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Lucy F. Lee

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The Life of Lucy Lee

Synopsis

Lucy F. Lee was born in China but emigrated to the United States as a teen-ager where she attended Ohio Dominican College, the University of Maryland and, finally, Michigan State University where she earned a Ph.D. in biochemistry. She accepted a position with the USDA-ARS-Regional Poultry Research Laboratory (now Avian Disease and Oncology Laboratory (ADOL)) in 1968. Over the ensuing 43 years at ADOL, she built a distinguished career conducting research on avian tumor viruses. Much of her work focused on Marek's disease virus (MDV) where she began with chemical characterization, moved to immunology with special emphasis on monoclonal antibodies, moved again to molecular biology to focus first on the identification of viral genes and later to sequence the entire genome, and finally to the development and evaluation of recombinant vaccines. She also contributed to knowledge on avian leukosis virus and reticuloendotheliosis virus. Many of her monoclonal antibodies continue to be in widespread use in research and commercial laboratories. She was the first to obtain a complete genetic sequence of MDV. She mentored a large number of Chinese students and scholars, beginning in the early 1980s, many of whom developed their own distinguished careers in science, both in China and the United States. She earned the

respect of her colleagues, co-workers and students with her high standards of professional achievement, her substantial research contributions, her strong collaborations, her skill as a mentor and teacher, and her warm and engaging personality.

The early years in China

Lucy was born in China in Gu-Tian village, near Ji-An City in Jiangxi Province on November 3, 1931. Her birth name was Zhu-sheng Fang. The name, "Zhu-sheng," meaning "birth in a bamboo grove," was given her by her grandfather and was considered unusual for a girl at the time. Apparently, there was indeed a lot of bamboo around their home. The grandfather considered the name simple, and easy to remember. She never knew her mother, Yun-feng Gan, a girl of 15 or 16 years who died a year after her birth. Likewise, she did not know her father, Guo-hua Fang, who was almost never home. Apparently, her father was also a teenager at the time of her birth and took no responsibility. He later joined the military and, like many other youths of his time, sympathized with the communists. Lucy recalls seeing her father only once, at the age of 6.

Lucy lived with her paternal grandparents, who served as father and mother to her. Her grandparents were Christians, unusual for China, but of critical importance for Lucy's future. Her grandfather's name was San-yuan Fang; her grandmother was Ding-yin Zhou, although Lucy never used their names in conversation. She was baptized shortly after birth, receiving the Christian name of Lucia, after St. Lucia of enlightenment. According to Lucy, her grandfather, a merchant, was very broad minded and told her (in Lucy's words) "that instead of saving money for my dowry, he would save it for my high school education. This was uncommon because in the Chinese situation at that time parents rarely thought about putting girls through high school." Her grandfather also told her of his high expectations for her future using the metaphor of "placing pieces of her hair on top of the barn," indicating that she would grow high in professional stature.

Her grandparents moved from Jiangxi to Zhejiang province when she was one year old to escape the violence between nationalists and communists in Jiangxi province at the time. There, her grandfather operated a retail store that sold silk cloth. In 1937, when Lucy was 6, her father suddenly reappeared with warnings about impending violence from the Japanese invasion. Taking heed of this advice, the grandparents moved once again, this time to the city of Jian'ou in Fujian province – a wild and mountainous region that appeared to offer greater safety for the family. Jian'ou was located northwest of the port city of Fuzhou. In Jian'ou, Lucy's grandfather operated a small general store and hotel. The hotel was only open for short seasons in the spring and fall which coincided with the time of the Chinese black mushroom harvest. The year 1937 marked the start of open hostilities between Japan and China which continued through the end of the Second World War.

Lucy's grandfather, defying the normal tradition, promised Lucy an education. She was never asked to stay home and help with the family business. Her education was given priority from the start, an unusual arrangement for girls at the time but one that was of critical importance to her career.

In Fujian province, Lucy attended elementary school and at age 13 moved to a middle school for 3 years. From 16 to 18 years of age, she attended the Chinese high school, excelling in English and doing well also in science and mathematics. A Catholic school was located in the vicinity of the high school. As Lucy was walking 3 miles each way from her grandfather's home to school, it was easier to take lodging in facilities within the Catholic school complex, normally used as an orphanage. She could still return home on the weekends. Although she did not formally attend classes at the Catholic school, she attended mass every morning and became involved in the day-to-day activities of the center. The priest, Dominic Chang, took a serious interest in her well-being. He was educated in the United States and became an important person in Lucy's life. Lucy learned good study habits, worked hard and did well. Dominic Chang talked with Lucy frequently and knew that she aspired to go to the United States. The fact that the Dominican order had a college located in Columbus, OH was well known to Lucy. Her access to the Catholic school was made possible because her grandparents were Christians, and Lucy was brought up as a Catholic.

Meanwhile, a war was going on. The Japanese had invaded, taken Shanghai, and occupied much of the coastal regions of China. Lucy recalls no Japanese soldiers in her town. However, there were bombing raids at frequent intervals. In fact, her house was burned from the effects of one raid and the family had to rebuild across the street. Progress in the war was followed by reading newspapers. There were horrible stories of atrocities against the Chinese people. Lucy remembers the joy when the end of World War Two was announced in August 1945. This was about the same time as she started high school.

However, the joy of victory was quickly replaced by the reemergence of the long time conflict between nationalists and communists in China. For some time, Lucy experienced no problems and did not appear to be in danger. However, in the spring of 1949 the communists had gained the upper hand and the fate of Christians was increasingly uncertain. One morning she awoke at 6am, attended mass as was her custom, and immediately afterwards was approached by Sister Carlos who told Lucy a group of nuns were preparing to leave for the United States to insure their safety. If Lucy wanted to join them, she needed to be at the bus station by 10 am – 3 hours hence. Lucy dashed home and woke up her grandparents who gave Lucy their blessing. She was at the bus at the appointed time with her suitcase, ready for whatever would be the next chapter. The entourage included 4 American nuns, 4 Chinese nuns, Lucy, and another Chinese student named Rose. It took all day on the bus to reach the port city of Fuzhou where they stayed for several days. Inexplicably and without warning, after 8 days the 8 nuns disappeared on a boat for Hong Kong, leaving Lucy and Rose with Catholic priests in Fuzhou. Several days later, the priests left Fuzhou taking Lucy and Rose with them, ultimately meeting up with the original party in Hong Kong which was at that time a British protectorate. Lucy's suitcase was taken by the original nuns but left on the boat and was lost (or stolen). All of her possessions – diploma, photos, clothes, everything – were gone. She remembers being sick on the boat and could eat no food. It was a difficult 3 day trip to Hong Kong without knowledge of what she would experience on her arrival.

Fortunately, she was met by the original nuns. They stayed in Hong Kong some weeks in order to secure entry visas for Lucy to the United States. Lucy had no photo. Ultimately, she was photographed in a black vestment worn by the Dominican order and with this photo was granted the necessary visa.

She and Rose departed with 8 nuns by plane, refueling in Alaska and landing in Seattle. Then, she proceeded by train to Columbus, OH, arriving around July 4th of 1949. The trip from her home took about 2 months. It was stressful, frightening and unpleasant but was tempered by thoughts that it would have been worse to stay in China. She never saw her grandparents again, and her beloved mentor, Dominic Chang, was put in jail and was never heard from thereafter. A new chapter was about to begin.

