocysts of Eimeria tenella, with particular reference to conditions of incubation. Cornell Vet. 28: 267, 1938.

Erasmus, J., M. L. Scott, and P. P. Levine. A relationship between coccidiosis and vitamin A nutrition in chickens. Poultry Sci. 39:565-572, 1960.

Escorcia, M., M. W. Jackwood, B. Lucio, V. M. Petrone, C. Lopez, T. Fehervari, and G. Tellez. Characterization of Mexican strains of avian infectious bronchitis isolated during 1997. Avian Dis. 44:944-947, 2000.

Fabricant, C.G., P. J. VanDemark and J. Fabricant. The effect of atmospheric environment upon the growth of Mycoplasma gallisepticum. Avian Dis. 6:328-332, 1962.

Fabricant, C. G., J. Fabricant and P. J. Van Demark. Studies on the nutrition and growth requirements of

Mycoplasma gallisepticum Strain 293. J. Gen. Microbiol. 35:123-134, 1964.

Fabricant, J. Chronic respiratory disease. Worlds Poultry Science J. 8:294-296, 1962.

Fabricant, J. Swine serum and C02 in the isolation of PPLO. Avian Dis. 3:428-439, 1959.

Fabricant, J. Some pathological and epidemiological considerations of animal mycoplasmosis. Yale J. Biol. Med. 40:449-453, 1968.

Fabricant, J. Avian Mycoplasmas. In: The Mycoplasmatales and the L-phases of bacteria (L. Hayflick, Ed.). Appleton Century-Crofts, New York: pp. 621-641, 1969.

Fabricant, J. Problems in the isolation and identification of avian PPLO. Annals N.Y. Acad. Science, 79:393-396, 1960.

Fabricant, J. Immunization of chickens against Mycoplasma gallisepticum. Amer. J. Vet. Res. 36:566-567, 1975.

Fabricant, J. The present status of killed vaccines in the control of Newcastle disease. Proc. Book AVMA:326-329, 1955.

Fabricant, Julius. Studies on the diagnosis of Newcastle disease and infectious bronchitis of fowls. Cornell Vet. 39:202, 1949.

Fabricant, Julius. Studies on the diagnosis of Newcastle disease and infectious bronchitis of fowls II. The diagnosis of infectious bronchitis by virus isolation in chick embryos. Cornell Vet. 39:414, 1949.

Fabricant, Julius. Studies on the diagnosis of Newcastle disease and infectious bronchitis of fowls. III. The differential diagnosis of Newcastle disease and infectious bronchitis. Cornell Vet. 40:39-48, 1950.

Fabricant, Julius. Studies on the diagnosis of Newcastle disease and infectious bronchitis. IV. The use of the serum neutralization test in the diagnosis of infectious bronchitis. Cornell Vet. 41:68, 1951.

Fabricant, J. Immunization against Newcastle disease with killed and wing-web vaccines. Abstract, Proc. Vet. Med. Assoc. 1951.

Fabricant, Julius. Immunization against Newcastle disease with killed and wing web vaccines. Abstract, Proc. Vet. Med. Assoc. p. 264, 1952.

Fabricant, Julius. A modified chicken embryo inoculation technique for the isolation of viruses of the respiratory tract of chickens. Avian Dis. 1:62, 1957.

Fabricant, Julius. A reevaluation of the effectiveness of culture media for the isolation of avian pleuropneumonia-like organisms. Avian Dis. 2:4, 1958.

Fabricant, J. Serological studies of avian pleuropneumonia-like organisms with Edward'os technique. Avian Dis. 4:505, 1960.

Fabricant, C.G. and J. Fabricant. Marek's disease virus-induced atherosclerosis and evidence for a herpesvirus role in the human vascular disease. In: International Symposium on Marek's disease (Calnek, B.W. and J.L. Spencer, eds.). Amer. Assn. Avian Pathologists, New Bolton Center, PA. pp.391-407, 1985.

Fabricant, C.G., J. Fabricant, and G. Knaysi. Effects of the composition of the medium on the growth, morphology and virulence of Mycobacterium tuberculosis var. avium. Amer. Rev. Tuberculosis 66:567-577, 1952.

Fabricant, C.G., J. Fabricant, M.M. Litrenta, and C.R. Minick. Virus-induced atherosclerosis in chickens. Circulation 56:144, 1977.

Fabricant, C.G., J. Fabricant, M.M. Litrenta and C.R. Minick. Virus-induced arteriosclerosis. J. Exp. Medicine 148:335-340, 1978.

Fabricant, C.G., J. Fabricant, C.R. Minick and M.M. Litrenta. Herpesvirus-induced atherosclerosis. Cold Spring Harbor Conf. Cell Prolif. 7:1251-1258, 1980.

Fabricant, C.G., D.P. Hajjar, C.R. Minick and J. Fabricant. Herpesvirus infection enhances cholesterol and cholesteryl ester accumulation in cultured arterial smooth muscle cells. Am. J. Path. 105:176-184, 1981.

Fabricant, J., and B.W. Calnek. Avian Diseases. Cornell Vet. 75:124-129, 1985.

Fabricant, J., B.W. Calnek,, and K.A. Schat. The early pathogenesis of turkey herpesvirus infection in chickens and turkeys. Avian Dis. 26:257-264, 1982.

Fabricant, J., B.W. Calnek, K.A. Schat and K.K. Murthy. Marek's disease virus induced tumor transplants: development and rejection in various genetic strains of chickens. Avian Dis. 22:646-658, 1978.

Fabricant, J. and C.G. Fabricant. Immunological studies on Marek's disease virus-induced atherosclerosis. In:, International Symposium on Marek's disease (Calnek, B.W. and J.L. Spencer, eds.). Amer. Assn. Avian Pathologists, New Bolton Center, PA. pp.408-417, 1985.

Fabricant, J., C.G. Fabricant, M.M. Litrenta and C.R. Minick. Vaccination prevents atherosclerosis induced by Marek's disease virus. Fed. Proc. 40:335, 1981.

Fabricant, J. and E. A. Freundt. The importance of extension and standardization of laboratory tests for the identification and classification of mycoplasmas. Proc. N.Y. Acad. Sciences. 143:50-58, 1967.

Fabricant, J., M. Ianconescu, and B.W. Calnek. Comparative effects of host and viral factors on early pathogenesis of Marek's disease. Infect. Immun. 16:136-144, 1977.

Fabricant, J. and P. P. Levine. The persistence of infectious bronchitis virus in eggs and tracheal exudates of infected chickens. Cornell Vet. 41:240, 1951.

Fabricant, J. and P. P. Levine. New aspects in the control of chronic respiratory disease. Abstract. Poultry Sci. 40:1400, 1961.

Fabricant, J., and P. P. Levine. Experimental production of complicated chronic respiratory disease (air sac disease). Avian Dis. 6:13, 1962.

Fabricant, J. and P. P. Levine. Infection in young chickens for the prevention of egg transmission of Mycoplasma gallisepticum in breeders. Proc. 17th World Veterinary Congress. pp. 1467-1474, 1963.

Fabricant, J., P.P. Levine, B.W. Calnek, H.E. Adler, and J.R. Berg. Studies of egg transmission of PPLO in chickens. Avian Dis. 3:197-222, 1959.

Fabricant, Julius, C. G. Rickard, and P. P. Levine. The pathology of duck virus hepatitis. Avian Dis. 1:256, 1957.

Fasina, S.O. and J. Fabricant. In vitro studies of hemorrhagic enteritis virus with immunofluorescent antibody technique. Avian Dis. 26:150-157, 1982.

Fasina, S.O. and J. Fabricant. Immunofluorescence studies on the early pathogenesis of hemorrhagic enteritis virus infection in chickens and turkeys. Avian Diseases 26:158-163, 1982.

Fernando, W.W.D. and B.W. Calnek. Influence of bursa of Fabricius on the infection and pathological response of chickens exposed to Marek's disease herpesvirus. Avian Dis. 15:467-476, 1971.

Garcia-Camacho, L., K. A. Schat, R. Brooks, Jr., D. I. Bounous. Early cell-mediated immune responses to Marek's disease virus in two chicken lines with defined major histocompatibility complex antigens. Vet Immunol Immunopathol, 95:145-153, 2003.

Gillespie, J. H. and J. Fabricant. The isolation of Newcastle disease virus from a starling. Cornell Vet. 40:93-94, 1950.

Gilman, Herbert L. and E.L. Brunett. Bact. abortus infection in the fowl. Cornell Vet. 20:371, 1930.

Gilman, Herbert L. and E.L. Brunett. Bact. abortus infection in the fowl II. Report of NYS Veterinary College for 1930-31. pp. 149-156, 1931.

Giordano, A.R. and B.W. Calnek. Research Note: attempts to substitute cytopathogenic viruses for Rous sarcoma virus in the resistance-inducing factor (RIF) test. Avian Dis. 8:317-319, 1964.

Glantz, P.J., S. Narotsky, and G. Bubash. Escherichia coli serotypes isolated from salpingitis and chronic respiratory disease of poultry. Avian Dis. 6:322, 1962.

Gonzaga, Arcadio C. A contribution to the chemical study of chicken blood. Report of NYS Veterinary College for 1933-34. pp. 53-57, 1934.

Goss, Leonard J. The incidence and classification of avian tumors. Cornell Vet. 30:75, 1940.

Gould, W.J., P.H. O'Connell, H.L. Shivaprasad, A.E. Yeager, and K.A. Schat. Detection of retrovirus sequences in budgerigars with tumors. Avian Pathol. 22:33-45, 1993.

Graham, D.L. and B.W. Calnek. Papovavirus infection in hand-fed parrots: virus isolation and pathology. Avian Dis. 31:398-410, 1987.

Graham, D. L., C. J. Mare, F. P. Ward, and M. C. Peckham. Inclusion body disease of falcons. J. Wildlife Dis. 11:82-91 1975.

Grodio, J.L., K.V. Dhondt, P.H. O'Connell, and K.A. Schat. Detection and quantification of Mycoplasma gallisepticum genome load in conjunctival samples of experimentally infected house finches (Carpodacus mexicanus) using real-time polymerase chain reaction, Avian Pathol. 37:385-391, 2008.

Hagan, Jean R. Diagnostic techniques in avian vibrionic hepatitis. Avian Dis. 8:428-437, 1964.

Haider, S.A. and B.W. Calnek. In vitro isolation, propagation and characterization of duck hepatitis virus type III. Avian Dis. 23:715-729, 1979.

Hajjar, D.P., D.T. Falcone, C.G. Fabricant and J. Fabricant. Altered cholesteryl ester cycle is associated with lipid accumulation in herpesvirus-infected arterial smooth muscle cells. J. Biol. Chem. 260:6124-6128, 1985.

Hajjar, D.P., C.G. Fabricant, C.R. Minick and J. Fabricant. Virus-induced atherosclerosis herpesvirus infection alters chicken arterial cholesterol metabolism and accumulation. Amer. J. Pathol. 122:62-70, 1986.

Hayden, C.E. and E.L. Brunett. A study of the influence of Bact. pullorum infection upon some organic and inorganic constituents of the blood of S.C. White Leghorns. Report of NYS Veterinary College for 1928-2. pp. 135-142, 1929.

Hayden, C.E. and Jesse Sampson. A study of some organic and inorganic constituents of the wing and throat blood of laying and non-laying Rhode Island Red hens. Report of NYS Veterinary College for 1929-30. pp. 174-182, 1930.

Heddleston, K. L., T. Goodson, L. Leibovitz, and C. I. Angstrom. Serological and biochemical characteristics of Pasteurella multocida from free flying birds and poultry. Avian Dis. 16:729-734, 1972.

Heggen-Peay, C. L. M.A. Qureshi, F.W. Edens, B. Sherry, P.S. Wakenell, P.H. O'Connell, and K.A. Schat. Isolation of a reovirus from poult enteritis and mortality syndrome (PEMS) and its pathogenicity in turkey poults. Avian Dis. 46:32-47, 2002.

Heggen-Peay, C. L., M. A. Cheema, R. A. Ali, K. A. Schat, M. A. Qureshi. Interactions of poult enteritis and

mortality syndrome-associated reovirus with various cell types in vitro Poultry Sci 81:1661-1667, 2002.

Heller, E.D., and K.A. Schat. Inhibition of natural killer activity in chickens by Marek's disease virus-transformed cell lines. In: Proc. International Symposium on Marek's disease (Calnek, B.W., Spencer, L.J., eds.). pp. 286-294, 1985.

Heller, E.D. and K.A. Schat. Enhancement of natural killer cell activity by Marek's disease vaccines. Avian Pathol. 16:51-60, 1987.

Hendrickson, J.M. The veterinarian's relation to the poultry situation. Report of NYS Veterinary College for 1926-27. pp. 207-213, 1927.

Hendrickson, J.M. Why veterinarians should be interested in poultry disease control. Report of NYS Veterinary College for 1926-27 198-206, 1927.

Hendrickson, J. M. and K. F. Hilbert. The persistence of Pasteurella avicida in the blood and organs of fowls with spontaneous fowl cholera. Report of NYS Veterinary College for 1930-31. pp.167-176, 1931.

Hendrickson, J. M. and K. F. Hilbert. A new and serious septicemic disease of young ducks with a description of the causative organism, Pfeifferella anatipestifer, N.S. Report of NYS Veterinary College for 1931-32. pp. 61-72, 1932.