Education and life in Ohio

On her arrival in Columbus, Lucy was greeted with hugs and kisses, a totally foreign custom to her. Lucy, and her companion, Rose, lived in the mother house for Catholic sisters in Columbus, Ohio. She now adopted her Christian name, shortened to "Lucy." Tutored by a Dominican nun, her English steadily improved over the first summer. She was also taught to eat with a fork and knife, and many other customs that differed from her experience in China. With visions of becoming a doctor, Lucy entered St. Mary of the Springs College (now Ohio Dominican College) in Columbus in September 1949. This was a small college with about 200 female students, of which she was the only student of Chinese origin. She received a full scholarship (work-study) for her studies. She took a full load of courses and worked 5 hours a day in the cafeteria. She studied Latin and piano on weekends. She remembers the kindness and friendship of her classmate, Joan Ford, during this difficult period. Also, Sister Virginia Gordon who lived in the mother house treated Lucy with much kindness, providing her pocket money on occasions. Lucy graduated in 1953 with a B.S. in biology and with a minor in mathematics. Lucy recalls many lonely hours during her college experience, especially on holidays, but this was tempered by her dedication to study and the companionship of Rose and Joan, both of whom became nuns after college and remained lifelong friends. During this period there was no contact with her family or friends in China.

The Washington DC years

After graduation, Lucy decided against medical school, perhaps because the medical terminology appeared to be too difficult (and tuition was expensive). She considered nursing and tried this for a period one summer at a hospital in Columbus but found the work too physically demanding. Discouraged about medicine but still interested in biology and science, she set about to find a suitable position. She had long held a desire to see Washington DC. In February 1954, responding to a newspaper ad, she accepted a position as a research assistant at Georgetown University Medical Center in Washington D.C. Her job was to work as a histology technician for a physician, Dr. Roger Baker (urologist), who maintained a private research laboratory. She cut tissue sections and prepared stained slides for examination. She remembers Baker as a pleasant person although her contact with him was limited.

Although her social life in Washington DC was minimal, she did manage to attend a few parties. In June 1954, she met a handsome and elegant assistant naval attaché from her home province in China. The story of their meeting bears telling. Upon her arrival in Washington DC, Lucy lived in a rooming house with a roommate who was dating a Chinese Naval Officer. On one occasion this Naval Officer was not available at the last minute and arranged for a substitute. When Joe Lee arrived to greet the roommate, Lucy was also present – and very impressed. And in addition, Joe had a car. A friendship between Joe and Lucy ensued, fueled in part by Joe's offer to teach Lucy how to drive. The driving lessons were conducted over the objection of Lucy's friend, a protector appointed by the Bishop from Jian 'ou. Lucy was stubborn enough so that his objections did not dissuade either the lessons or the friendship.

Three months later, on October 2, 1954, Joseph Jenhwa Lee and Lucy were married. The ceremony was performed in the Catholic Church, which also required Joe to adopt the Catholic faith. Lucy and Joe continued to attend church, enjoying the Latin service. But later, when the services changed to English, their enthusiasm waned.

Joe had graduated from the Chinese Naval Academy and served as a Navy Officer, later stationed in Taiwan after the Nationalists were defeated on the mainland of China. He was then appointed to a diplomatic post in Washington D.C. and worked at the Chinese embassy. Joe also was interested in higher education and obtained permission to take classes at the University of Maryland, which he paid for by himself.

Once Joe and Lucy were married, Joe encountered problems with the Chinese Embassy. The marriage was kept secret for some months but when discovered in early 1955, the Embassy did not approve. Apparently, since Lucy was from the mainland and her history not well documented, she was suspect. Also, Joe was considered by the Embassy as too young to marry (he was 24 when he married Lucy). This made it impossible for Joe to continue in his role as Naval Attaché and he was forced to resign from his post. This also took away his original dream to return to China and serve his countrymen, something he and Lucy had discussed. However, he was not interested in returning to Taiwan and a return to mainland China at that time was not realistic, as the country under Communist leadership had been recently closed to all outside persons. As he also was motivated towards graduate education in the United States, a decision to stay in the US became a practical second choice. Lucy, at this point in her life, was prepared to follow her husband to whatever destination he chose.

During the summer of 1955, Joe taught history and statistics at St. Mary of the Springs College in Columbus, Ohio, the same college where Lucy had received her education. This position helped provide a basis for Joe to receive permanent resident status. While Joe was teaching, Lucy took a job as a research assistant at Ohio State University in

Columbus, working with Dr. E. B. Morgan. However, by September, Joe and Lucy were back in Washington DC.

US Citizenship became a goal for both Lucy and Joe from the first and they worked simultaneously towards this end. They first applied for green cards in 1955 and received approval in 1958. This process was facilitated by the Catholic Institute in Washington DC.

In 1955 Lucy started to take night classes at the University of Maryland where she earned a M.S. degree in cellular biology in 1959. Actually, she was able to qualify for a research assistantship in the Zoology Department, which covered her tuition. Her thesis research was on earthworm anatomy. Using her skills in histological techniques, she did a thesis proposed by her advisor, Joshua Brown, who was the only faculty member involved with cellular biology at the time. She remembers collecting earthworms in the rain and the many, many sections that were required. Some of the sections were prepared in the research laboratory at Georgetown University, the site of her day job. Because of this, and because she was only at the University of Maryland in evenings, she rarely encountered her advisor. Although Lucy remembers him as a kind and pleasant person, she never was very excited about the research.

At the same time, Joe obtained a graduate scholarship at the University of Maryland and became a full time graduate student, working towards his Ph.D. in American history. His area of specialization was the American Civil War. However, he also held a strong interest in poetry and literature, subjects that would become his focus in later years. He was also good at mathematics, physics and other sciences. Thus Joe and Lucy both were graduate students at the same time in the same university. Lucy remembers that encouragement from Joe was an important factor in her own application for graduate school. There was even some teamwork. Lucy recalls that Joe would assist her with the staining procedures at her work so she could have time to take classes during the day.

In 1958, Lucy left her day job in Georgetown and began work as a research assistant in biophysics at the Armed Forces Institute of Pathology in Washington DC. The new position as an electron microscopy technician provided training in this new technology under the guidance of Martin Flax. She also worked with Col. Joe Blumburg and Dr. S. Zachs on a research project to study the ultrastructure of the myoneural junction. As before, Lucy continued her graduate studies at the University of Maryland. Lucy and Joe both finished their respective programs in 1959 and received their degrees together.

The Wisconsin years

After Joe and Lucy finished at the University of Maryland, they moved to West De Pere, Wisconsin where Joe had obtained a position teaching American History at St. Norbert College. Of the 75 applications sent out by Joe, St. Norbert was the only employer to respond. Joe became a successful teacher and was awarded a highly competitive fellowship for Indian studies at the University of Wisconsin where he spent one summer. During the Wisconsin period, Lucy initially enjoyed the freedom from a paying job but this soon was boring. She took up ice skating, but fell and broke her leg. She was badly

burned in a fire in their home when a gasoline can caught on fire in the basement. This resulted in a year of intensive medical treatments with many skin grafts. She briefly rekindled her idea of a medical education and was actually accepted at the University of Wisconsin, but she did not pursue this as it was logistically remote from their location near the city of Green Bay. She pursued the idea of graduate work with Hans Ris, a prominent cellular biologist at Madison, but rejected this also. In 1960, she took a job at St. Vincent Hospital in Green Bay as a laboratory supervisor and instructor in histology and pathology where she provided training to students enrolled in the nursing program. There was no research program. All in all, Lucy remembers the Wisconsin era as a period fraught with difficulties and devoid of intellectual opportunities.

Lucy and Joe became US citizens in 1961. Lucy remembers this as a big day in her life and one which opened the door to many opportunities.

In Joe's department at St. Norbert there were two other young faculty members. One of these, Tom Kishler, left to take a job at Michigan State University (MSU). When a second position became available at MSU shortly thereafter, Joe was recommended by Kishler, got an interview, and ultimately was offered a faculty position in the Department of American Thought and Language (later the Humanities Department) which he accepted. In 1963 Lucy and Joe moved to East Lansing to start a new chapter.

The Michigan State University experience

Now in East Lansing and with strong encouragement from Joe, Lucy investigated graduate programs at MSU; first in cellular biology, then in zoology and finally in biochemistry. Interestingly, she was told by Gaurth Hansen, the Department Chair of Biochemistry, that she would not be permitted to enroll until she had taken his class and received the grade of "A". Of course, Lucy worked very hard and this goal was accomplished. She was admitted to the Department as a Ph.D. candidate in 1964.