Higgins, D.A. and B.W. Calnek. Fowl immunoglobulins: Quantitation and antibody activity during Marek's disease in genetically resistant and susceptible birds. Infect. Immun. 11:33-41, 1975.

Higgins, D.A. and B.W. Calnek. Fowl immunoglobulins: Quantitation in birds genetically resistant and susceptible to Marek's disease. Infect. Immun. 12:360-363, 1975.

Higgins, D.A. and B.W. Calnek. Some effects of silica treatment on Marek's disease. Infect. Immun. 13:1054-1060, 1976.

Hilbert, K. F. Disease problems of duck raisers. New England Poultryman 27:7, 1938.

Hilbert, K. F. Renal coccidiosis in a goose on Long Island. Cornell Vet. 41:54, 1951.

Hilbert, K. F. Broiler mortality. Cornell Poultry Pointers, Nov, 1957.

Hilbert, K. F. Visceral gout in broilers. Cornell Poultry Pointers, Dec, 1957.

Hilbert. K. F. Omphalitis (navel infection) in broilers. Cornell Poultry Pointers, Jan, 1958.

Hilbert, K. F. Renal coccidiosis in a goose on Long Island. Cornell Vet. 41:54, 1951.

Hilbert, K. F. and Herman Tax. The value of the chemically-killed cultures for the control of cholera in ducks. Cornell Vet. 28:275, 1938.

Hilbert, K. F. and Herman Tax. The value of chemically-killed cultures for the control of cholera in ducks (second report). Report of NYS Veterinary College for 1938-39. pp.165-167, 1939.

Hirai, K. and B.W. Calnek. In vitro replication of infectious bursal disease virus in established lymphoid cell lines and chicken B lymphocytes. Infect. Immun. 25:964-970, 1979.

Hirai, K., S.B. Hitchner and B.W. Calnek. Characterization of a new coronavirus-like agent isolated from parrots. Avian Dis. 23:515-525, 1979.

Hirai, K., S.B. Hitchner and B.W. Calnek. Characterization of parmyxo-herpes- and orbiviruses isolated from psittacine birds. Avian Dis. 23:148-163, 1979

Hirai, K., S.B. Hitchner and B.W. Calnek. Correction in identification of a coronavirus-like agent isolated from parrots. Avian Dis. 26:169-170, 1982.

Hitchner, S. B. Infectivity of infectious bursal disease virus for embryonating eggs. Poult. Sci. 49:511-516, 1970.

Hitchner, S.B. The differentiation of infectious bursal disease (Gumboro) and avian nephrosis. Proc. 14th World's Poultry Congress, Madrid, Spain. pp. 229-232, 1970.

Hitchner, S.B. Immunological response to vaccines. In: Poultry Disease and World Economy (R.F. Gordon and B.M. Freeman, eds.). Brit. Poult. Sci. pp. 109-118, 1971.

Hitchner, S. B. Persistence of parental infectious bursal disease antibody and its effect on susceptibility of young chickens. Avian Dis. 15:894-900, 1971.

Hitchner, S. B. Immunological response to vaccines. In: Poultry Disease and World Economy (R. F. Gordon and B. M. Freeman, eds.). Brit. Poult. Sci., Edinburgh.109-118, 1971

Hitchner, S.B. Persistence of parental infectious bursal disease antibody and its effect on susceptibility of young chickens. Avian Dis. 15:894-900, 1971.

Hitchner, S.B. Infectious bursal disease. In: Diseases of Poultry, 6th Ed. (M.S. Hofstad, B.W. Calnek, C.F. Helmboldt, W.M. Reid, and H. W. Yoder, Jr., eds.). Iowa State University Press, Ames, Iowa. pp. 760-768, 1972.

Hitchner, S.B. Marek's disease control in the U.S.A. Proc. Australasian Poultry Science Convention. pp.225-229, 1974.

Hitchner, S.B. Immunization of adult hens against infectious bursal disease virus. Avian Dis. 20:611-613, 1976.

Hitchner, S.B. Serendipity in sciences. Discovery of the B-1 strain of Newcastle disease virus. Avian Dis. 19:215-223, 1976.

Hitchner, S.B. Canary pox vaccination with live embryo-attenuated virus. Avian Dis. 25:874-881, 1981.

Hitchner, S.B. Reflections: Blending business and research in avian medicine. J. Amer. Vet. Med. Assoc,

198:1526-30, 1991.

Hitchner, S.B. Poultry vaccine laboratories in the United States: A historical perspective. Avian Dis. 40:255-265, 1996.

Hitchner, S.B. and B.W. Calnek. Inactivated Vaccine for Parrot Herpesvirus Infection (Pacheco's Disease). J. Vet. Res. 41:1280-1282, 1980.

Hitchner, S.B. and K. Hirai. Isolation and growth characteristics of psittacine viruses in chicken embryos. Avian Dis. 23:139-147, 1979.

Hitchner, S.B., J. Fabricant and T.J. Bagust. A fluorescent-antibody study of the pathogenesis of infectious laryngotracheitis. Avian Dis. 21:185-194, 1977.

Hofstad, M. S. A study of infectious bronchitis in chickens I. The pathology of infectious bronchitis. Cornell Vet. 35: 22-31, 1945.

Hofstad, M. S. A study of infectious bronchitis in chickens II. Observations on the carrier status of chickens recovered from infectious bronchitis. Cornell Vet. 35: 32-40, 1945.

Hofstad, M. S. A study of infectious bronchitis in chickens III. Attempts of utilize the chicken red cell agglutination test as a diagnostic aid [with] infectious bronchitis. Cornell Vet. 35:60-61, 1945.

Hofstad, M. S. A study of infectious bronchitis in chickens IV. Further observations on the carrier status of chickens recovered from infectious bronchitis. Cornell Vet. 37:29-34, 1947.

Hogenmueller, L., P.S. Wakenell, and K.A. Schat. Preparation and characterization of chicken intraepthelial leukocytes. Avian Pathol. 22:509-524, 1993.

Hooft van Iddekinge, B.J.L., L.M. Stenzler, K.A. Schat, H. Boerrigter, and G. Koch. Genome analysis of Marek's disease virus strain CVI988: effect of cell culture passage on the inverted repeat regions. Avian Dis. 43:182-188, 1999.

Hu, L., B.Lucio, and K.A. Schat. Abrogation of age-related resistance to chicken infectious anemia by embryonal bursectomy. Avian Dis. 37:157-169, 1993.

Hu, L., B. Lucio, and K.A. Schat. Depletion of CD4+ and CD8+ T lymphocyte subpopulations by CIA-1, a chicken infectious anemia virus. Avian Dis. 37:492-500, 1993.

Hwang, J. Duck hepatitis virus in duck embryo fibroblast cultures. Avian Dis. 9:285-290, 1965.

Hwang, J. A chicken-embryo-lethal strain of duck hepatitis virus. Avian Dis. 9:417-422, 1965.

Hwang, J. Duck hepatitis virus in duck embryo liver cell cultures. Avian Dis. 10:508-512, 1966.

Hwang, J. Research Note -- Comparative titration of eastern encephalitis virus in cell suspension and in cultures of duck embryo fibroblasts. Avian Dis. 11:593-594, 1967.

Hwang, J. Duck hepatitis virus-neutralization test in chicken embryos. J. Vet. Res. 30:861-864, 1969.

Hwang, J. Immunizing breeder ducks with chicken embryo-propagated duck hepatitis virus for production of parental immunity in their progenies. J. Vet. Res. 31:805-807, 1970.

Hwang, J. Active immunization against duck hepatitis virus. J. Vet. Res. 33:2539-2544, 1972.

Hwang, J. Early induction of resistance in ducklings against virus hepatitis. J. Vet. Res. 32:2095-2097, 1971.

Hwang, J., and E. Dougherty, III. Multiplications and cytopathogenicity of eastern encephalitis virus in a duckling kidney cell culture system. Avian Dis. 5:116, 1961.

Hwang, J. and E. Dougherty, III. Serial passage of duck hepatitis virus in chicken embryos. Avian Dis. 6:435-440, 1962.

Hwang, J. And E. Dougherty, III. Distribution and concentration of duck hepatitis virus in inoculated ducklings and chicken embryos. Avian Dis. 8:264-268, 1964.

Hwang, J., William J. Ash and E. Dougherty, III. Production of passive immunity against viral hepatitis in white Pekin ducklings. J. Amer. Vet. Med. Assoc. 141:1474-1477, 1962.

Hwang, J., L. A. Devenpeck, and E. Dougherty, III. Incidence on commercial duck farms of duck virus hepatitis in White Pekin ducklings hatched from immunized and unimmunized dams. Avian Dis. 5:411-416, 1963.

Jagne, J., I. Aini, K.A. Schat, A. Fennell, and O. Touray. Short Communication: Vaccination of village chickens in The Gambia against Newcastle disease using the heat-resistant, food- pelleted V4 vaccine. Avian Path. 20:721-724, 1991.

Jarosinski, K. W. and K.A. Schat. Multiple alternative splicing to exons II and III of viral interleukin 8 (vIL-8) in the Marek's disease virus genome: the importance of vIL-8 exon I. Virus Genes: 34:9-22, 2007

Jarosinski, K.W., J. Wei, and K.A. Schat. Decreased natural killer cell cytotoxicity in chickens treated with a high dose of recombinant chicken interferon-alpha In: Current progress on Marek's disease research (K.A. Schat, R.M. Morgan, M.S. Parcells, and J.L. Spencer, eds). Amer. Assoc. Avian Pathol., Kennett Square, PA. pp.131-134, 2001.

Jarosinski, K.W., W. Jia, M.J. Sekellick, P.I. Marcus, and K.A. Schat. Cellular responses in chickens treated with IFN-alpha or inoculated with recombinant Marek's disease virus expressing IFN-alpha. J Interferon Cytokine Research 21:287-296, 2001.

Jarosinski, K.W., R. Yunis, P.H. O'Connell, C.J. Markowski-Grimsrud, and K.A. Schat. Increased nitric oxide in chickens resistant to Marek's disease, but not susceptible chickens infected with Marek's disease virus (MDV), and

in chickens infected with very virulent + MDV. Avian Dis. 46:636-649, 2002.

Jarosinski, K.W., P.H. O'Connell, and K.A. Schat. Impact of deletions within the Bam HI-L fragment of attenuated Marek's disease virus on vIL-8 expression and the newly identified transcript of open reading frame LORF4. Virus Genes 26:255-269, 2003.

Jarosinski, K.W., B.L. Njaa, P.H. O'Connell, and K.A. Schat. Pro-inflammatory responses in chicken spleen and brain tissues after infection with very virulent Marek's disease virus. Viral Immunology 18: 148-161, 2005.

Jarosinski, K.W., N. Osterrieder, V.K. Nair, and K.A. Schat. Attenuation of Marek's disease virus (MDV) by deletion of open reading frame RLORF4 but not RLORF5a. J. Virol. 79, 11647-11659, 2005

Jia, Wei and Syed Naqi. Sequence analysis of gene 3, gene 4, and gene 5 of avian infectious bronchitis virus strain CU-T2. Gene 189:189-193, 1997.

Jia, W. and S. Naqi. Antigenic and genetic characteristics of avian infectious bronchitis virus isolates from the 1940s. Avian Dis. 46:437-441, 2002.

Jia, Wei, Xinzhong Wang, Colin Parrish and Syed Naqi. Analysis of the serotype-specific epitopes of avian infectious bronchitis virus strains Ark99 and Mass41. J. Virol. 70:7255-7259, 1996.

Jia, Wei, K. Karaca, Colin Parrish and S.A. Naqi. A novel variant of avian infectious bronchitis virus resulting from recombination among three different strains. Arch. Virol. 140:259-271, 1995.

Jones, F.S. Fatal septicemia or bacillary white diarrhea in young chickens. Report of NYS Veterinary College for 1909-10. pp.111-129, 1910.

Jones, F.S. Further studies on bacillary white diarrhea in young chicks. Report of NYS Veterinary College for 1910-11. pp.69-88, 1911.

Jones, F.S. An outbreak of acute disease in adult fowls, due to Bact. pullorum. Report of NYS Veterinary College for 1911-12. pp.140-148, 1912.

Jones, F.S. The value of the macroscopic agglutination test in detecting fowls that are harboring Bact. pullorum. Report of NYS Veterinary College for 1911-12. pp.149-155, 1912.

Jones, F.S. An outbreak of avian tuberculosis. Report of NYS Veterinary College for 1911-12. pp. 156-159, 1912.

Jones, F.S. Avian tuberculosis. Report of NYS Veterinary College for 1911-12. pp. 159-164, 1912.

Jones, F.S. The value of the macroscopic agglutination test in detecting fowls that are harboring Bacterium pullorum. J. Med. Res. 27:481-495, 1913.

Jortner, B. S., R. Porro, and L. Leibovitz. Central-nervous system lesions of spontaneous Pasteurella anatipestifer infection in ducklings. Avian Dis. 13:27-35, 1969.

Kaplan, S.L., K.A. Schat, and B.W. Calnek. Identification of the promoter enhancer regions of ICP4, a viral transcription in Marek's disease, and lack of in vitro modulation of the promoter with recombinant chicken interferons In: Current progress on Marek's disease research (K.A. Schat, R.M. Morgan, M.S. Parcells, and J.L. Spencer, eds). Amer. Assoc. Avian Pathol., Kennett Square, PA. pp. 245-248, 2001.