Lucy then proceeded to select an advisor. She considered John Boezi, a young faculty member with an emerging program. She was advised against this by Hansen, a person who once again underestimated Lucy's dedication and ability, because Boezi would want her to work hard and that she was just a housewife – fighting words for Lucy, indeed. She accepted the position with Boezi, a decision that provided her the first real mentor of her career and launched her towards her ultimate field of virology. The subject was bacteriophage obtained from Pseudomonas. Lucy isolated several phages and proceeded to characterized one of these by biochemical analyses and electron microscopy, the main tools for characterization of viruses at the time. It was a productive period and Lucy established life-long bonds with Boezi and also with Bob Armstrong, another graduate student in Boezi's lab. These bonds carried over to many social occasions.

Her work was published in two papers (1966 and 1967) in the Journal of Bacteriology and the Journal of Virology, respectively. This marked Lucy's first true research contributions and the first peer reviewed papers in what would become a long list. She was now a scientist.

Lucy completed her Ph.D. in 1967. She presented the obligatory graduate seminar in May, which was a critical moment in her career as will be explained below, and then soon left for a 1 year postdoctoral position with Dr. Fernandez-Moran at the University of Chicago where she hoped to study electron microscopy with a true expert in the field. However, she found her new mentor difficult and had less than an optimal experience. Midway in her program she switched to another professor who was working with bacteriophage. Joe went with her to Chicago and did a sabbatical at the University of Chicago studying Chinese art.

By this time, however, she had been contacted about permanent positions. As Joe was still employed at Michigan State University, a job in mid Michigan was important. Lucy received an offer from the Microbiology Department at Michigan State University but declined when she realized that she would not receive a tenure-track position.

Also in East Lansing was a small laboratory working on avian tumor viruses operated by the Agricultural Research Service (ARS), which was part of the United States Department of Agriculture (USDA). The laboratory was known as the Regional Poultry Research Laboratory or USDA lab (now Avian Disease and Oncology Laboratory or ADOL). Established in 1939, the laboratory had established a strong reputation in tumor virus research. An emerging disease, designated as Marek's disease (MD), was the subject of much of the work. This disease was of great economic importance to the poultry industry. The causative herpesvirus had just been described in 1967 by workers at the USDA lab (and also by other workers in England). This was a huge breakthrough and much exciting work lay ahead.

Keyvan Nazerian, a veterinarian, had joined the USDA laboratory in 1966 as a principal scientist and was developing projects on the characterization of the recently discovered MD virus (MDV). In 1968, Nazerian's work was rapidly evolving and he convinced Ben Burmester, the laboratory director, that a biochemist should be recruited to study MDV. Burmester agreed and Nazerian started to look for a candidate.

Nazerian had recently completed his Ph.D. in virology at Michigan State University. John Boezi was on Nazerian's graduate committee. Nazerian had been present when Lucy presented her seminar in the spring of 1967 because of his interest in the chemical characterization of viruses and the close proximity of the USDA lab to the MSU campus. A year had passed, but Nazerian, remembering the young lady who had presented the earlier seminar, contacted John Boezi for information on her whereabouts. Boezi then contacted Lucy in Chicago, who responded directly to Nazerian. Shortly thereafter, in the summer of 1968, Lucy visited at the lab, talked to Nazerian and Burmester, the laboratory director, but with few other staff. Surprisingly, she was not even asked to give a seminar. However, in an amazingly short time, considering how government usually works, she had a firm offer. Meanwhile, she had a competing offer from the Microbiology Department at Michigan State University. At this point, Lucy had expertise in electron microscopy (EM) and also in DNA – she liked both. The MSU position was focused on EM. The USDA position was focused on DNA (Nazerian was

doing the EM). Lucy chose the USDA position because it offered more potential for tenure and advancement, and because she liked the challenge of working with DNA.

The ADOL Years – The Biochemistry Chapter

Lucy started work at ADOL in September 1968, little expecting to spend the next 43 years in this laboratory. Her official position was as a research chemist, GS-12. Administratively, she reported to Nazerian. She worked in his laboratory with a small office but soon moved to a pathology laboratory recently vacated by Frank Siccardi. According to Keyvan Nazerian, this space contained nothing she could use. She started to grow the MD virus in cell cultures using 150mm plastic dishes. However, this system yielded too few infected cells and too little DNA for quality chemical analyses. In the spring of 1969, Lucy attended a meeting of the American Society of Microbiology and heard a talk by Bernard Roizman on the use of roller bottles to produce large quantities of virus. She discussed the technique with Roizman after the talk and he invited her to visit his laboratory to learn the procedure. This idea was approved by ADOL and she proceeded to arrange a 3 month training visit to the University of Chicago which was accomplished in the summer of 1969. This was a productive period in a top laboratory. Roizman was helpful to Lucy, as were Pat Spear and Elliot Kieff, both graduate students in Roizman's lab at the time. (All three of these scientists were later elected to the National Academy of Sciences, indicating the exceptional quality of this group). Lucy not only brought back roller bottle technology that allowed for the production of MDV-infected cells in quantities sufficient for biochemical analysis but she also authored her first peer reviewed paper on MD which described the buoyant density of MDV DNA. The paper was co-authored by Roizman, Spear, Kieff and others, and published in PNAS (The Proceedings of the National Academy of Sciences – a top rated journal). The catchy title "Marek's disease herpesvirus – a cytomegalovirus?" was Roizman's idea. This was an auspicious start for a new scientist in the MD field, indeed.

Returning from Roizman's laboratory in the fall of 1969, she moved into a new laboratory in the basement of ADOL. This space, previously used as a necropsy room, was recently renovated. However, visitors would claim they could still hear the squawking of chickens, at least as echoes of the past. She would use this space for her laboratory for the next 25 years. New incubators were installed to contain roller bottles – glass bottles that rolled slowly on rollers, each containing a complement of living cells and a nutrient medium. This was state of the art at the time and allowed for the harvest of 10-fold more cells from a single bottle than could be obtained from a single large Petri dish.

This was a productive period for Lucy. She studied the characteristics of MDV DNA and MDV structural proteins. She compared DNA from tissue-cultured virus, tumors and lymphoblastoid cell lines. She contributed to the development of a multilayer technique which increased the yield of infected cells from roller bottles and thus improved the efficiency of production of turkey herpesvirus (HVT) vaccine. She continued her collaboration with Roizman's laboratory on the chemical composition of MDV DNA, revising the earlier estimate of the buoyant density and establishing the molecular weight. She collaborated with Nazerian on an electron microscopy study. She maintained a close

relationship with John Boezi's laboratory at Michigan State University, who by now had turned his attention to MDV as well. This collaboration resulted in interesting work conducted throughout the 1970s on MDV DNA polymerase and its inhibition by phosphonoacetate.

Also in this period, Lucy supervised much of the research of J. H. Chen, a Ph.D. student recruited by Nazerian. Although technically this may have been the first of her many Chinese students, Lucy did not have the full responsibility and considered Chen as Nazerian's student. Conducted with the relatively crude techniques of the time, Chen published in 1972 on the characteristics of MDV proteins, the first study on this important subject and a subject to which Lucy would return in subsequent years.

In 1970, life changed again for Joe and Lucy, with the simultaneous adoption of two daughters, Becky (2½ yrs) and Yvonne (1½ yrs). Suddenly, Lucy, who never had a real mother of her own, was the mother of two.

About 1972, Lucy was reassigned and now reported to Burmester, the laboratory director, thus giving her full status as a senior investigator in the unit. This move was requested by Lucy, the only female among the group of 8 investigators, who recognized a need to assert her position and status at frequent intervals. At about the same time Lucy moved her office to the new physical addition to the USDA lab. Following the retirement of Burmester at the end of 1974, Dick Witter became the laboratory director and also became Lucy's supervisor, an association that would last 23 years. Lucy was promoted to GS-13 in 1971 and to GS-14 in 1976, which was clearly a rapid ascent in the world of government science. She was promoted to GS-15 in 1996, a grade she maintained until her retirement.

Meanwhile, Joe was building his reputation as an outstanding teacher and scholar. He and Lucy visited China in 1972, one of the first outside visitors to this country after the border was opened following President Nixon's visit. This was a special invitation by the Chinese government to Joe because of his involvement with an activist group advocating for Chinese ownership of disputed islands (Diaoyu *Islands*) that lay between China and Japan. Needless to say, Joe and Lucy received a royal reception.

By this time, Joe and Lucy had become a vital part of the social fabric of ADOL. This author remembers well the many opportunities to learn of Chinese culture and cuisine, courtesy of their hospitality.

The Immunology Chapter

As opportunities for further chemical characterization of MDV and HVT waned and the biotechnology boom was starting, Lucy changed the direction of her research to immunology. This was a considered decision, prompted in part by the advice of Dick Witter who recognized the need to study mechanisms of MD immunity and was trying to establish a solid niche for Lucy in the fabric of the laboratory's program. It all started with Lucy's development of assays to test the responsiveness of chicken lymphocytes to stimulation with mitogens such as phytohemagglutinin. The ability of lymphocytes to

enter the cycle of replication appeared to be linked to their immunological function and, thus, the test was considered an indicator of immune competence. However, it had not yet been worked out in chickens. Lucy conducted a systematic and seminal study on parameters for the assay (1974), and subsequently adapted this to tests on whole blood (1978). This was a time when other laboratory scientists were looking at the effect of tumor virus infections on immunity and on the mechanism by which HVT vaccine induced protective immune responses. Therefore, these new tools had immediate applications and would remain staples in the field for many years.

As this new initiative was unfolding, it was decided that Lucy would benefit from a training leave (sabbatical). During this period, the USDA was able to sponsor a year's leave with pay for a scientist to visit another laboratory and learn new techniques that would advance their careers. Laboratory scientists that had done such outside training included Lyman Crittenden (Denver), Graham Purchase (England), Dick Witter (Germany) and Keyvan Nazerian (Sweden). It was Lucy's turn. In consultation with Witter she chose the Houghton Poultry Research Station, which was located in England. This was the home laboratory of Peter Biggs, Jim Payne, Norman Ross, and Patrick Powell, all well known experts in the field of avian tumor viruses. Importantly, Payne and Powell were actively involved with immunology research. At this time the group was led by Jim Payne, who had himself spent a year with the East Lansing group, already knew Lucy well and who readily approved the arrangement. Lucy spent a year at the Houghton lab commencing in the summer of 1978. Working mainly with Patrick Powell, Lucy compared immune responses in resistant and susceptible chicken lines, thereby shedding light on the role of immunity in genetic resistance to MD. Lucy was impressed by the English custom of coffee in the morning, and high tea in the afternoon (moments when the entire laboratory shut down) and the many productive brainstorming sessions that occurred during these breaks. This model was foreign to the East Lansing laboratory. Jim Payne recalls Lucy's contribution at Houghton as "an excellent experimental analysis of one type of genetic resistance to MD."

While at Houghton, Joe spent the year studying Chinese literature at Cambridge University, only a short distance away. Lucy remembers frequent weekend trips to many venues in England and Scotland and a few longer trips to Europe. Life was improved through access to a nearby US military PX (store) which provided all the goods from home at bargain prices. They also visited Laurent Cauchy in Tours, France, who had been a visiting scientist at ADOL.

Following her return to ADOL in 1979, Lucy resumed her immunology-based research program but Jagdev Sharma had taken over the initiative in traditional immunology at ADOL and Lucy was looking for another niche. By this time, monoclonal antibodies were starting to be developed and Lucy was immediately intrigued with the possibilities associated with this technology. She visited Bill Smith at MSU who had started a monoclonal program. Larry Bacon recalls attending, with Lucy, the Federation Meetings in Anaheim, CA in the spring of 1979. There was much discussion about the new monoclonal antibody technology. Larry and Lucy agreed over dinner in Anaheim that this should be attempted at ADOL. Larry, armed with his background working with

mice, immediately established a small mouse breeding colony and maintained it personally for several years. His efforts to create monoclonals against MHC chicken antigens were unsuccessful. Real progress only commenced in 1981 upon the arrival of Xiufan Liu to Lucy's laboratory. Larry remembers it was a nonstop, brute strength effort that resulted in the first positive results, culminating in an important paper (1983) on monoclonal antibodies specific for each of the 3 serotypes of MD virus. This proved to be a landmark achievement. Although the existence of the 3 serotypes had been worked out earlier with chicken antibodies, these reagents were not very specific and were in short supply. The amazing specificity of monoclonals and the ability to produce ample quantities of these antibodies from hybridoma cell lines created an instant tool to differentiate the serotypes with ease and accuracy. Assays based on these original antibodies are still in use at this writing, not only at ADOL but around the world. Among other applications, commercial vaccine companies have found these antibodies useful to verify the purity of their vaccines and, in some cases, to quantify the amounts of two vaccine serotypes mixed in the same ampule.

This work launched a major effort by Lucy's laboratory to create monoclonal antibodies that identified a variety of antigens on MDV-infected cells and also of cells infected with avian leukosis virus and reticuloendotheliosis virus. She even made antibodies that reacted with hemorrhagic enteritis virus of turkeys. During the 1980s and 1990s, Lucy estimates that more than 1000 different hybridomas were produced from which at least 50 monoclonals were characterized. Of these, less than 25% have proved to have unusual value.

While this initiative was proceeding, Lucy continued collaborating with ADOL scientists who needed to perform mitogen stimulation assays in their research. Similarly, scientists everywhere valued the use of Lucy's monoclonals which became part of standard assays for specific types of avian tumor viruses. Thus, she became involved with a large number of studies initiated by others but where her technology or reagents played a key role. She also developed several enzyme-linked immunosorbent assays (ELISA) utilizing her monoclonals that added to the available test systems of the period.

The Molecular Biology Chapter

During the 1980s, the use of techniques stemming from the new field of biotechnology (or molecular biology) began to pervade all of science. The availability of monoclonals allowed the subject of MDV viral proteins to be revisited. In 1984 Bob Silva and Lucy published a paper on MDV viral proteins that had been isolated by immunoprecipitation with Lucy's monoclonals. The availability of highly specific antibodies was the key to this work. This technology opened up a new opportunity for Lucy, the identification and characterization of the various proteins of MDV. As the viral proteins were presumed to have a major role in eliciting immune responses, it was clearly important to learn more about the proteins and their respective functions.

The work on viral proteins was also popular with other laboratories and a large body of information was soon available. Lucy was quick to perceive, however, that the most important information was associated with the viral genes that encoded each of the proteins. Lucy remembers that Bob Silva was also interested in the use of her monoclonals to fish out MDV genes, an area Lucy coveted for herself. This was resolved when Silva encountered difficulties with the technology and moved on to work on herpesvirus vector systems, leaving the gene identification project for Lucy. Some of her first work on viral genes dates from the early 1990s with a focus on pp38, a phosphorylated protein of MDV, which she considered to be possibly involved with oncogenic transformation. With Zhizhong Cui, a long-time visitor in Lucy's laboratory and a prominent scientist in China, the pp38 gene was identified and sequenced (the first MDV gene to be so characterized). The H19 monoclonal antibody (specific for pp38) was a key to this work.

The above story illustrates how protective Lucy was of her antibodies. During her tenure at ADOL, one *always* had to secure Lucy's OK in order to use her antibodies in their work, regardless of whether you worked at ADOL or not.

Lucy then turned her efforts towards characterization of gB. She considered the glycoproteins of potential importance as immunogens and gB seemed among the most important. With the help of Yi Li she successfully fished out the gB gene with monoclonal antibodies L78 (specific for HVT) and 1AN86 (both HVT and MDV) and determined its molecular sequence.