Karaca. and S.A. Naqi. A monoclonal antibody blocking ELISA to detect serotype-specific infectious bronchitis virus antibodies. Vet. Microbiol. 34:249-257, 1993.

Karaca, K. and S. Naqi. Characterization of a novel monoclonal antibody which identifies chicken secretory component. Hybridoma 16:545-550, 1997.

Karaca, K., S. Naqi, P. Paulkaitis and B. Lucio. Serological and molecular characterization of three enteric isolates of infectious bronchitis virus. Avian Dis. 34:899-904, 1990.

Karaca, K., S.A. Naqi and J. Gelb. Production and characterization of monoclonal antibodies to three infectious bronchitis virus serotypes. Avian Dis. 36, 903-915, 1992.

Karaca, K., P. Palukaitis and S.A. Naqi. Oligonucleotide probes in infectious bronchitis virus diagnosis and strain identification. J. Virol. Methods 42:293-300, 1993.

King, D., Page, D., Schat, K.A. and B.W. Calnek. Difference between influences of homologous and heterologous maternal antibodies on response to serotype-2 and serotype-3 Marek's disease vaccines. Avian Dis. 25:74-81, 1981.

Lahti, J.M, C-L.H. Chen, L.W. Tjoelker, J.M. Pickel, K.A. Schat, B.W. Calnek, C.B. Thompson, and M.D. Cooper. Two distinct T-cell lineages can be distinguished by the differential usage of T-cell receptor V gene segments. Proc. Natl. Acad. Sci., USA 88:10956-10960, 1991.

Layton, H. W. Efficacy of broth-grown Pasteurella multocida bacterins in ducklings. Avian Dis. 28:1086-1095, 1984.

Layton, H. W. and T. S. Sandhu. Protection of ducklings with a broth-grown Pasteurella anatipestifer bacterin. Avian Dis. 28:718-726, 1984.

Lee, Ji-Eun, Syed A. Naqi, Elizabeth Kao, and Rodney R. Dietert. Embryonic exposure to lead: Comparison of immune and cellular responses in unchallenged and virally stressed chickens. Arch Toxicol 75:717-724, 2002.

Lee, J.E., R.E. Austic, S.A. Naqi, K.A. Golemboski and R.R. Dietert. Dietary arginine intake alters avian leukocyte population distribution during infectious bronchitis virus challenge. Poultry Sci. 81:793-798, 2002.

Leibovitz, L. Wenyonella philiplevinei, n. spl, a coccidial organism of the White Pekin duck. Avian Dis. 12:670-681, 1968.

Leibovitz, L. Progress report: duck plague surveillance of American Anseriformes. Bull. Wildlife Disease Assoc. 4:87-91, 1968.

Leibovitz, L. The comparative pathology of duck plague in wild Anseriformes. J. Wildlife Management 33:294-303, 1969.

Leibovitz, L. Natural occurrence and experimental study of pox and Haemoproteus infections in a Mute Swan (Cygnus olor). Bull. Wildlife Disease Assoc. 5:130-136, 1969.

Leibovitz, L. Duck Plague. In: Diseases of Wild Birds. Iowa State University Press. (J. Davis, ed.). pp. 22-33, 1971.

Leibovitz, L. Survey of the "so-called anatipestifer syndrome." Avian Dis. 16:836-851, 1972.

Leibovitz, L. Duck Plague. In: Diseases of Poultry, 6th Ed. (M.S. Hofstad, B.W. Calnek, C.F. Helmboldt, W.M. Reid, and H. W. Yoder, Jr., eds.). Iowa State University Press, Ames. pp. 732-744, 1972.

Leibovitz, L. Necrotic enteritis of breeder ducks. J. Amer. Vet. Med. Assoc. 34:1053-1061, 1973.

Leibovitz, L. and J. Hwang. Duck plague on the American Continent. Avian Dis. 12:361-378, 1968.

Leibovitz, L. and J. Hwang. Duck plague in American anseriformes. Bull. Wildlife Disease Assoc. 4:13-14, 1968.

Leibovitz, L. and Jen Hwang. The histopathology of duck plague (DVE) in White Pekin ducklings. Proc. IVth Congress of the World Veterinary Poultry Assoc. pp. 441-454, 1970.

Levine, P.P. The treatment of ascariasis in chickens. Cornell Vet. 26:119, 1936.

Levine, P.P. A new method for embryonating nematode eggs in fecal discharges. J. Parasitol. 22:291, 1936.

Levine, P.P. The effect of atmospheres of hydrogen, carbon-dioxide, and oxygen, respectively, and of mixtures of these gases on the growth of Bacillus subtilis. J. Bacteriol. 31:151, 1936.

Levine, P.P. The viability of the ova of Ascaridia lineata when exposed to various environmental conditions. J. Parasitol. 23:368, 1937.

Levine, P.P. The effect of various environmental conditions on the viability of the ova of Capillaria columbae (RUD). J. Parasitol. 23:425, 1937.

Levine, P.P. Infection of the chicken with Capillaria columbae (RUD). J. Parasitol. 24:45, 1938.

Levine, P. P. The effect of infection with Davainea proglottina on the weights of growing chickens. J. Parasitol. 24:550, 1938.

Levine, P.P. Observations on the biology of the poultry cestode Davainea proglottina in the intestine of the host. J. Parasitol. 24:423, 1938.

Levine, P. P. Eimeria hagani N. SP. (Protozoa: Eimeriidae) a new coccidium of the chicken. Cornell Vet. 28:263, 1938.

Levine, P. P. Studies on the control of the poultry cestode Davainea proglottina (DAV.). Cornell Vet. 28:220, 1938.

Levine, P. P. The effect of sulfanilamide on the course of experimental avian coccidiosis. Cornell Vet. 29:309, 1939.

Levine, P. P. The effect of sulfapyridine on experimental avian coccidiosis. J. Parasitol. 26:233, 1940.

Levine, P. P. The initiation of avian coccidial infection with merozoites. J. Parasitol.26:337, 1940

Levine, P. P. Sub-clinical coccidial infection in chickens. Cornell Vet. 30:127, 1940.

Levine, P. P. The coccidiostatic effect of sulfaguanidine (sulfanilyl guanidine). Cornell Vet. 31:107, 1941.

Levine, P. P. Sulphur therapy in experimental avian coccidial infection with Eimeria necatrix. Cornell Vet. 31:120, 1941.

Levine, P. P. Chemotherapy in the control of avian coccidiosis. Proc. United States Livestock Sanitary Association, 1941.

Levine, P. P. A new coccidium pathogenic for chickens, Eimeria brunetti N. Sp. (Protozoa: Eimeriidae). Cornell Vet. 32:430, 1942.

Levine. P. P. The periodicity of oocyst discharge in coccidial infection of chickens. J. Parasitol. 28:346-348, 1942.

Levine, P. P. Excystation of coccidial oocysts of the chicken. J. Parasitol. 28:426-428, 1942.

Levine, P. P. The selective action of sulfaguanidine on avian coccidia. J. Parasitol. 29:362-363, 1943.

Levine, P. P. Additional field outbreaks of coccidiosis in chickens due to Eimeria brunetti. Cornell Vet. 33:4, 1943.

Levine, P. P. Specific diagnosis and chemotherapy of avian coccidiosis. J. Amer. Vet. Med. Assoc. 106:88-90, 1945.

Levine, P. P. Histomoniasis in a kidney of a turkey. Cornell Vet. 37:269-270, 1947.

Levine, P. P. Infectious bronchitis. Proc. U. S. Livestock San. Assoc, 1951. p. 183.

Levine, P. P. Recent developments in our knowledge of poultry diseases. Proc. 1st Pan-American Vet. Congress, Lima Peru, 1951.

Levine, P. P. Transmission of infectious bronchitis and Newcastle disease. Proc. Vet. Med. Assoc, 1952.

Levine, P. P. Duck Virus Hepatitis. In:Diseases of Poultry, 3rd Ed. (H.E. Biester and L.H. Schwarte, eds.) Iowa State University Press. pp. 689-694, 1952.

Levine. P. P. Transmission of Newcastle disease and infectious bronchitis. Proc. Book, Vet. Med. Assoc. p. 247, 1952.

Levine, P. P. Avian diseases ? a human health hazard? Proc. Internat. Farmers? Convention in Israel Gov't. Press, Achva Co-op Printing Press Ltd., Jerusalem. p. 368, 1959

Levine, P. P. Bosquejo de lot problemas actuales de la enfermedad de Newcastle. I. Symposium de la enfermedad Newcastle, Folleto miscellaneo No. 11, Secretaria de Agricultura y Ganaderia, Oficina de Estudios Especiales, Mexico, Dec, 1960. p. 86.

Levine, P. P. Egg immersion and other new developments in controlling CRD. Proc. 10th Ann. New Hampshire Health Conf. pp. 16-23, 1961.

Levine, P. P. Immunization procedures in broilers - their role in air sac infection and disease transmission. In: Symp. Proc. Disease: Environmental and management factors related to poultry health, Agric. Research Serv., ARS 45-2:57, 1961.

Levine, P.P. The place of vaccination in the control of poultry diseases. Vet. Record 74:1394-1402, 1962.

Levine, P. P. World dissemination of Newcastle disease. In: Newcastle Disease Virus - an Evolving Pathogen, Chapter 4 (Robert P. Hanson, ed.) University of Wisconsin Press, Madison. pp. 65-69, 1964.

Levine, P. P. Duck virus hepatitis. In: Diseases of Poultry, 5th ed. (H. E. Biester and L. H. Schwarte, eds.). Iowa State University Press, Ames, Iowa. pp. 838-843, 1965.

Levine, P. P. Recent developments in the field of avian diseases. Proc. 15th Annual Pfizer Conference, 47-53, 1967.

Levine, P. P. and C. W. Barber. The comparative efficiency of some coccidiostatic agents against experimental infection with Eimeria tenella. Report of NYS Veterinary College for 1946-47. pp. 235-238, 1947.

Levine, P. P. and Julius Fabricant. Susceptibility to Newcastle infection of chicks with congenital serum antibodies. Cornell Vet. 40:213-225, 1950.

Levine, P. P. and Julius Fabricant. A hitherto undescribed virus disease of ducks in North America. Cornell Vet. 40:71-86,1950.

Levine, P. P. and Julius Fabricant. Efficacy of Newcastle disease vaccine under controlled conditions. Cornell Vet. 42:449, 1952.

Levine, P. P., and Julius Fabricant. CRD - the most important respiratory infection in poultry today. Farm Research, Dec, 1959. p. 3.

Levine, P.P., and J. Fabricant. Effect of dipping eggs in antibiotic solutions on PPLO transmission in chickens. Avian Dis. 6:72-85, 1962.

Levine, P. P. and J. Fabricant. Control of PPLO by egg dipping in antibiotic solutions. Proc. IV Pan American Congress of Veterinary Medicine and Zootechnics. Mexico City, Mexico, Vol 4:85-92, 1962.

Levine, P. P. and M. S. Hofstad. Attempts to control air-borne infectious bronchitis and Newcastle disease of fowls with sterilamps. Cornell Vet. 37:204-211, 1947.

Levine, P. P. and John Sickles. Insure your flock against these diseases. Poultry Improvement Board (N.Y.). Yearbook for 1954-55. p. 28, 1955.

Levine, P. P., Julius Fabricant, and Grayson B. Mitchell. Newcastle disease in ring-necked pheasants. Cornell Vet. 37:265-267, 1947.

Levine, P. P., Julius Fabricant, J. H. Gillespie, C. I. Angstrom and G. B. Mitchell. The results of pen contact exposure of susceptible chickens to chickens recovered from Newcastle disease. Cornell Vet. 40:206-210, 1950.

Li, J., B.W. Calnek, K.A. Schat and D.L. Graham. Pathogenesis of reticuloendotheliosis virus infection in ducks. Avian Dis. 27:1090-1105, 1983.

Li, X. and K.A. Schat. Quail cell lines supporting replication of Marek's disease virus serotype 1 and 2 and herpesvirus of turkeys. Avian Dis. 48:803-812, 2004.

Li, X., K.W. Jarosinski, and K.A. Schat. Expression of Marek's disease virus phosphorylated polypeptide pp38 enhances metabolic activity and produced splice variants. Vet Microbiol. 117:154-168, 2006.

Lillehoj, H.S., E.P. Lillehoj, D. Weinstock, and K.A. Schat. Functional and biochemical characterization of avian T lymphocyte antigens identified by monoclonal antibodies. Eur. J. Immunol. 18:2059-2065, 1988.

Locke, Louis N., L Leibovitz, Carlton M. Herman, John W. Walker. Duck viral enteritis (duck plague) in North American waterfowl. Proc Southeastern Assoc. of Fish and Game Commissioners 22:96-98, 1968.

Loudovaris, T., B.W. Calnek, B.H. Yoo and K.J. Fahey. Genetic susceptibility of chicken macrophages to in vitro infection with infectious laryngotracheitis virus. Avian Pathol. 20: 291-302, 1991.

Lucio, B., and R. D. Schultz. Prevention of infectious bursal disease (IBD) by feeding IBD virus-immune bovine colostrum. Vet. Immunol. and Immunopathol. 1:379-386, 1980.

Lucio, B. Quantitative agar gel precipitation test - an alternative for monitoring infectious bursal disease

vaccination programs. In: Proc. 36th Western Poultry Disease Conference. Sacramento, CA. pp. 116-119, 1987.

Lucio, B. Infectious anemia transovarian transmission: repercussion on growth & egg production. In: Proc. 45th Western Poultry Disease Conference. Western Poultry Disease Conference, Davis, CA. pp. 131-132, 1996.

Lucio, B. Chicken infectious anemia: from isolation to control. In: Proc. 47th Western Poultry Disease Conference. Sacramento, CA. p. 48, 1998.

Lucio, B. Impact of vv Marek's disease on mortality and production in a multiple-age farm. In: Proc. 48th Western Poultry Disease Conference. Davis, CA. pp. 55-56, 1999.

Lucio-M, B. Chicken infectious anemia. In: VIII International Seminar on Avian Diseases. University of Georgia and Asociación de Médicos Veterinarios Especialistas en Avicultura (Colombia), Athens, GA. pp. 495-506, 1994.

Lucio, B. Velogenic viscerotropic Newcastle disease (VVND): a threat for the United States? In: Proc. 50th Western Poultry Disease Conference. Davis, CA. pp. 122-124, 2001.

Lucio-M, B. Fallas de vacunación contra la infección de la bolsa de Fabricio. In: XIX Reunión Anual de la Asociación de Especialistas en Ciencias Avícolas. Asociación de Especialistas en Ciencias Avícolas, Pto. Vallarta, Jalisco, México. pp. 138-149, 1994.

Lucio-M, B. Actualidades en bronquitis infecciosa, estrategias para su prevención y control. In: XXII Convención Anual ANECA. Asociacion Nacional de Especialistas en Ciencias Avicolas, Zihuatanejo, Gro, 1997.

Lucio-M, B. Interacción de los agentes inmunodepresores. In: XXIII Convención Anual ANECA. Asociacion Nacional de Especialistas en Ciencias Avicolas, Puerto Vallarta, Jal, México, 1998.

Lucio-M, B. Efecto de la anemia infecciosa del pollo sobre la producción. In: 1er. Pre-Congreso Científico Avícola IASA. S. A. Investigacion Aplicada, ed., Acapulco, Gro. México. pp. 9-21, 2001.

Lucio, B., and B. W. Calnek. Comparative susceptibility of MSB-1 and CU-147 lymphoblastoid cell lines to chicken infectious anemia virus. Proceedings of 42th Western Poultry Disease Conference. Davis, Calif. 1993.

Lucio, B., and J. Fabricant. Tissue tropism of three cloacal isolates and Massachusetts strain of infectious bronchitis virus. Avian Dis. 34:865-870, 1990.

Lucio, B., R. G. Getchell, C. W. Maddox, D. Kradel, and p. McDonough. Discrimination between SE-negative and SE-positive table-egg layer flocks by ELISA. In: Proc. 44th Western Poultry Disease Conference. Sacramento, CA. pp. 74-76, 1995.

Lucio Martinez, B., and S. B. Hitchner. Effect of passive antibodies on avian infectious bursitis and active immunization. In: Proc. 29th Western Poultry Disease Conference. Acapulco, Mexico, pp. 20-23, 1980.

Lucio, B. and S.B. Hitchner. Differentiation and detection of infectious bronchitis virus subtypes by immunofluorescence. Avian Dis. 14:9-24, 1970.

Lucio, B. and S.B. Hitchner. Response of susceptible versus immune chicks to killed, live-modified, and wild infectious bursal disease virus vaccines. Avian Dis. 23:1037-1050,
1979.

Lucio, B. and S.B. Hitchner. Infectious bursal disease emulsified vaccines effect upon neutralizing-antibody levels in the dam and subsequent protection of the progeny. Avian Dis. 23:466-478, 1979.

Lucio, B. and S.B. Hitchner. Immunosuppression and active response induced by infectious bursal disease virus in chickens with passive antibodies. Avian Dis. 24:189-196, 1980.

Lucio, B. and S.B. Hitchner. Response of Mibolerone-treated chickens to infectious bursal disease virus. Avian Dis. 24:334-3, 1980.

Lucio, B., T. C. McNamara, and R. G. Getchell. Effect of a tragopan herpesvirus on chickens. In: Proc. 46th Western Poultry Disease Conference. Sacramento, CA, 1997.

Lucio, B., and K. A. Schat. Transient positive reactions and cross-reactivity in the indirect fluorescent antibody test for chicken infectious anemia antibody detection. In: Proc. the 39th Western Poultry Disease Conference. Sacramento, CA. pp. 37-38, 1990.

Lucio, B., and K.A. Schat. Anemia infecciosa del pollo, una nueva enfermedad immunosupresora. Actualidades en inmunodepresion. ANECA, Mexico City, pp: 61-67, 1990.

Lucio, B., K. A. Schat, and H. L. Shivaprasad. Identification of the chicken anemia agent, reproduction of the disease, and serological survey in the United States. In: Proc. 38th Western Poultry Disease Conference. Davis, CA. p. 49, 1989.

Lucio, B., Schat, K.A., and H.L. Shivaprasad. Identification of the chicken anemia agent, reproduction of the disease and serological survey in the United States. Avian Dis. 34:146-153, 1990.

Lucio, B., K.A. Schat, and S. Taylor. Direct binding of Protein A, Protein G, and anti-IgG conjugates to chicken infectious anemia virus. Avian Dis. 35: 180-185, 1991.

Lucio, B., and S. C. Trock. An AI outbreak in Swan Lake. In: Proc. 45th Western Poultry Disease Conference. Davis, CA. pp. 43-44, 1996.

Lucio, B., J.J. York, E.Z. Lucio and B.W. Calnek. Diagnosis of avian infectious laryngotracheitis by antigen-capture and ELISA test. Proc. Western Poultry Dis. Conf., Davis, CA. pp. 132-134, 1988.

Lucio-M., B., G. Zavala, and B. L. Njaa. Sarcomas in white Leghorns. A re-emerging disease? Proceedings 54th Western Poultry Disease Conference. Vancouver, BC, Canada. 2005.

Lucio-Forster, A., D. D. Bowman, B. Lucio-M., M. P. Labare, and M. A. Butkus. Inactivation of the avian influenza virus (H5N2) in typical domestic wastewater and drinking water treatment systems. Environmental Engineering Science 23:897-903, 2006.

Luginbuhl, R.E., C.F. Helmboldt, and B.W. Calnek. Avian encephalomyelitis (epidemic tremor). In: Diseases of Poultry 8th Ed.(Hofstad, M.S., Barnes, J.H., Calnek, B.W., Reid, W.M., and Yoder, H.W., Jr., eds.). Iowa State University Press, Ames, Iowa. pp. 471-481, 1984.

Majiyagbe, K.A. and S.B. Hitchner. Antibody response to strain combinations of Newcastle disease virus as measured by hemagglutination-inhibition. Avian Dis. 21:576-584, 1977.

Markowski-Grimsrud, C. J., and K. A. Schat. Impairment of cell-mediated immune responses during chicken infectious anemia virus infection. Proc 2nd Int Symp Infect Bursal Dis Chick Infect Anaemia, Rauischholzhausen, Germany. pp. 395-402, 2001.

Markowski-Grimsrud, C.J., and K.A. Schat. Cytotoxic T lymphocyte responses to Marek's disease herpesvirus-encoded glycoproteins. Vet. Immunol. Immunopathol, 90: 133-144, 2002.

Markowski-Grimsrud, C.J., and K.A. Schat. Infection with chicken anemia virus impairs the generation of pathogen-specific cytotoxic T lymphocytes. Immunology 109:283-294, 2003.

Markowski-Grimsrud, C. J., P.H. O'Connell, and K.A. Schat. Syngeneic cell-mediated immune responses to Marek's disease virus (MDV)-encoded glycoproteins. In: Current progress on Marek's disease research. (K.A. Schat, R.M. Morgan, M.S. Parcells, and J.L. Spencer, eds.) Amer. Assoc. Avian Pathol., Kennett Square, PA. pp.127-130, 2001.

Markowski-Grimsrud, C.J., M.M. Miller, and K.A. Schat. Development of strain-specific real-time PCR and RT-PCR assays for quantitation of chicken anemia virus. J. Virol. Meth. 101:135-147, 2002.

Matheson, Robert, E.L. Brunett, and A.L. Brody. The transmission of fowl pox by mosquitoes, preliminary report. Report of NYS Veterinary College for 1930-31. pp. 177-186, 1931.

McColl, K.A., B.W. Calnek, W.V. Harris, K.A. Schat and L.F. Lee. Expression of a putative tumor-associated surface antigen on normal versus Marek's disease transformed lymphocytes. J. Natl. Cancer Inst. 79:991-1000, 1987.

McDonough, P.L, R. H. Jacobson, J.F. Timoney, A. Mutalib, D.C. Kradel, Y.F. Chang, S.J. Shin, D.H. Lein, S. Trock, and K. Wheeler. Interpretations of antibody responses to Salmonella enterica serotype enteritidis gm flagellin in poultry flocks are enhanced by a kinetics-based enzyme-linked immunosorbent assay. Clin. Diagn. Lab. Immunol. 5:550-555, 1998.

Menendez, N.A., B.W. Calnek and B.S. Cowen. Experimental egg transmission of avian reovirus. Avian Dis, 19:104-111, 1975.

Menendez, N.A., B.W. Calnek and B.S. Cowen. Localization of avian reovirus (FDO) isolant in tissues of mature chickens. Avian Dis, 19:112-117, 1975.

Miller M.M., and K.A. Schat. Chicken infectious anemia virus: an example of the ultimate host-parasite relationship. Avian Dis. 48:734-745, 2004.

Miller, M., W. B. Oswald, J. Scarlet, and K. A. Schat. Patterns of chicken infectious anemia virus (CIAV) seroconversion in three Cornell SPF flocks. Proc 2nd Int Symp Infect Bursal Dis Chick Infect Anaemia, Rauischholzhausen, Germany. pp. 410-417, 2001.

Miller, M.M., K. A. Ealey, W. B. Oswald, K. A. Schat. Detection of chicken anemia virus DNA in embryonal tissues and eggshell membranes. Avian Dis. 47: 662-671, 2003.

Miller, M.M., K.W. Jarosinski, and K.A. Schat. Positive and negative regulation of chicken anemia virus transcription. J. Virol., 79:2859-2868, 2005.

Miller, M.M., K.W. Jarosinski, and K.A. Schat. Negative modulation of the chicken infectious anemia virus promoter by COUP-TF1 and an E box-like element at the transcription start site binding δEF1. J Gen Virol 89:2998-3003, 2008.

Miller, T.K., D.D. Bowman, and K.A. Schat. Inhibition of the in vitro development of Eimeria tenella in chick kidney cells by immune chicken splenocytes. Avian Dis. 38:418-427, 1994.

Minick, C.R., C.G. Fabricant, J. Fabricant and M. Litrenta. Atheroarteriosclerosis induced by infection with a herpesvirus. Amer. J. Pathology 96:673-706, 1979.

Mondal, S. and S. Naqi. Maternal antibody to infectious bronchitis virus: Its role in protection against challenge and development of active immunity to vaccine. Veterinary Immunology and Immunopathology 79:31-40, 2001.

Mondal, S., B. Lucio and S. Naqi. Isolation and characterization of a novel infectious bronchitis virus isolates from New York State that genetically resemble Delaware 072 variant. Avian Dis. 45:1054-1059, 2001.

Moore, E. N. Diseases of turkeys in New York. Report of NYS Veterinary College for 1946-47. pp. 224-230, 1947.

Moore, E. N. Sulfaquinoxaline as a treatment for coccidiosis in turkeys. Cornell Vet. 39:229, 1949.

Moore, E. N. and J. A. Brown. A new coccidium pathogenic for turkeys, Eimeria adenoeides, n. sp. Cornell Vet. 31:124, 1951.

Moore, E. N. and Jesse Brown. A new coccidium of turkeys, Eimeria innocua, N.S. Cornell Vet. 42:395, 1952.

Moore, F.R., K.A. Schat, N. Hutchison, C. Leciel, and S.E. Bloom. Consistent chromosomal aberration in cell lines transformed with Marek's disease herpesvirus: evidence of genomic DNA amplification. Int. J. Cancer 54:685-692, 1993.

Moore, F.R., B.W. Calnek, and S.E. Bloom. Cytogenetic studies of cell lines derived from Marek's disease virus-induced local lesions. Avian Dis. 38:797-799, 1994.

Murthy, K.K. and B.W. Calnek. Pathogenesis of Marek's disease: early appearance of Marek's disease tumor associated surface antigen (MATSA) in infected chickens. J. Natl. Cancer Inst. 61:849-854, 1978.

Murthy, K.K. and B.W. Calnek. Pathogenesis of Marek's disease: effect of immunization and inactivated viral and tumor-associated antigens. Infect. Immun. 26:547-553, 1979.

Murthy, K.K. and B.W. Calnek. Marek's disease tumor-associated surface antigen (MATSA) in resistant versus susceptible chickens. Avian Dis. 23:831-837, 1979.

Murthy, K.K., R.R. Dietert, and B.W. Calnek. Demonstration of chicken fetal antigen (CFA) on normal splenic lymphocytes, Marek's disease lymphoblastoid cell lines and other neoplasms. Int. J. Cancer 24:349-354, 1979.

Mutalib A. Studies on transmissibility of a tissue-culture-modified laryngotracheitis virus. J. Vet. Diag. Invest. 4:412-415, 1992.