During the late 1980s, Keyvan Nazerian established a program to create recombinant DNA vaccines based on fowl pox vectors. Progress was slow but the program received significant stimulus when in the early 1990s an agreement was made with Nippon Zeon Ltd. of Japan, an arrangement apparently facilitated by Hiram Lasher (according to Hiram, who never let this writer forget). The company wanted access to gB and other MDV genes. However, ADOL preferred to have visiting scientists from Nippon Zeon do the work in East Lansing so that the technology could be more easily retained. Noboru Yanagida and Rhyo Ozawa from Nippon Zeon helped create a number of recombinant viruses expressing different MDV genes. Lucy became involved in this work with Shigeto Yoshida, another Nippon Zeon scientist, using her monoclonals and other tools to isolate additional glycoproteins and evaluate expression levels. After Nazerian retired in 1995, Lucy continued with the Nippon Zeon project until it came to a conclusion. She also moved her office and lab to occupy the somewhat better space formerly used by Nazerian.

Lucy participated in work with Joanne Kivela and Hsing-Jien Kung that resulted in the identification of the meq gene of MDV, which proved important in tumor induction (see later).

Lucy's attention turned to a number of other viral genes including gB, gD, gE, gI, gH, gL and gp82. However, it became apparent that it was not sufficient to know the genetic sequence of a single gene. There were many genes and there was talk of ways to

sequence all of them – the entire viral genome. Lee Velicer had published a sequence of the unique short region but the bulk of the genome remained. About 1993, Lucy decided she should complete the sequencing of the entire genome of MDV. This was a daunting task, given the tools of the time. Gels were poured in 15"x20" glass plates, a delicate and exacting job. Bands in 4 columns (ATGC) were read with a hand digitizer and recorded.

Lucy started with the sequence of pp38 and several other glycoprotein genes. This work was done a few bases at a time over a period of years but was largely complete by 1998. However, Lucy was slow to finalize and publish the work. As the project was nearing completion, it became apparent that others, especially the Dan Rock group at the USDA Plum Island Animal Disease Laboratory, were also in the race and had more automated equipment. Lucy published her work – the complete sequence of the unique long region and genomic organization of the GA strain of MDV – in 2000, representing at least 7 years of effort. This was another landmark accomplishment. This same amount of sequencing could be done, a decade later, in about 7 days for a cost of $1000 or less.

Given the genomic sequence, it was now possible to create recombinant viruses that would be useful tools to study the function of specific genes. Sanjay Reddy and his team (including Lucy) created pp38 deletion and revertant viruses and used them to show that pp38 is involved in early cytolytic infection in lymphoid organs but not in tumor induction. Similar studies on the MDV gene, vIL8, also elucidated important functions controlled by this gene. She played a strong role in work by Sanjay Reddy and Hsing-Jien Kung to elucidate the function of the meq gene. Clearly, the availability of the genetic sequence of MDV was a key to elucidating the function of many important viral genes.

Sanjay Reddy recalls his development of the first cosmid clone virus from the Md5 strain of MDV derived directly from the sequencing effort by Lucy and her colleagues. He later focused much of his research, both at ADOL and later at Texas A&M University, on the function of the meq gene. Both of these research areas were rich with Lucy's fingerprints.

The Vaccine Chapter

Vaccination has been important for the control of MD in the field since the development of the HVT vaccine in 1970. However, the need for better vaccines has been recognized since about 1980. Almost all workers in the field have searched for the elusive "better" vaccine. Lucy published a paper on inactivated MD vaccines in 1991 which was probably more an exercise in gene function than a serious search for a practical product. The work with Nippon Zeon on recombinant fowlpox vaccines that expressed gB or other MDV genes has been mentioned earlier. Several of these vaccines induced immunity to MD challenge, as published by Nazerian and Lucy in 1996, but were not better than other products. Lucy's followup papers (2003 and 2004) described an interesting synergism between rFPV and HVT vaccines, and a dependence of protection on the genetic characteristic of the chicken but the FPV recombinants did not prove to be advantageous in the field. The finding that cell-free bivalent vaccine composed of HVT and rFPV/gB provided better protection than cell-free HVT alone identified a way to create an

improved cell-free vaccine, but this has been ignored by industry thus far, probably because the market for cell-free vaccines is limited to certain developing countries.

Sanjay Reddy, who joined ADOL in 1997, used cosmid clone technology to develop a meq-deleted strain of MDV, work that derived directly from the genome sequence work in Lucy's lab. This recombinant virus was fully attenuated for oncogenicity and induced strong immunity to challenge with virulent MDV. However, the virus also induced lymphoid organ atrophy when administered to chickens free of maternal antibodies to MDV. Lucy, a collaborator on the original work with the Md5Δmeq vaccine, picked up the project when Reddy left ADOL in 2001, recognizing the potential of this unique strain. Her subsequent work published in 2008 and 2010 established this recombinant strain as a candidate for commercial use based on its protective efficacy. However, issues of safety are still being addressed.

In the course of the vaccine studies, Lucy conducted experiments that utilized large numbers of chickens, something that she had little experience with until her later years. Dick Witter and others helped with necropsy evaluations, at least in some studies. One especially large study with >1000 chickens was conducted with Kenton Kreager at the facilities of Hy-Line International. Lucy at the end of her career had come a long way from the chemistry laboratory.

The China Connection

A highlight and critical component of Lucy's career is the sequence of scholars and students who graced her laboratory. At the beginning, Timothy Chang, a professor of poultry science at MSU, became socially acquainted with Lucy in the 1970s. Chang had a PhD in immunology and was knowledgeable about poultry health matters. He was also dedicated to giving back to China, his homeland. When there was a general opening of travel barriers to China in 1979, Chang was quick to visit and was immediately embraced by many in the poultry health field as a link to Western technology. Chang made a number of such trips, establishing himself as something of an ambassador to the poultry health industries in China.

Timothy Chang was successful in attracting several Chinese scholars to his laboratory in the early 1980s, probably as a result of his frequent travels to China (above). This becomes important to our story as three of Chang's early scholars migrated to Lucy's lab and formed the start of her own "China connection."

Lucy remembers inviting a Professor Tsai, a Chinese scientist who was visiting Timothy Chang at the time, to her home for New Years Day, 1981. Tsai asked whether he could bring his younger colleague, who was also in Chang's laboratory, and Lucy quickly agreed. The younger scientist was Xiufan Liu who was in Chang's laboratory as a scholar, supported by the Chinese government, for scientific studies. Once he learned

about Lucy's exciting projects with monoclonal antibody techniques, he quickly realized his goals would be better met working with Lucy. With the blessing of all concerned, Xiufan was able to arrange a switch to her lab. Xiufan was talented and provided much needed physical and intellectual input to Lucy's monoclonal antibody program, resulting in the first successful monoclonal production at ADOL and securing the basis for Lucy's program for the next decade and beyond. As discussed elsewhere, Xiufan was involved with the development of monoclonals that differentiated the 3 MDV serotypes.

Also early migrants from Timothy Chang's laboratory to Lucy were Sun-gow Liu (1982) and You-quan Cheng (1983). You-quan Cheng worked with Lucy on ELISA tests for MDV and avian leukosis virus antigens, using monoclonal antibodies.

Zhizhong Cui, a scholar recommended by Xiufan Liu, came to Lucy in 1984 and stayed until 1990 – probably the longest tenure of any of Lucy's scholars. Zhizhong worked initially on monoclonals against MATSA (an antigen found on MD tumor cells). He subsequently earned a PhD developing monoclonals and diagnostic tests to detect reticuloendotheliosis virus. Zhizhong periodically visited Lucy's laboratory for weeks or months at a time throughout the 1990s and remained closely connected to Lucy's program until her retirement. His daughter, Xiaoping Cui, also earned her PhD with Lucy on the characterization of the vIL8 gene. Zhizhong also recommended other scholars to Lucy's program, thus joining Xiufan Liu as principal "talent scouts" for Lucy.

Yi Li helped Lucy with the work on gB. Desin Sui and Ping Wu worked with Lucy on identification of MDV glycoproteins during the 1990s. Other notable scholars included Puyan Chen, Ding Yan, Delin Ren, and Aijian Qin. In total, Lucy brought at least 21 persons to ADOL over 2 decades, most of whom were Chinese. Nearly all worked in her own laboratory. This not only was a key to Lucy's success but also created for Lucy a firm legacy of respect in China, a country where teachers are revered by their students. This group included several persons who went on to distinguished careers in science and science administration, both in China and the United States. In many ways, this group became a "family" for Lucy and has continued to maintain contact with her over the years.

This group was the life blood of Lucy's program for more than 20 years. The successful experience of her first scholars convinced Lucy that such programs would be important for her future. The ability of Xiufan Liu, You-quan Cheng and Zhizhong Cui to recruit additional scholars for Lucy after their own successful tenures in her lab was also helpful (this trio was the source of 8 later scholars). Nine scholars came from Jiangsu Agricultural University in Yangzhou. Lucy recruited several others during her own travels in China. No funding for any of these scholars and students came from the Federal budget. Several scholars were supported by the Chinese government. Others were supported by Lucy through grants or creative agreements with companies who needed her hybridomas. With hindsight, Lucy brought as much creativity into the matter of selecting and funding her scholars as she did to her research. The results speak for themselves.

Collaboration

One could say that Lucy was the ultimate collaborator (in the best sense of the word). All of these collaborations were based on strong personal relationships and often involved persons of high stature in science. Her early work as a student in John Boezi's laboratory extended to additional work with him on DNA polymerase in the 1970s resulting in 8 co-authored papers. This productive association was cut short by Boezi's untimely death in 1980. Her proximity to Keyvan Nazerian and his work resulted in at least 38 joint authorships on papers, spanning more than 30 years. She collaborated frequently with other ADOL staff members (this writer's name appears on nearly 50 of her publications). Lucy depended on the veterinarians to help with pathology; other scientists depended on Lucy for access to monoclonal antibodies and to technology for lymphocyte stimulation assays, or ELISA assays, or other specialized procedures being done in her laboratory.

The collaboration with Hsing-Jien Kung deserves special mention. Hsing-Jien joined the faculty of Michigan State University in 1978, in part because of the opportunity to work with ADOL on tumor viruses. His office was adjacent to that of John Boezi in the biochemistry department. Hsing-Jien credits Boezi for his first introduction to Lucy, which occurred shortly after Lucy's return from England in 1979. However, his early interest was in retroviruses and thus his contacts at ADOL did not involve Lucy. One of his graduate students, Joanne Kivela, had been working in Larry Bacon's lab trying to clone the chicken MHC genes. This project was not fruitful and Kung, who was in the process of moving on to Case Western Reserve University in 1987, approached Lucy to come up with a suitable new project for Kivela. Lucy and Hsing-Jien designed a project on MDV transcripts expressed in MD tumors. Kivela would work in Lucy's lab under Lucy's direction. Using a library already available from Meihan Nonyama, Kivela isolated RNA from tumors and did hybridization to identify regions related to MDV. She cut out transcripts and performed the sequencing, and then immediately left for a postdoc position in New York. While there, Kivela read a recent paper about the oncogenes, *jun* and *fos*, checked her sequences, and then called Lucy with the news that her sequence had a leucine zipper and appeared related to *jun* and *fos*. Lucy called Kung and the rest is history. Kung proposed the nomenclature, "meq" which stands for Marek's Eco Q. This landmark finding was reported at the 1988 MD symposium in Japan and launched a flurry of activity that continues to the present. A truly world-class scientist, Hsing-Jien had a broad knowledge of the field, an interest in both retroviruses and herpesviruses, and the ability to attract significant grant support. Importantly, he was also an open and caring person, with respect for all who he worked with. Hsing-Jien and Lucy authored several major grants and 32 papers together, beginning in 1988 and covering the years he spent at Case Western and then later at the University of California, Davis.

Collaboration was important to Lucy. She rarely performed experiments or published without the involvement of others. This was a model that defined Lucy's program for many years, bringing her help with decision making, finances and providing the right mix of persons to accomplish tasks, many of which were unusually labor intensive. Again, her success speaks for itself.

Technology Transfer

Throughout her career, Lucy was quick to recognize opportunities for the practical application of her research. Her portfolio of monoclonal antibodies was of special interest as the critical components of virus assays or diagnostic kits. She pioneered the use of CRADAs (Cooperative Research And Development Agreements) at ADOL. These agreements were made with a commercial company who would pay money to the laboratory to support specific research projects and, in some cases, would directly participate in this research. In Lucy's case, at least 7 vaccine companies executed CRADAs to "evaluate" specific monoclonal antibodies for use in the assay of specific serotypes of MDV used in vaccine manufacture. In reality, this provided a legal way for the company to get access to the hybridoma cell line (not just the antibody) and thus obtain a permanent supply of specific antibodies that were otherwise not available. In return, ADOL received funds which were used to support Lucy's research programs including salary money for visitors and scholars.

The monoclonal antibodies were also the basis for Elisa kits to detect reticuloendotheliosis virus, MDV, hemorrhagic enteritis virus and avian leukosis virus.

Lucy was also able to capitalize from her research to identify and sequence MDV genes. Her isolation of the gB gene set the stage for a major CRADA with Nippon Zeon, Ltd. of Tokyo, Japan who was interested in working with ADOL on recombinant fowl pox virus (rFPV) that expressed gB. This agreement, developed about 1991, provided funds to ADOL for research for 3 years. In addition, in three senior scientists from Nippon Zeon joined the laboratory and worked with Nazerian and Lucy for the duration of the project (see earlier). Several rFPV vaccines against MD were developed and patented but none were licensed, to the disappointment of Lucy and others.

In her later years at ADOL, Lucy became involved (with Sanjay Reddy and others) with the development and evaluation of another putative MD vaccine, Md5Δmeq, which provided excellent protection against MD challenge. Several vaccine companies looked critically at this product but, as yet, no products have been proposed for licensing. The search for better MD vaccines that meet the stringent requirements of the poultry industry and federal licensing remain elusive.

Lucy has accumulated 4 patents during her career, 2 relating to rFPV vaccines and 2 for a diagnostic kits for reticuloendotheliosis virus and ALV-J, respectively. To date, only the ALV-J kit has been commercially licensed.

For many years, the issue of how best to provide a permanent supply of monoclonal antibodies based on the hybridoma cell lines developed by Lucy, was unresolved. Lucy would send small units of antibody to other laboratories on request but did not distribute the hybridomas (except under CRADAs as discussed earlier). Several options involving storage and distribution by external laboratories or companies have been considered but no agreement has been yet executed. Thus, the access to these antibodies, for many years Lucy's personal province, is now in the hands of ADOL.

Professional Activities

Like most laboratory-oriented scientists, Lucy owes much to the technicians who worked with her over the years. It was the technician that provided the continuity and house knowledge that was invaluable not only to Lucy but to the scholars and others who worked in her laboratory for shorter periods. Although preceded by two shorter term techs, Mary Cleland (later Hutcheson) joined Lucy in 1973. By the time of her retirement in 1996 she had participated in many of Lucy's signature accomplishments. She was followed by Barry Coulson, a senior technician at ADOL who had worked with Nazerian, Sharma and others for many years. Lucy credits both with providing quality assistance.

Lucy never became heavily involved with professional associations and was on relatively few committees. She had membership in the American Society of Biological Chemists, American Association of Immunologists and the American Society of Virologists and attended at least some of the meetings held by these organizations.