Mutalib A, P. McDonough, S. Shin, V. Patten, and D. Lein. Salmonella enteritidis in commercial layer farms in New York state; environmental survey results and significance of available monitoring tests. J. Vet. Diag. Invest. 4:416-418, 1992.

Mutalib A.A., J.M. King, and P.L. McDonough. Erysipelas in caged laying chickens and suspected erysipeloid in animal caretakers. J. Vet. Diag. Invest. 5:198-201, 1993.

Myers, T.J., and K.A. Schat. Propagation of avian rotavirus in primary chick kidney cell and MA104 cell cultures. Avian Dis. 33:578-581, 1989.

Myers, T.J., and K.A. Schat. Natural killer cell activity of chicken intraepithelial leukocytes against rotavirus-infected target cells. Vet. Immunol. Immunopathol. 26:157-170, 1990.

Myers, T.J., and K.A. Schat. Intestinal IgA response and immunity to rotavirus infection in normal and antibody-deficient chickens. Avian Pathol, 19:697-712, 1990

Myers, T.J., Schat, K.A., and Mockett, A.P. Development of Ig class-specific Elisa assays for the measurement of antibodies against avian rotavirus. Avian Dis. 33:53-59, 1989.

Naqi, S. A monoclonal antibody-based immunoperoxidase procedure for rapid detection of infectious bronchitis virus in the infected tissues. Avian Dis. 34:893-898, 1990.

Naqi, S.A. Coronaviral enteritis of turkeys. In: Virus Infections of Vertebrates (J.B. McFerran and M.S. McNulty, eds.) Elsever Science Publishers, 1993.

Naqi, S.A. Infectious bronchitis. In: The Merck Veterinary Manual. (S.A.E. Aiello, ed.), Merck and Co. 1979-1980, 1998 and 2002.

Naqi, S. Production of monoclonal antibodies specific to avian infectious bronchitis virus and their application in the isolation and identification of IBV serotypes. A manual prepared in connection with a workshop given at the Madras Veterinary College, Chennai, India, Jan. 6-10, 2002.

Naqi, S., K. Karaca and B. Bauman. A monoclonal antibody-based antigen capture enzyme-linked immunosorbent assay for identification of infectious bronchitis virus serotypes. Avian Pathol., 22:555-564, 1993.

Naqi, S.A., K. Gay, P.S. Patala and C. Wang. Age-related mucosal immunity to IBV in chickens. Proc. of Internat. Symp. on Infectious Bronchitis and Pneumovirus Infections in Poultry, Rauischholzhausen, Germany. pp. 327-331, 1998

Naqi, S., G. Thomson, B. Bauman and H. Mohammed. Infectious bronchitis virus exacerbates infectious bursal disease virus-induced suppression of opsonization by E. coli antibody in chickens. Avian Dis. 45:52?60, 2001.

Naqi, S.A., Kathryn Gay, Prasad Patalla, Shankar Mondal and Runzhong Liu. Establishment of Persistent avian infectious bronchitis virus infection in maternal antibody-free and maternal antibody-positive chickens. Avian Dis. 47:594-601, 2003.

Narotsky, Saul. Two field cases of Erysipelothrix rhusiopathiae infection in chickens. Cornell Vet. 44:32, 1954.

Narotsky, Saul. Hemorrhagic syndrome. Eastern Feed Merchant 5:26, 1954.

Narotsky, Saul, and J. R. E. Taylor. Clinical evidence of suspected egg-transmission of infectious avian hepatitis. Avian Dis. 2:4, 1958.

Ohashi, K., and K.A. Schat. cDNA clones derived from the Marek's disease tumor cell line MDCC-CU41. Proc. XIX World Poultry Congress, Amsterdam, The Netherlands. pp. 54-57, 1992.

Ohashi, K., P.H. O'Connell, and K.A. Schat. Characterization of Marek's disease virus BamHI-A-specific cDNA clones obtained from a Marek's disease lymphoblastoid cell line. Virology 199:275-283, 1994.

Ohashi, K., W. Zhou, P.H. O'Connell, and K.A. Schat. Characterization of a Marek's disease virus BamHI-L-specific cDNA clone obtained from a Marek's disease lymphoblastoid cell line. J. Virol. 68:1191-1195, 1994.

Olson, Carl. Attempts to transmit fowl paralysis. J. Infect. Dis. 61:325, 1937.

Olson, Carl and Alexander Zeissig. A study of the antigenic properties of certain normal and pathological lymphoid deposits in tissues of chickens. J. Immunol. 31:309, 1936.

Olson, Carl and H. H. Dukes. The basal metabolic rate of chickens affected with fowl paralysis, transmissible fowl leukosis and certain spontaneous neoplasms. Folia Haematologica 60:57, 1938.

Olson, Carl and P. P. Levine. A study of the cellular elements and hemoglobin in the blood of chickens experimentally infected with Capillaria columbae (RUD). Poultry Sci.18:3, 1939.

Olson, Carl and George R. Goetchius. The reaction of chickens to certain members of the colon-paratyphoid group of bacteria. Cornell Vet. 27:354, 1937.

Omar, A.R., and K.A. Schat. Syngeneic Marek's disease virus (MDV)-specific cell-mediated immune responses against immediate early, late, and unique MDV proteins. Virology 222: 87-99, 1996.

Omar, A.R., and K.A. Schat. Characterization of Marek's disease herpesvirus (MDV)- specific cytotoxic T lymphocytes in chickens inoculated with a nononcogenic vaccine strain of MDV. Immunology 90:579-585, 1997.

Omar, A. R., and Schat, K. A. Recent advances in molecular biology and immunology of Marek's disease. Asia Pacific J. Mol. Biol. Biotechnol. 6:1-12, 1998.

Omar, A.R., K.A. Schat, L.F. Lee, and H.D. Hunt. Cytotoxic T lymphocyte response in chickens immunized with a recombinant fowlpox virus expressing Marek's disease herpesvirus glycoprotein B. Vet. Immunol. Immunopathol. 62:73-82, 1998.

Owen, R.L., B.S. Cowen, A.L. Hattel, S.A. Naqi and R.A. Wilson. Detection of viral antigen following exposure of one-day-old chickens to Holland 52 strain of infectious bronchitis virus. Avian Pathol. 20:663-673, 1991.

Panigraphy, B., S.A. Naqi and N. Sahin. Effect of antibiotics on humoral immune responses in domestic poultry. Chemical Regulation of Immunity in Veterinary Medicine. Alan R. Liss Inc., New York. pp: 347-354, 1987.

Patterson, F. D. Studies on the viability of Eimeria tenella in soil. Cornell Vet. 23:232-249, 1933.

Patterson, F. D. Cross infection experiments with coccidia of birds. Cornell Vet. 23:249-253, 1933.

Patterson, F. D. Viability of coccidial oocysts. Tech. Bull. Tuskegee Normal and Indus. Inst. 1:3-17, 1933.

Patrascu, I.V. and B.W. Calnek. In vitro assay of cell-free turkey herpesvirus. Avian Dis. 16:297-413, 1972.

Patrascu, I.V., B.W. Calnek, and M.W. Smith. Vaccination with lyophilized turkey herpesvirus (HVT): minimum infective and protective doses. Avian Dis. 16:86-93, 1972.

Patrascu, I.V., B.W. Calnek, and M. Smith. Turkey herpesvirus. VII. The evolution of Marek's disease in chickens vaccinated at one day of age and challenged at different periods of time after vaccination. Virologie 39:35-40, 1988.

Peckham, M.C. Lens opacities possibly associated with epidemic tremor. Avian Dis. 1:247, 1957.

Peckham, M.C. An anaerobe, the cause of ulcerative enteritis, "quail disease." Avian Dis. 3:471, 1959.

Peckham, M.C. Further studies on the causative organism of ulcerative enteritis. Avian Dis. 4:449, 1960.

Peckham, M.C. and Robert Reynolds. The effiency of chemotherapeutic drugs in the control of experimental ulcerative enteritis in quail. Avian Dis. 6:111, 1962.

Peckham, M.C. Vices and miscellaneous conditions, Chap. 39. In: Diseases of Poultry, 5th Ed. (H. E. Biester and L. H. Schwarte, eds). Iowa State University Press, Ames, Iowa. pp. 1162-1211, 1965.

Peckham, M. C. Poisons and toxins, Chap. 40. In: Diseases of Poultry, 5th Ed. (H. E. Biester and L. H. Schwarte, eds). Iowa State University Press, Ames, Iowa. pp. 1212-1252, 1965.

Peckham, M.C. Ulcerative enteritis, quail disease, Chap. 17. In: Diseases of Poultry, 5th Ed. (H. E. Biester and L. H. Schwarte, eds). Iowa State University Press, Ames, Iowa. pp. 481-493, 1965.

Peckham, M.C. An outbreak of streptococcus (apoplectiform septicemia) in White Rock chickens. Avian Dis. 10:413-421, 1966.

Peckham, M.C. The diagnosis of poultry diseases. Scope, Vol XI. p. 2, 1966.

Peckham, M.C. Green leg disease. Poultry Pointers. Poultry Department, NYS Agric. Coll. Ithaca, NY, 1968.

Peckham, M.C. Salmonella and the poultry industry. Official Directory of Poultry Improvement Board, Ithaca, N.Y, 1968.

Peckham, M.C. Clean and cool to vaccinate. Poultry Pointers. Poultry Department. NYS Agric. Coll., Ithaca, NY, 1968.

Peckham, M.C. A look at litter. Poultry Pointers. NYS Agric. Coll, Ithaca, NY, 1969.

Peckham, M.C. Quail disease (ulcerative enteritis). In: Infectious and Parasitic Disease of Wild Birds (J. Davis, et al., eds.) Iowa State Univ.Press, Ames, Iowa, 1971.

Plummer, P.J., T. Alefantis, S. Kaplan, P. O'Connell, S. Shawky, and K.A. Schat. Detection of duck enteritis virus by polymerase chain reaction. Avian Dis. 42:554-564, 1998.

Poonia, B., P.A. Dunn, H. Lu, K.W. Jarosinski, and K.A. Schat. Isolation and molecular characterization of a new parvovirus from Muscovy ducks in the USA. Avian Pathol. 35:435-442. 2006.

Pratt, W.D., R.W. Morgan, and K.A. Schat. Characterization of reticuloendotheliosis virus-transformed avian T-lymphoblastoid cell lines infected with Marek's disease virus. J.Virol. 66:7239-7244, 1992.

Pratt, W.D., R. Morgan, and K.A. Schat. Cell-mediated cytolysis of lymphoblastoid cells expressing Marek's disease virus-specific phosphoproteins. Vet. Microbiol. 33: 93-99, 1992.

Pratt, W.D., K.A. Schat, H-C. Chen, and R.W. Morgan. Regulation of expression of the 38 KD phosphoprotein in MSB-1. Proc. XIX World Poultry Congress, Amsterdam, The Netherlands. pp. 97-99, 1992.

Pratt, W.D., Cantello, J., R.W. Morgan, and K.A. Schat. Enhanced expression of the Marek's disease virus-specific phosphoproteins after stable transfection of MSB-1 cells with the Marek's disease virus homolog of ICP4. Virology 201:132-136, 1994.

Price, J. I. Studies on Pasteurella anatipestifer infection in White Pekin ducks. Avian Dis. 3:486, 1959.

Price, J.I., and E. Dougherty, 3rd. Studies with eastern encephalitis in White Pekin ducklings. Avian Dis. 4:444, 1960.

Price, J.I. and E. Dougherty, III. Salmonella infections in white Pekin ducks. A short summary of the years 1950-1960. Avian Dis. 6:145-147, 1962.

Price, R.D. and L. Leibovitz. A new species of actornithophilus (mallaphaga: menophonidae) from the know. Canadian Entomologist 101 #9, 1969.

Quimby, F., K.A. Schat, B. Lucio-Martinez, J. Ludders, and A. van Tienhoven. Poultry. In: The experimental animal in biomedical research. Vol II (B.E. Rollin and M.L. Kesel, eds.). CRC Press, Boca Raton. pp.195-249, 1995.

Renshaw, R.W., C. Soine, T. Weinkle, P.H. O'Connell, K. Ohashi, S. Watson, B. Lucio, S. Harrington and K.A. Schat. A hypervariable region in VP1 of chicken infectious anemia virus mediates rate of spread and cell tropism in tissue culture. J. Virol. 70:8872-8878, 1996.

Rhoades, K. R., R. B. Rimler and T. S. Sandhu. Pasteurellosis and pseudotuberculosis. In: A Laboratory Manual for the Isolation and Identification of Avian Pathogens. 3rd Ed. Amer. Assoc. Avian Pathol., Kennett Square, PA. pp. 14-21, 1989.

Rigdon, R. H. and L. Leibovitz. Spontaneous-occurring tumors in the duck: Review of the literature and report of three cases. Avian Dis. 14:431-444, 1970.

Rodenberg, J., J.M. Sharma, S.W. Belzer, R.M. Nordgren, C.L. Chen and S. Naqi. Flow cytometric analysis of B-cell and T-cell subpopulation in specific-pathogen-free chickens infected with infectious bursal disease virus. Avian Dis. 38:16-21, 1994.

Ross, L.J.N., B.S. Milne, and K.A. Schat. Restriction enzyme analysis of MDV DNA and homology between strains. In: Proc. International Symposium on Marek's disease (Calnek, B.W. and J.L Spencer, eds.). Amer. Assoc. Avian Pathol., Kennett Square, PA. pp. 51-67, 1985.

Ross, L.J.N., M.M. Binns, M. Sanderson, and K.A. Schat. Alterations in DNA sequence and RNA transcription of the BamHI-H fragment accompanying attenuation of oncogenic Marek's disease herpesvirus. Virus Genes 7:33-99, 1993.

Sandhu, T.S. Infectious diseases of Anseriformes. In: Zoo and Wild Animal Medicine. (M.E. Fowler, ed.) W.B. Saunders Company, Philadelphia. pp.193-200, 1978.

Sandhu, T. Immunization of White Pekin ducklings against Pasteurella anatipestifer infection. Avian Dis. 23:662-669, 1979.

Sandhu, T.S. Infectious Diseases, Ducks, Geese, Swans, and Screamers (Anseriformes). In: Zoo and Wild Animal Medicine. 2nd ed. (M.E. Fowler, ed.) W. B. Saunders Company, Philadelphia. pp. 346-352, 1986.

Sandhu, T.S. Important diseases of ducks. In: Duck Production and World Practice. (D. J. Farrell and P. Stapleton, eds.). Univ. of New England, Australia. pp. 111-134, 1986.

Sandhu, T.S. Pasteurella anatipestifer live vaccine: Laboratory and field trials in White Pekin ducklings. Proc.XXIII World Vet. Congr. Montreal, Canada. p. 325, 1987.

Sandhu, T.S. Fecal Streptococcal Infection of Commercial White Pekin ducklings. Avian Dis. 32:570-573, 1988.

Sandhu, T. S. Immunogenicity and safety of a live Pasteurella anatipestifer vaccine in White Pekin ducklings: laboratory and field trials. Avian Pathol. 20:423-432, 1991.

Sandhu, T. S. Maternal immunity to Pasteurella anatipestifer infection in ducks and its effect on active immunization. Proc. 132nd AVMA meeting, Pittsburgh, July 8-12, 1995.

Sandhu, T. S. and W. F. Dean. Effect of chemotherapeutic agents on Pasteurella anatipestifer infection in White Pekin ducklings. Poult. Sci. 59:1027-1030, 1980.

Sandhu, T.S. and E.G. Harry. Serotypes of Pasteurella anatipestifer isolated from commercial White Pekin ducks in the United States. Avian Dis. 25-497-502, 1981.

Sandhu, T.S. and V. Hinshaw. Influenza A virus infection of domestic ducks. Proc. 1st International Symposium on Avian Influenza, Beltsville, MD. pp. 93-99, 1981.

Sandhu, T. S. and H. W. Layton. Laboratory and field trials with a formalin-inactivated Escherichia coli (078) Pasteurella anatipestifer bacterin in White Pekin ducks. Avian Dis. 29:128-135, 1985.

Sandhu, T.S., and L. Leibovitz. Duck Virus Enteritis (Duck Plague). In: Diseases of Poultry, 10th Ed. (B.W. Calnek, H.J. Barnes, C.W. Beard, L.R. McDougald and Y.M. Saif., eds.) Iowa State University Press, Ames, Iowa. pp. 675-683, 1997.

Sandhu, T.S., and M.L. Leister. Serotypes of Pasteurella anatipestifer isolates from poultry in different countries. Avian Pathol. 20: 233-249, 1991.

Sandhu, T. S. and R. B. Rimler. Riemerella anatipestifer infection. In: Diseases of Poultry, 10th Ed.(B. W. Calnek, H. J. Barnes, C. W. Beard, L. R. McDougald and Y. M. Saif, eds.). Iowa State University Press, Ames, Iowa. pp. 161-166, 1997.

Sandhu, T.S., K. R. Rhoades and R. B. Rimler. Pasteurella anatipestifer infection. In: Diseases of Poultry,9th Ed.(B. W. Calnek, H. J. Barnes, C. W. Beard, W. M. Reid and H. W. Yoder. Jr. eds.) Iowa State University Press, Ames, Iowa. pp. 166-171, 1991.

Sandhu, T.S., B.W. Calnek, and L. Zeman. Pathologic and serologic characterization of a variant of duck hepatitis type I virus. Avian Dis. 36:932-936, 1992.

Schat, K.A., J. Gonzalez del Angel. La enfermedad de Marek. En: Cienca Veterinaria 1. (R. Moreno Chan, ed.) UNAM, Mexico City. pp. 298-337, 1976.

Schat, K.A. Role of the spleen in the pathogenesis of Marek's disease. Avian Pathol. 10:171- 182, 1981.

Schat, K.A. Criterios para el empleo de la vacuna SB-1 contra la Enfermedad de Marek. Proc. IX Congreso Latino Americano de Avicultura pp. 18-31, 1985.

Schat, K.A. Characteristics of the virus (Payne, L.N. ed.) In: Marek's disease. Developments in Veterinary Virology. Martinus Nijhoff Publishers, Boston/The Hague. pp. 77-112, 1985.

Schat, K.A. Immunity in Marek's disease and other tumors. In: Avian Immunology: Basis and Practice. (A. and P. Toivanen, eds.) CRC Press, Boca Raton, FL. Vol II. pp. 101-128, 1987.

Schat, K.A. Marek's disease - A model for protection against herpesvirus-induced tumors. Cancer Surveys 6:1-37, 1987.

Schat, K.A. Biological characterization of Marek's disease herpesvirus. A review. In: Advances in Marek's Disease Research (S. Kato, T. Horiuchi, T. Mikami, and K. Hirai, eds.). Jap Assoc. on Marek's Disease, Osaka. pp. 169-176, 1988.

Schat, K.A. Estragia de vacunacion contra la Enfermedad de Marek. In: Primer curso de actualizacion Avimex "Enfermedad de Marek". Avimex, Mexico City pp: 39-59, 1989.

Schat, K.A. Patogenesis de la enfermedad de Marek. Un virus herpetico inductor de lymphomas. In: Primer curso de actualizacion Avimex "Enfermedad de Marek". Avimex, Mexico City pp: 23-31, 1989.

Schat, K.A. Estrategia de vacunacion contra la enfermedad de Marek. In: VII Seminario Internacional de Patologia Aviar, Ed. Pedro Villegas. AMEVEA/CMV University of Georgia, Athens, Ga. pp. 397-417, 1990.

Schat, K.A. Importance of cell-mediated immunity in Marek's disease and other viral tumor diseases. Poultry Sci. 70:1165-1176, 1991.

Schat, K.A. T cell immunity: Mechanisms and soluble mediators. In: Avian Cellular Immunology, (J.M. Sharma, ed.)CRC Press, Boca Raton, FL. pp. 35-50, 1991.

Schat, K.A. Immune responses against Marek's disease virus. Proc. XIX World Poultry Congress, Amsterdam, The Netherlands. pp. 233- 236, 1992.

Schat, K.A. Influence of infectious bursal disease virus or chicken infectious anemia virus on the avian immune system. Proc. Intl. Symp. on Infectious Bursal Disease and Chicken Infectious Anemia. Rauischholzhausen, Germany. pp. 17-21, 1994.

Schat K.A. Cell-mediated immune effector functions in chickens. Poultry Sci. 73:1077-1081, 1994.

Schat, K.A. Mucosal immunity in chickens: the challenge for the future. In: Advances in Avian Immunology Research (T.F. Davison, N. Bumstead, P. Kaiser, eds) Carfax Publishing Co, Abingdon, UK. pp. 247-254, 1995.

Schat, K.A. Marek's disease vaccines:current options and future developments. Proc. XIX World Poultry Congress vol II, New Delhi, India, pp. 521-526, 1996.

Schat, K.A. Immunity to Marek's disease, lymphoid leukosis and reticuloendotheliosis. In: Avian Immunology (F. Davison, L.N. Payne, and T.R. Morris, eds). Carfax Publishing Company, Abingdon, U.K. pp. 209-233, 1996.

Schat, K.A. Vaccinal immunity to Marek's disease. In: Avian tumor virus symposium (A.M. Fadly, K.A. Schat, J.L. Spencer, eds). Amer. Assoc. Avian Pathol., Kennett Square, PA. pp. 33-41,1997.

Schat, K.A. Tumors of the immune system. In. Handbook of Vertebrate Immunology, Section Immunology of poultry (P.P. Pastoret, H.Bazin, A. Govaerts, and P.J. Griebel, eds). Academic Press, London, p108-111, 1998.

Schat, K.A. Importance of immunosuppresive viruses in modern poultry industry. Proc. 10th European Poultry Congress, Jerusalem, Vol. 1, 32-35, 1998.

Schat, K.A. Leukosis mieloide. In: III Poultry Science Seminar, Buenos Aires, Argentina. May, 1998.

Schat, K.A. Specific and nonspecific immune responses to Marek's disease virus. In: Current progress on Marek's disease research (K.A. Schat, R.M. Morgan, M.S. Parcells, and J.L. Spencer eds). Amer. Assoc. Avian Pathol., Kennett Square, PA. pp. 123-126, 2001.

Schat, K.A. The immunological system and neoplasia. In: Infection, resistance and immunity, 2nd Ed. (J.P. Kreier, ed). Gordon and Breach Scientific Publications. pp. 223-246, 2002.

Schat, K.A. Circovirus infections, Chicken infectious anemia. In: Diseases of Poultry, 11th Ed., (Y.M. Saif, H.J. Barnes, A.M. Fadly, J. R. Glisson, L.R. McDougald, and D.E. Swayne, eds). Iowa State Press, Ames, Iowa. pp.182-202, 2003.

Schat, K.A. Marek's disease immunosuppression. In: Marek's disease: an evolving problem (F.Davison and V. Nair, eds). Elsevier Academic Press, London. pp.142-155, 2004.

Schat, K.A. Understanding Marek's disease immunity: a continuing challenge. Int. J. Poultry Sci. 3: 89-95, 2004.

Schat, K.A. Isolation of Marek's disease virus: revisited. Avian Pathol. 34:91-95, 2005.

Schat, K.A. Chicken Anemia Virus Infection. In: The Merck Veterinary Manual 9th Ed. (Kahn C.M. and Line S.W., eds). Whitehouse Station NJ: Merck & Co. pp. 2196-2197, 2005.

Schat, K.A. Interaction between Marek's disease virus and the host cell. A review. In: Proc. International Symposium on Marek's disease (Calnek, B.W. and Spencer, J.L., eds.). Amer. Assoc. Avian Pathol., Kennett Square, PA. pp. 156-172, 1985.

Schat, K.A. Developments in poultry vaccines and the future of genetically engineered vaccines. Proc. XIIth International Congress of the World Veterinary Poultry Association, Cairo, Egypt. pp. 141-150, 2001.

Schat, K.A. Marek's disease, chicken infectious anemia, and immunosuppression, a nasty combination. Proc. Australian Poultry Science Symposium Vol 15. pp.51-57, 2003.

Schat, K.A. Mechanisms of immunosuppression caused by Marek's disease virus and chicken infectious anemia virus. Proc.5th Asia Pacific Poultry Health Conference, Australian Veterinary PoultryAssociation. pp. 41-47, 2003.

Schat. K.A. Circovirus infections, Introduction. In: Diseases of Poultry, 11th Ed.(Y.M. Saif, H.J. Barnes, A.M. Fadly, J. R. Glisson, L.R. McDougald, and D.E. Swayne, eds), Iowa State Press, Ames, Iowa. pp.181-182, 2003.

Schat, K.A. A pathogenia do virus da anemia infecciosa das galinhas, a relaco hospedeiro- virus definitiva. Proceedings Conferencia de Ciencia e Technologia Avicolas. FACTA, Campinas Brazil. pp. 183-190, 2004.

Schat, K.A. Doenca de Marek: problemas antigos e novos. Proceedings Conferencia de Ciencia e Technologia Avicolas. FACTA, Campinas Brazil. pp. 191-200, 2004.

Schat, K.A. Nuevas estrategias para la prevencion y control de las enfermedades immunosupresivas. Memorias XX Congreso Latinoamericano de Avicultura, Brasil. Union Brasilena de Avicultura, Sao Paulo. pp. 101-110, 2007.

Schat, K.A. Chicken anemia virus. Curr Top Microbiol Immunol, 331:151-184, 2009.

Schat, K.A., and E. Baranowski. Animal vaccination and the evolution of viral pathogens. Rev. Sci. Tech. Off. Int. Epiz. 26:237-338, 2007.

Schat, K.A. and B.W. Calnek. Demonstration of Marek's disease tumor-associated surface antigen in chickens infected with nononcogenic Marek's disease virus and herpesvirus of turkeys. J. Natl. Cancer Inst. 61:855-857, 1978.

Schat, K.A. and B.W. Calnek. Characterization of an apparently nononcogenic Marek's disease virus. J. Natl. Cancer Inst. 60:1075-1081, 1978.

Schat, K.A., and B.W. Calnek. Protection against Marek's disease-derived tumor transplants by the nononcogenic SB-l strain of Marek's disease virus. Infect. Immun. 22:225-232, 1978.

Schat, K.A. and B.W. Calnek. In vitro inactivation of cell-free Marek's disease herpesvirus by immune peripheral blood lymphocytes. Avian Dis. 22:693-697, 1978.

Schat, K.A. and B.W. Calnek. In vitro cytotoxicity of spleen lymphocytes against Marek's disease tumor cells: induction by SB-l, an apparently nononcogenic Marek's disease virus. Proc. Symp. Resistance and Immunity to Marek's disease, W. Berlin. pp. 301-315, 1978.