She joined the American Association of Avian Pathologists (AAAP) about 1980. Throughout her career she attended AAAP meetings on a regular basis and participated in the scientific program, probably because this meeting typically offered strong programs in tumor virus research. She was a member of the AAAP Avian Tumor Virus Committee. She received the Upjohn Achievement Award from AAAP in 1989 for research excellence. Her scholar, Aijian Qin, now Dean, College of Veterinary Medicine, Jiangsu Agricultural University, received a poster award from AAAP in 1999. Aijian reflected on that award at Lucy's retirement, more than a decade later, as being "one of his proudest moments."

She also participated in most of the International Symposia and Workshops on Marek's Disease, starting the 1978 Conference in Berlin, and which have been held at 2-4 year intervals since.

She served as a consultant to the Chinese Ministry of Agriculture in 1986 and again with the United Nations Development Program on avian disease research for the People's Republic of China in 1990.

Awards and Publications

During her career, Lucy received awards and other recognitions for excellence in research. These include election to Sigma Xi (1967), USDA awards for scientific achievement (1971, 1983), and the Upjohn Achievement Award presented by AAAP in 1989. She was also recognized by various institutions in China. She received an honorary professorship from Jiangsu Agricultural University and the International Award for Biotechnology from the Chinese Ministry of Agriculture.

Lucy received a lifetime achievement award for her contributions to Avian Health and Tumor Virus Research at the 9th International Symposium on Marek's Disease and Avian Herpesviruses, Berlin, Germany, June 2012. Dick Witter presented a synopsis of her life story, taking liberally from this biography which, unbeknown to Lucy, was prepared for both AAAP and the symposium. The ruse worked and Lucy was fittingly surprised.

Her publication list numbers, at this writing, more than 135 papers in refereed journals plus numerous abstracts, review papers and book chapters.

Travel

Lucy's life as a scientist took her to meetings in all parts of the US and in many different countries. The most memorable of these trips was her first return trip to China in 1972, the first MD symposium in Berlin (1978) and her sabbatic year in England in 1978-1979. She has travelled to China at least 8 times. However, Lucy has never enjoyed air travel and especially did not like to travel or stay alone. This problem was solved in some cases through arranging appropriate travel companions and persons to share rooms at the destination. Joe would travel with her to many conferences. Her son, Chris, travelled with Lucy on other occasions.

Family Life

For the first 9 years of their married life, Lucy and Joe lived in Washington DC or in Wisconsin – each person dedicated to their education and professional preparation. This was a good period, with a lot of mutual support and enough time, occasionally, for some fun. But both persons were highly motivated to succeed in this adopted country and no effort was spared to achieve this end.

Upon arrival in East Lansing, Lucy and Joe first lived in Cherry Lane apartments, a part of faculty housing at MSU. This was followed by short term stays in several rental apartments and houses. In 1968 they bought a classic house on Sunset Lane in East Lansing. In 1980, needing yet more space, they bought a new home on Whittier Drive in East Lansing, which has remained Lucy's residence to the present time. When in Lucy's house, you were surrounded by Chinese art and décor. Dinners (and most other meals) were in the Chinese tradition. Lucy was a good cook and enjoyed entertaining at home. Joe especially liked to regale his MSU students with special Chinese dinners at a local restaurant where the menu was preordered and included specialties not on the regular menu. Other friends and colleagues received similar treatment. Hsing-Jien Kung writes "Lucy and Joe are the most gracious hosts. I often stayed with the Lees. They opened their house up, making sure the guest receives the warmest welcome with the best meals and accommodation, and Lucy never forgets to pack a sandwich for me on my way to the airport."

Lucy's family life revolved around her husband, Joe. They did everything together. After 16 years of childless marriage, they simultaneously adopted two children from Korea in 1970. The adoption agency had sent photos of two girls and, not knowing which one to pick, Joe and Lucy adopted both. Becky and Yvonne were 2½ and 1½ years old, respectively, at the time. Although there were many positive family moments, this was also the start of a stressful time. None of these four persons were raised in what we (from a Western perspective) would call a typical family environment. The two girls were competitive and never became close. Becky left the Lee household before finishing

high school. Yvonne delivered a baby boy in 1986 which was raised by Lucy and Joe (with Yvonne still in the house). One year later, Christopher was formally adopted by Lucy and Joe by which time Yvonne had already left the family.

Almost devoid of blood relatives, Joe and Lucy took a special interest in Joe's nephew, Fanfu Li who immigrated in 1985 to the United States and worked for a United States company with interests in Hong Kong. Fanfu has remained a close friend of the family, and was especially helpful to Lucy at the time of Joe's death.

About 1970, Joe and Lucy purchased property in a rural setting. This acreage, known affectionately as "the farm" was indeed a sheep farm but was designed to be the site of a future residence. This land was recreational property for Lucy and Joe, but especially Joe who tended to mowing the fields, planting trees and enjoying the solitude of nature. Although plans were made, no house was ever built on this land, which remains a family treasure and nature park. Hsing-Jien Kung remembers accompanying Lucy and Joe to the farm to select and cut a Christmas tree, with the proceeds donated to charity. Many others remember similar experiences.

Joe died in 1993. When physicians in the US could provide no hope for his liver cancer, Joe turned to Chinese medicine and returned to his birth country, spending the last months of his life in Beijing surrounded by professors and discussing academic questions until the end. During this difficult period, Professor An of Beijing University became a close friend and provided much assistance. Lucy was suddenly left alone with her career and a 7 year old son to raise. Joe had made most of the family decisions and Lucy was hardly prepared to take on the broad range of responsibilities now on her shoulders. But Lucy was resilient.

Christopher (Chris) became a focus of Lucy's life. With the help of friends, Lucy saw to it that Chris was reared and schooled. Although motherhood was a sometimes difficult challenge, Lucy provided both love and support for Chris who has continued to live with Lucy until recently.

Lucy was diagnosed with breast cancer in 1999, much to the concern of Chris and the rest of her friends and colleagues. She went through surgery and chemotherapy but was rarely sick and did not miss a beat at work. She is cancer free today.

In 1994, Lucy initiated the Joe Lee Memorial Lecture at Michigan State University with a generous endowment to the College of Arts and Letters. From the beginning this has been a partnership with Beijing University whereby Professor An, Joe's colleague, selects and accompanies a distinguished speaker from China. Lectures have occurred yearly since October 1994, a time selected to coincide with Joe's birth month. Lucy's endowment pays the speaker's honorarium while in East Lansing. She also acts as host of the entourage, planning the requisite social programs. Lectures are given in Chinese, with English translations, usually focused on Chinese poetry and literature which is a unique experience for students and faculty alike.

Ethnic and Women's Issues

As Lucy's long time colleague, I perceived that Lucy was somewhat sensitive to being the only women in a group of male scientists, and had a need, often unfulfilled, to be taken seriously in all matters. In our discussions on this biography, Lucy disavowed concerns of discrimination based on her Asian heritage or her gender. But that does not mean she was insensitive to these issues. Barry Coulson, her long-time technician, saw her as "persevering as a woman in science."

Retirement at Last

Although most coworkers could only guess at her age, for many years there was conversation at ADOL about when Lucy was going to retire. If this was broached with Lucy one received a noncommittal response and perhaps a subliminal message that this was none of your business, anyway. But the work kept going on. In her last decade of employment, Lucy focused on vaccine development and evaluation (see earlier) and never seemed to run out of energy or enthusiasm. Barry Coulson, her technician since 1995, brought many skills in animal experimental work which enabled a productive new phase of work involving vaccine evaluation.

Ultimately, however, Lucy could see that it was probably time to consider retirement. Her decision was prompted in part by her desire to make room for the recruitment of John Dunn, a promising veterinarian who had trained at ADOL and was in a temporary position. Also, she faced the need of preparing an extensive case writeup for peer review, normally an onerous and time-consuming process. Money had ceased to be an issue years earlier. At her wish, her retirement was effective May 3, 2011, marking nearly 43 years of service at ADOL. This is surely a record at least among the professional staff at this institution.

Aly Fadly, the Laboratory Director and her direct supervisor, had to convince her that a celebratory luncheon should be held, as she initially eschewed any interest in such matters. Needless to say, she was properly feted and appeared to enjoy the festivities.