Schat, K.A., and B. Lucio. Immunosuppresion inducida por la enfermedad de Marek. In: Actualidades en inmunodepresion. ANECA, Mexico City, pp: 52-59, 1990.

Schat, K.A., and B. Lucio. Diagnostico de laboratorio de las "nuevas" enfermedades de las aves. In: Tercer curso de actualizacion Avimex "Nuevos retos virales en la avicultura. Avimex, Mexico City. pp. 59-66, 1991.

Schat, K.A., and B. Lucio. Anemia infecciosa del pollo. In: Tercer curso de actualizacion Avimex "Nuevos retos virales en la avicultura. Avimex, Mexico City, pp:28-35, 1991.

Schat, K.A. and C. Davies. Resistance to Viral Diseases. In: Breeding for disease resistance in farm animals. 2nd Ed.(R.F.E. Axford, J.B. Owen, and F. Nicholas, eds). CAB International, Wallingford, UK. pp. 271-300, 2000.

Schat, K.A., and C.J. Markowski. Immune responses to Marek's disease virus. Curr. Top. Microbiol Immunol. 225:91-120, 2001.

Schat, K.A., and E.D. Heller. A chromium release assay for the study of cell-mediated immune response to Marek's disease antigens. In: Proc. International Symposium on Marek's disease (Calnek, B.W., Spencer, L.J., eds.). pp. 306-314, 1985.

Schat, K.A., and H.G. Purchase. Cell-Culture Methods. In: A Laboratory Manual for the Isolation and Identification of Avian Pathogens, 4th ed. (D.E. Swayne, J.R. Glisson, M.W. Jackwood, J.E. Pearson, W.M. Reed, eds.). Amer. Assoc. Avian Pathol., Kennett Square, PA. pp. 223-234, 1998.

Schat, K.A., and H.G. Purchase. Cell-Culture Methods. In: A Laboratory Manual for the Isolation and Identification of Avian Pathogens, 3rd ed., (H.G. Purchase, L.H. Arp, C.H. Domermuth, and J.E. Pearson, eds.). Amer. Assoc. Avian Pathol., Kennett Square, PA. pp. 167-175, 1990.

Schat, K.A. and K.K. Murthy. In vitro cytotoxicity against Marek's disease lymphoblastoid cell lines after enzymatic removal of MATSA. J. Virol. 34:130-135, 1980.

Schat, K.A., and P. Kaiser. Avian cytokines. In: Cytokines in Veterinary Medicine (V. Schijns and M.C. Horzinek, eds). CAB International, Wallingford, UK. pp. 289-300, 1997.

Schat, K.A. and T.J. Myers. Cultivation of avian rotaviruses in chicken lymphocytes and lymphoblastoid cell lines. Arch. of Virology 94:205-213, 1987.

Schat, K.A., and T.J. Myers. Avian Intestinal Immunity. CRC Crit. Rev. Poultry Biol. 3:19-34, 1991.

Schat, K.A. and V. Nair. Marek's disease. In Diseases of Poultry 12th ed. (Y.M. Saif, A.M. Fadly, J.R. Glisson, L.R. McDougald, L.K. Nolan, and D.E. Swayne, eds). Wiley-Blackwell. pp. 452-514, 2008.

Schat, K.A., and H.S. Sellers. Cell-Culture Methods. In: A Laboratory Manual for the Isolation and Identification of Avian Pathogens, 5th ed., (L. Dufour-Zavala, D.E. Swayne, J.R Glisson, J.E. Pearson. W.R. Reed, M.W. Jackwood and P.R. Woolcock, eds.). American Association of Avian Pathologists. Athens, GA., pp. 195-203, 2008.

Schat, K.A., and W.R. Shek. Separation of cytotoxic lymphocytes against Marek's disease lymphoblastoid cell lines on PercollR gradients. Avian Pathol. 13:469-478, 1984.

Schat, K.A., and M.A. Skinner. Immunosuppressive diseases and immune evasion. In: Avian Immunology (Davison, F., Kaspers, B., and Schat, K.A., eds.). Elsevier, London, San Diego, CA. pp. 299-322, 2008.

Schat, K.A. and V.L. van Santen. Chicken infectious anemia. In Diseases of Poultry 12th ed. (Y.M. Saif, A.M. Fadly, J.R. Glisson, L.R. McDougald, L.K. Nolan, and D.E. Swayne, eds). Wiley-Blackwell. pp. 211-235, 2008.

Schat, K.A. and L.W. Woods. Chicken infectious anemia virus and other circovirus infections. In Diseases of Poultry 12th ed. (Y.M. Saif, A.M. Fadly, J.R. Glisson, L.R. McDougald, L.K. Nolan, and D.E. Swayne, eds). Wiley-Blackwell. pp. 209-211, 2008.

Schat K.A, and Z. Xing. Specific and nonspecific immune responses to Marek's disease virus. Devel Comp Immunol 24:201-221, 2000.

Schat, K.A., Buckmaster, A., and L.J.N. Ross. Partial transcription map of Marek's disease herpesvirus in lytically infected cells and lymphoblastoid cell lines. Int. J. Cancer 44:101-109, 1989.

Schat, K.A., B.W. Calnek and J. Fabricant. Influence of the bursa of Fabricius on the pathogenesis of Marek's disease: In: Advances in Comparative Leukemia Research 1979 (Yohn, Lapen, and Blakeslee, eds.). Elsevier/North-Holland Biomedical Press. pp. 401-402, 1980.

Schat, K.A., B.W. Calnek and J. Fabricant. Influence of the bursa of Fabricius on the pathogenesis of Marek's disease. Infect. Immun. 31:199-207, 1981.

Schat, K.A., B.W. Calnek, and J. Fabricant. Characterisation of two highly oncogenic strains of Marek's disease virus. Avian Path. 11:593-605, 1982.

Schat, K.A., C. Heggen, and M. Qureshi. Isolation of unusual viruses from turkeys affected with poult enteritis and mortality syndrome. In: First International Symposium on Turkey Diseases (H.M. Hafez, ed). German Veterinary Medical Society, Giessen, Germany. pp. 223-227, 1998.

Schat, K.A., B. Lucio and J.C. Carlisle. Pathogenesis of infectious bursal disease in embryonally bursectomized chickens. Avian Dis. 25:996-1004, 1981.

Schat, K.A., J. Gonzalez and A. Solorzano Silva. Behavior of Marek's disease herpesvirus under different agar overlay mediums. XV World Poultry Conference, New Orleans. pp. 49-50, 1974.

Schat, K.A., B.W. Calnek and D. Weinstock. Cultivation and characterisation of avian lymphocytes with natural killer cell activity. Avian Pathol. 15:539-556, 1986.

Schat, K.A., B.W. Calnek and D. Weinstock. Cultured avian lymphocytes with natural killer activity. In: Avian Immunology II. (W.T. Weber and D.L. Ewert, eds.). Alan Liss, Inc., New York, NY. pp. 157-169, 1987.

Schat, K.A., R.D. Schultz, and B.W. Calnek. Marek's disease: effect of virus pathogenicity and genetic susceptibility on responses of peripheral blood lymphocytes to Concanavalin A. In: Advances in Comp. Leukemia Res, 1977 (Bentvelzen, et al., eds.) Elsevier/North Holland. Biomedical Press. pp. 183-186, 1978.

Schat, K.A., B.W. Calnek, J. Fabricant and H. Abplanalp. Influence of oncogenicity of Marek's disease virus on evaluation of genetic resistance. Poultry Sci. 60:2559-2566, 1981.

Schat, K.A., Shek, W.R., Calnek, B.W., and H. Abplanalp. Syngeneic and allogeneic cell-mediated cytotoxicity against Marek's disease lymphoblastoid tumor cell lines. Int. J. Cancer 29:187-194, 1982.

Schat, K.A., C-L. Chen, W.R. Shek, and B.W. Calnek. Surface antigens on Marek's disease lymphoblastoid cell lines. J. Natl. Cancer Inst. 69:715-720, 1982.

Schat, K.A., R.F. Schinazi, and B.W. Calnek. Cell-specific antiviral activity of 1-(2-Fluoro-2-deoxy-B-D-arabinofuranosyl)-5-iodocytosine (FIAC) against Marek's disease herpesvirus and turkey herpesvirus. Antiviral Research 4: 259-270, 1984.

Schat, K.A., B.W. Calnek, J. Fabricant, and D.L. Graham. Pathogenesis of infection with attenuated Marek's disease virus strains. Avian Pathol. 14:127-146, 1985.

Schat, K.A., C-L. Chen, H. Lillehoj, B.W. Calnek and D. Weinstock. Characterization of Marek's disease cell lines with monoclonal antibodies specific for cytotoxic and helper T cells. In: Proc. 3rd Intl. Symp. on Marek's disease - Advances in Marek's Disease Research (S. Kato, T. Horiuchi, T. Mikami, and K. Hirai, eds.). Osaka, Japan, 1988.

Schat, K.A., C-L. Chen, B.W. Calnek, and D. Char. Transformation of T-lymphocyte subsets by Marek's disease herpesvirus. J. Virology 65:1408-1413, 1991.

Schat, K.A., W.R. Pratt, R. Morgan, D. Weinstock, and B.W. Calnek. Stable transfection of reticuloendotheliosis virus-transformed lymphoblastoid cell lines. Avian Dis. 32:432-439, 1992.

Schat K.A., R.L. Taylor, Jr., and W.E. Briles. Resistance to Marek's disease in chickens with recombinant haplotypes of the major histocompatibility (B) complex. Poultry Sci. 73:502-508, 1994.

Schat, K.A., B.J.L. Hooft van Iddekinge, H. Boerrigter, P.H. O'Connell, and G. Koch. Open reading frame L1 of Marek's disease herpesvirus is not essential for in vitro and in vivo replication and establishment of latency. J. Gen Virol 79:841-849, 1998.

Scott, M. L., R. C. Baker, and E. Dougherty, 3rd. Improvement of growth, feathering, and carcass composition in ducks with iodinated casein. Cornell Feed Service 52:10-11, 1960.

Scott, M. L. and W. F Dean. Nutrition and Management of Ducks. Published by M.L. Scott of Ithaca, Ithaca, NY, 1991.

Scott, M. L., E. H. Parsons, Jr., and E. Dougherty, III. Studies on duck nutrition. Unidentified growth factor supplements and methionine in rations for ducks. Poultry Sci. 36: 1181, 1957.

Sevoian, Martin, and B.W. Calnek. Avian infectious hepatitis. III. Treatment of chickens in egg production. Avian Dis. 3:302-321, 1959.

Sevoian, M. and P. P. Levine. Effects of infectious bronchitis on the reproductive tracts, egg production, and egg quality of laying chickens. Avian Dis. 1:136, 1957.

Sharma, J.M., and K.A. Schat. Natural immune functions. In: Avian Cellular Immunology (J.M. Sharma, ed). CRC Press, Boca Raton, FL. pp. 51-70, 1991.

Shawky, S. Target cells for duck enteritis virus in lymphoid organs. Avian Pathol. 29:609-616, 2000.

Shawky, S. A. and T. S. Sandhu. Inactivated vaccine for protection against duck virus enteritis. Avian Dis. 41:461-468, 1997.

Shawky, S. and K.A. Schat. Latency sites and reactivation of duck enteritis virus. Avian Dis. 46:308-313, 2002.

Shawky, S., T. Sandhu, and H. L. Shivaprasad. Pathogenicity of a low-virulence duck virus enteritis isolate with apparent immunosuppressive ability. Avian Dis. 44:590-599, 2000.

Shek, W.R., K.A. Schat and B.W. Calnek. Characterization of non-oncogenic Marek's disease virus-infected lymphocytes. J. gen. Virol. 63:333-341, 1982.

Shek, W.R., B.W. Calnek, K.A. Schat and C-L.H. Chen. Characterization of Marek's disease virus-infected lymphocytes: Discrimination between cytolytically and latently infected cells. J. Natl. Cancer Inst. 70:485-491, 1983.

Shen, T. F. and W. F. Dean. True metabolizable energy value of corn and soybean meal for ducks (Abstract). Poult. Sci. 61:1543, 1982.

Shivaprasad, H. L., B. Lucio, and S. A. Naqi. A study of egg production and quality problems in New York layer flocks. In: Proc. the 39th Western Poultry Disease Conference, Sacramento, CA. pp. 82-83, 1990.

Shivaprasad HL, J.F Timoney, S. Morales, B. Lucio, and R.C. Baker. Pathogenesis of Salmonella enteritidis infection in laying chickens. I. Studies on egg transmission, clinical signs, fecal shedding, and serologic responses. Avian Dis. 34:548-557, 1990.

Smith, M.W. and B.W. Calnek. Effect of virus pathogenicity on antibody production in Marek's disease. Avian Dis. 17:727-736, 1973.

Smith, M.W. and B.W. Calnek. Comparative features of low-virulence and high-virulence Marek's disease virus infections. Avian Pathol. 4:229-246, 1974.

Smith, M.W. and B.W. Calnek. High virulence Marek's disease virus infection in birds previously infected with low-virulence virus. J. Natl. Cancer Inst. 52:1595-1603, 1974.

Smith, S. L. Pl J. Van Demark and J. Fabricant. Respiratory pathways in the Mycoplasma I. Lactate oxidation by Mycoplasma gallisepticum. J. Bacteriology 5:893-897, 1963.

Smith, T.W., D.M. Albert, N. Robinson, B.W. Calnek and O. Schwabe. Ocular manifestations of Marek's disease. Invest. Ophthalmology 13:586-592, 1974.

Soine, C., S.K. Watson, E. Rybicki, B. Lucio, R.M. Nordgren, C.R. Parrish, and K.A. Schat. Determination of the detection limit of the polymerase chain reaction for chicken infectious anemia virus. Avian Dis. 37:467-476, 1993.

Soine, C., R.H. Renshaw, P.H. O'Connell, S.K. Watson, B. Lucio, and K.A. Schat. Sequence analysis of cell-culture and non-cell culture adapted strains of chicken infectious anemia virus. Proc. Intl. Symp. on infectious bursal disease and chicken infectious anemia. Rauischholzhausen, Germany. pp. 364-365, 1994.

Spencer, J. L. Marek's disease herpesvirus: in vivo and in vitro infection of kidney cells of different genetic strains of chickens. Avian Dis. 13:753-761, 1969.

Spencer, J. L. Marek's disease herpesvirus; comparison of foci (macro) in infected duck embryo fibroblasts under agar medium with foci (macro) in chicken cells. Avian Dis. 14:565-578, 1970.

Spencer, J.L. and B.W. Calnek. Storage of cells infected with Rous sarcoma virus or JM avian lymphomatosis agent. Avian Dis. 11:274-287, 1967.

Spencer, J.L. and B.W. Calnek. Marek's disease: application of immunofluorescence for detection of antigen and antibody. Amer. J. Vet. Res. 31:345-358, 1970.

Taylor, J. R. E., J. Fabricant, and P. P. Levine. A comparison of four in vitro methods for the isolation of pleuropneumonia-like organisms of chronic respiratory disease from tracheal exudate. Avian Dis. 1:101, 1957.

Taylor, Patricia, J. and B.W. Calnek. Isolation and classification of avian enteric cytopathogenic agents. Avian Dis. 6:51-58, 1962.

Taylor, J. R. E. and Julius Fabricant. Studies on the isolation of the pleuro-pneumonia-like organisms of chronic respiratory disease of fowls. Cornell Vet. 47:112, 1957.

Thompson, G. and S. Naqi. Natural killer cell responses in the respiratory tracts of chickens inoculated with infectious bronchitis virus alone or infectious bursal disease virus plus infectious bronchitis virus. Avian Dis. 41:690-694, 1997.

Thompson, G., H. Mohammed, B. Bauman and S. Naqi. Systemic and local antibody responses to infectious bronchitis virus in infectious bursal disease inoculated and control chickens. Avian Dis. 41:519-527, 1997.

Timoney JF, Shivaprasad HL, Baker RC, Rowe B. Egg transmission after infection of hens with Salmonella enteritidis phage type 4. Vet. Rec. 125:600-601, 1989.

Timoney JF, Sikora N, Shivaprasad HL, Opitz M. Detection of antibody to Salmonella enteritidis by a gm flagellin-based ELISA. Vet. Rec. 18:168-169, 1990.

Toth, T. E. Research Note - A simple and rapid method for dropping chorioallantoic membrane of chick embryos. Avian dis. 13:895-896, 1969.

Toth, T. E. Chicken-embryo-adapted duck hepatitis virus growth curve in embryonated chicken eggs. Avian Dis. 13:535-539, 1969.

Toth, T. E. Studies of an agent causing mortality among ducklings immune to duck virus hepatitis. Avian Dis. 13:834-846, 1969.

Toth. T. E. Studies of an agent causing mortality among ducklings immune to duck virus hepatitis. Avian Dis. 13:834-846, 1969.

Toth, T. E. Two aspects of duck virus enteritis: parental immunity, and persistence/excretion of virulent virus. Proc. 74th Ann. Meet. U. S. Animal Health Assoc. Philadelphia, PA, 1970.

Toth, T. E. Immunologic and serologic response of White Pekin ducklings inoculated with duck virus hepatitis and duck virus enteritis mono- and bivaccines. Avian Dis. 14:697-705, 1970.

Toth, T. E. Active immunization of White Pekin ducks against duck virus enteritis (duck plague) with modified-live-virus vaccine. Immunization of ducklings. J. Vet. Res. 31:1275-1281, 1970.

Toth, T. E. Immunologic and serologic response of White Pekin ducklings inoculated with duck virus hepatitis and duck virus enteritis mono-and vaccines. Avian Dis. 14:697-705, 1970.

Toth T. E. Active immunization of White Pekin ducks against duck virus enteritis (duck plague) with modified-live-virus vaccine. Serological and immunological response of breeder ducks. J. Vet. Res. 32:75-81, 1971.

Toth, T. E. Immunization field trials in susceptible White Pekin ducklings against duck virus hepatitis: with modified-live-virus vaccines. Avian Dis. 16:217-229, 1972.

Toth, T. E. Immunization field trials with duck virus hepatitis modified-live-virus vaccines in susceptible White Pekin ducklings. Avian Dis. 16:217-229, 1972.

Toth, T. E. Alum-precipitated and sodium-hydroxide-conjugated vaccines for duck virus hepatitis: Immunologic and serologic response of susceptible and low-level parentally immune White Pekin ducklings. Avian Dis. 16:249-259, 1972.

Toth, T. E. Alum-precipitated and sodium-hydroxide-conjugated vaccines for duck virus hepatitis: serologic response of high-level parentally immune White Pekin ducklings. Avian Dis. 16:249-259, 1972.

Trock, S. C., D. A. Senne, M. Gaeta, A. Gonzalez, and B. Lucio. Low-pathogenicity avian influenza virus in live bird markets - what about the livestock area? Avian Dis. 47:1111-1113, 2003.

Ubertini, T. and B.W. Calnek. Marek's disease herpesvirus in peripheral nerve lesions. J. Natl. Cancer Inst. 45:507-514, 1970.

Uni, Z., W.D. Pratt, and K.A. Schat. Cell-mediated immune responses against the phosphorylated Marek's disease virus protein 38/40 Proc. XIX World Poultry Congress, Amsterdam, The Netherlands. pp. 251-253, 1992.

Uni, Z., W.D. Pratt, M.M. Miller, P.H. O'Connell, and K.A. Schat. Syngeneic lysis of reticuloendotheliosis virus-transformed cell lines transfected with Marek's disease virus genes by virus-specific cytotoxic T cells. Vet. Immun. Immunopath. 44:57-94, 1994.

Volpini, L., B.W. Calnek and B. Sneath. Cytokine modulation of latency in Marek's disease virus-infected cells. Proc. XIX World's Poult. Congr., Amsterdam, The Netherlands. pp. 254-257, 1992,

Volpini, L.M., B.W. Calnek, M.J. Sekellick, and P.I. Marcus. Stages of Marek's disease virus laency defined by variable sensitivity to interferon modulation of viral antigen expression. Vet. Microbiol. 47:99-109, 1995.

Volpini, L.M., B.W. Calnek, B. Sneath, M.J. Sekellick, and P.I. Marcus. Interferon modulation of Marek's disease virus genome expression in chicken cell lines. Avian Dis. 40-78-87, 1996.

Wade, L.L., E. W. Polack, P. H. O'Connell, G. S. Starrak, N. Abou-Madi, and K. A. Schat. Multicentric lymphoma in a European Starling (Sturnus vulgaris). J. Avian Med. Surgery. 13:108-115, 1999.

Wakenell, P.S., K.A. Schat, P. O'Connell, and D. Link. The role of herpesvirus in the induction of tumors in quail by methylcholanthrene. In: Current progress on Marek's disease research (K.A. Schat, R.M. Morgan, M.S. Parcells, and J.L. Spencer, eds.). Amer. Assoc. Avian Pathol., Kennett Square, PA. pp. 233-236, 2001.

Weinstock, D. and K.A. Schat. Virus specific syngeneic killing of reticuloendotheliosis virus transformed cell line target cells by spleen cells. In: Avian Immunology (W.T. Weber and D.L. Ewert, eds.). Alan R. Liss, NY. pp. 253-263, 1987.

Weinstock, D., K.A. Schat, and B.W. Calnek. Cytotoxic T lymphocytes in reticuloendotheliosis virus-infected chickens. Eur. J. Immunol, 19:267-272, 1989.

Weisman, J. and S.B. Hitchner. Virus-neutralization versus agar-gel precipitin tests for detecting serological response to infectious bursal disease virus. Avian Dis. 22:598-603, 1978.

Weisman, J. and S.B. Hitchner. Infectious bursal disease virus infection attempts in turkeys and Coturnix quail. Avian Dis. 22:604-609, 1978.

Wigley, P., Barrow, P., and Schat, K.A. The reproductive immune system. In: Avian Immunology (Davison, F., Kaspers, B., and Schat, K.A., eds), Elsevier, London, San Diego, CA. 289-298, 2008.

Williams, Walter L. The air sac mite of the fowl. Amer. Vet. Review. April, 1898.

Witter, R.L. The diagnosis of infectious bronchitis of chickens by the agar gel precipitin test. Avian Dis. 6:478, 1962.

Witter, R.L, and K.A. Schat. Marek's disease. In: Diseases of Poultry, 11th Ed.(Y.M. Saif, H.J. Barnes, A.M. Fadly, J. R. Glisson, L.R. McDougald, and D.E. Swayne, eds). Iowa State University Press, Ames, Iowa. pp. 407-465, 2003.

Witter, R.L., B.W. Calnek and P.P. Levine. Influence of naturally occurring parental antibody on visceral lymphomatosis virus infection in chickens. Avian Dis. 10:43-56, 1966.

Witter, R.L., B.W. Calnek and P.P. Levine. Occurrence of lymphomatosis in chickens free of resistance-inducing factor (RIF) virus. Avian Dis. 10:32-42, 1966.

Witter, R.L., B.W. Calnek, C. Buscaglia, L.M. Gimeno and K.A. Schat. Review: Classification of Marek's disease viruses according to pathotype - philosophy and methodology. Avian Pathol. 34: 75-90, 2005.

Woolcock, P. R. Duck Virus Hepatitis. In: Recommended Diagnostic Techniques and Requirements for Biological Products, Office International des Epizooties, Paris, France Vol. 1, B58. pp. 1-8, 1989.

Woolcock, P. R. Duck Virus Enteritis. In: Recommended Diagnostic Techniques and Requirements for Biological Products, Office International des Epizootics, Paris, France Vol. 1, B59. pp. 1-5, 1989.

Woolcock, P. R. Duck Virus Hepatitis. In: A Laboratory Manual for the Isolation and Identification of Avian Pathogens, 3rd Ed. (Purchase H. G., Arp, L.H., Domermuth, C.H. and Pearson, J.E., eds). Amer. Assoc. Avian Pathol., Kennett Square, PA. pp. 152-155, 1990.

Woolcock, P. R. Duck Hepatitis Virus type I- Studies with inactivated vaccines in breeder ducks. Avian Pathol 20:509-522, 1991.

Woolcock, P. R. and J. Fabricant. Duck virus hepatitis. In: Diseases of Poultry, 9th Ed. (Calnek, B. W., Barnes, H. J., Beard, C.W., Reid, W. M. and Yoder, H. W. Jr., eds.) Iowa State University Press, Ames. 597-608, 1991.

Xing, Z., Q. Xie, R.W. Morgan and K.A. Schat. A monoclonal antibody to ICP4 of Marek's diseases virus (MDV) recognizing ICP4 of serotype 1 and 3 MDV strains. Acta Virologica, 43:113-120, 1999.

Xing, Z. and K.A. Schat. Inhibitory effects of nitric oxide and gamma interferon on in vitro and in vivo replication of Marek's disease virus. J. Virol. 74:360-3612, 2000.

Xing, Z. and K.A. Schat. Expression of cytokine genes in Marek's disease virus-infected chickens and chicken embryo fibroblasts. Immunology 99:70-76, 2000.

Yamaguchi,T., S.L. Kaplan, P. Wakenell, and K.A. Schat. Transactivation of latent Marek's disease herpesvirus genes in QT35, a quail fibroblast cell line, by herpesvirus of turkeys. J Virol 74:10176-10186, 2000.

Yason, C.V., B. Summers, and K.A. Schat. Pathogenesis of rotavirus infection in different age groups of chickens and turkeys. II. Pathology. J. Vet. Res. 48:927-938, 1987.

Yason, C.V., and K.A. Schat. Isolation and characterization of avian rotaviruses. Avian Dis. 29:499-508, 1985.

Yason, C.V. and K.A. Schat. Pathogenesis of rotavirus infection in turkey poults. Avian Pathol. 15:421-435, 1986.

Yason, C.V. and K.A. Schat. Experimental infection of specific-pathogen-free chickens with avian rotaviruses. Avian Dis. 30:551-556, 1986.

Yason, C.V. and K.A. Schat. Pathogenesis of rotavirus infection in different age groups of chickens and turkeys. I. Clinical signs and virology. J. Vet. Res. 48:977-983, 1987.

Yunis, R., K.W. Jarosinski, and K.A. Schat. Association between rate of viral genome replication and virulence of Marek's disease herpesvirus strains. Virology 328:142-150, 2004.

Zavala, G., B. Lucio-Martinez, S. Cheng, and T. Barbosa. Sarcomas and myelocytomas induced by a retrovirus related to myeloblastosis-associated virus type 1 in White Leghorn egg layer chickens. Avian Dis. 50:201-208, 2006.