The idea of a scientific symposium in her honor had been raised up earlier in discussions between Yi Li and Lucy, when she was a visitor in Yi's home in Houston. This idea was rekindled by Yi, who found that an international meeting in Cancun in August 2011 would bring a number of prominent Chinese scientists to North America. Yi further found that several of Lucy's closest colleagues in China would be willing to make the trip on their own funds. Hsing-Jien Kung eagerly joined in and by the appointed time, on August 26th 2011, there was a blue-ribbon panel of distinguished scientists assembled in the historic conference room on the 3rd floor of ADOL to give lectures in honor of Lucy's many contributions both to science and their own careers. Former scholars included Xiufan Liu, Zhizhong Cui, Aijian Qin, Yi Li, Ping Wu, Dexin Sui, Maoxiang Li and her friend Zhongfang Shan. These were joined by Sanjay Reddy, Hsing-Jien Kung and, of course, many ADOL colleagues and retirees. Lucy counts this among her happiest moments.

Reasons for Success

The role of Lucy's Christian heritage, the concern of a Chinese priest, the help provided by Dominican nuns, the fact that her husband was prevented from his planned return to China, have been previously discussed. Had any of these factors turned out differently than they did, Lucy's career would not have had the same path.

Another factor was the fortuitous connection that brought Xiufan Liu to Lucy's laboratory in 1981. Lucy had the ability to surround herself with the right people, from start to finish, in her life. These persons became her extended family and provided a support system that sustained her in ways that her natural family could not. Of course, a superior intellect and work ethic did not hurt. In addition, she was never afraid to take on a challenge and had the unique ability to make things "work" in her laboratory. Had she decided against monoclonals as being too technically difficult or against genome sequencing as being too much work, things would have turned out much differently, indeed.

Importantly, Lucy was truly liked as a person by virtually every professional colleague. Jim Payne remembers her "friendliness and exuberance." Jagdev Sharma recalls Lucy with a smile on her face and one who would leave you feeling good about the matter under discussion. Helen Tiddy, secretary at Houghton when Lucy was there, remembers her laughter, her frequent token gifts to the staff and her dismay at the lack of appreciation by her English colleagues for St. Patrick's Day. Bernard Roizman and Pat Spear both recalled Lucy with fondness and appreciation. Although her colleagues recognized her to be sensitive about certain issues, this was not a significant obstacle. She burned no bridges, occasionally showed her displeasure but never anger, and did not hold a grudge. Lucy was always fun to be with but it says something that when asked about personal anecdotes, her colleagues struggled to come up with anything humorous. Her positive personality was a clear asset in her relations with colleagues. People liked to work with Lucy.

Keyvan Nazerian remembers her perseverance and resilience, attributes that served her well throughout her career. This was especially true when her projects and ideas received limited enthusiasm from the rest of the professional staff at ADOL, as was frequently the case in the early days. Once a target was established, she was able to stay focused upon it until the project was concluded.

Decisions were always difficult for Lucy. She would spend much time on the important ones, asking many persons for advice, and then doing what she wanted to do in the first place. It looked like an agonizing process to those outside, but it was simply "Lucy's way." And it seemed to work. Her decisions tended to be very good.

She had a unique ability to identify persons useful to her and cultivated these relationships to her advantage. This was not manipulation and may have not been even calculated, but she was attracted to collaborators who had complimentary skills. She was not shy about approaching even the most prestigious scientists, and she usually got what she wanted.

Lucy consistently had ideas at the cutting edge. She was quick to pick up on the new monoclonal antibody technology, first published in 1975, for which Kohler and Milstein were awarded a Nobel Prize in 1984. She remembers speculating with Keyvan Nazerian about the idea of growing MDV proteins in bacteria, an idea that in the early 1970s was a decade ahead of its time. She was involved in large scale DNA sequencing before this became popular. No idea was too new or too difficult.

The biggest reason for friction was the issue of turf. Lucy was protective of her space, both literally and figuratively. To invade her space was to invite her hackles to rise a bit. And in a small lab with 8 or 9 scientists all working on the same disease, there were always turf issues. There were issues of turf involving Sharma (in immunology) and Nazerian, Silva and others (in molecular biology). Lucy remembers, as do I, her impressions of being on the "short end of the stick" too often. In fact, Lucy had great abilities to adapt and wait for an opening and then charge out in front to claim her space. It was a technique that served her well. When Sanjay Reddy left ADOL and his work with meq-deleted MDV was abandoned, Lucy claimed this turf under an old phase (the term for project outline at ADOL) approved years earlier. This gave her a head start and she did not have to do battle for this piece of turf.

Her power base rested in part with control of her monoclonals and other specialized technology. In many cases her colleagues acknowledged the contribution of her monoclonals to their research with authorships.

Lucy sees herself as not very aggressive. Perhaps this is true in an interpersonal sense or in a leadership sense, but it is not true in scientific matters. She was tenacious, patient, willing to put in whatever amount of work was required, and see it through to the end. In this way, she was able to make difficult techniques work well in her laboratory, a skill not shared by all scientists. She could be stubborn in her pursuit of scientific goals even in the face of criticism. She never wore the coat of exclusivity and did not put on airs of superiority. She just worked quietly and hard, and surprised many with her insightful ideas and productivity.

She was not a natural leader or organizer, but provided quiet leadership by example. Committee and organizational work was of relatively low priority, providing perhaps more time for the science she loved.

Persons at all employment levels at ADOL, all her colleagues and students, and just about everyone addressed her as "Lucy." I believe she may have on occasions preferred to be addressed more formally as was the custom for at least some of the other ADOL senior staff, but this rarely happened. This reluctance to insist on deference by her subordinates may have been one of the keys to her success.

And she did all of this while dealing with many significant stressors in her personal life (see earlier). Somehow, she had the resilience to overcome these personal issues and stay focused on her science. Perhaps, in a sense, science was her salvation.

Summing Up

In the world of research on Marek's disease, few persons have contributed what might be considered landmark discoveries. Lucy's development of serotype-specific monoclonal antibodies is surely one of these. Another is her monumental project to derive the complete genetic sequence of MDV. Close behind are her contributions to the discovery of the meq and pp38 genes, her development of lymphocyte stimulation assays for immune competence in the chicken, her characterization of gB, vIL8 and assorted other MDV genes, and her role in the development and characterization of vectored and gene-deleted vaccines against MD. Her role in advancing knowledge of MDV has been significant, and is probably underappreciated. Lucy has never been one to blow her own horn.

In contrast, her role as a teacher and mentor, especially of the many Chinese scholars and students to spend time in her laboratory, is surely not underappreciated. Lucy is revered in China as a teacher and as a scientist, and is held in high esteem by her own students (and their students) in the Chinese tradition.

Lucy also will be remembered for her many personal qualities, her friendships, and her dedication to her family. And perhaps on the basis of this biography, she will also be admired for overcoming many obstacles, any one of which might have directed her down a much different path. This may have been good fortune for Lucy, but it is also good fortune for science and for all those who have come to know her or admire her career.

Author's note – This biography is the product of numerous interviews with Lucy, who participated enthusiastically in its preparation. Lucy also provided documents and photographs which provided the basis for the factual information contained herein. Although I have worked with Lucy on many research projects over the years, this latest collaboration may well be the most important as well as the most satisfying (to the author). I consider it a privilege to have been given the opportunity to record this story for posterity.

Other person who contributed materially to this biography include Hsing-Jien Kung, Mary Hutcheson, Barry Coulson, Keyvan Nazerian, Jagdev Sharma, Sanjay Reddy, Jim Payne, Bernard Roizman and Patricia Spear.

R.L. Witter, May 2012

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

Special Collections Dept. & University Archives

403 Parks Library
Iowa State University
Ames, IA 50011-2140
Phone: (515) 294-6648
Fax: (515) 294-5525
WWW: http://www.lib.iastate.edu/spcl/index.html