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EARLY HISTORY OF NSSL AND CONTRIBUTIONS OF EDWIN JAMES AND LOUIS N. BASS

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ABSTRACT

The National Seed Storage Laboratory (NSSL) opened for business in September of 1958 with the long-term mission of preserving the seed germplasm of those crops important to U.S. agriculture. The NSSL concept was a direct result of World War II, when it became apparent that germplasm may no longer be available, particularly from many foreign countries. Dr. Edwin James was named the first Head of the Laboratory and served until his retirement in 1970. His primary accomplishments included the administration of the new facility, generating publicity about the Laboratory, and initiating the acquisition and storage of seed samples. In addition, he conducted research on such topics as seed longevity and seed deterioration, including biochemical aspects of red cotyledon in lettuce and viability assessment using such tests as the glutamic acid decarboxlyase test. Dr. Louis N. Bass joined NSSL at its inception and was named Head in 1970, a post he held until his untimely death in 1986. Louis oversaw many dramatic changes in the Laboratory, such as the shift from storing seeds at 5°C to storage at –18°C, primarily as a result of his research on seed storage under various conditions of temperature, relative humidity and in different gases. Louis brought the Laboratory national and international recognition through his participation in the Association of Official Seed Analysts (AOSA) (President, Merit Award, editorial duties, numerous committees), the International Seed Testing Association (ISTA) (Associate Editor of *Seed Science and Technology*), the American Society of Agronomy (C-4 Chair and Board Representative, Fellow) and the International Board for Plant Genetic Resources. A bibliography of James' and Bass' primary publications while at NSSL is included.

INTRODUCTION

The National Seed Storage Laboratory (NSSL) is operated by the United States Department of Agriculture – Agricultural Research Service. The Laboratory began operation in the fall of 1958 (Fig. 1), however, its early beginnings date to the post World War II years. Prior to this time many new plant introductions had been made as a result of explorations and exchanges with foreign countries. Typically these materials were evaluated by plant breeders and either used directly or were incorporated into breeding programs. Seed accessions that had no obvious

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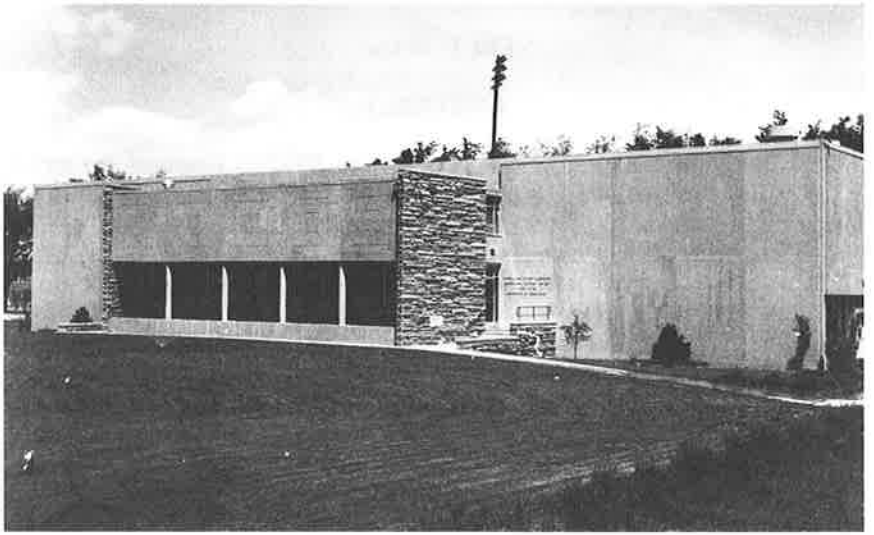

Figure 1. Front view of the National Seed Storage Laboratory shortly after it opened in the fall of 1958. The two story building was constructed of pre-stressed concrete slabs with the seed storage vaults and germination laboratory on the second floor and the mechanical systems on the ground floor. Offices and research laboratories were added to the ground floor later. The administrative offices were located on an intermediate floor (front of building behind the columns). This building was totally renovated and incorporated into the new addition to the NSSL completed in May of 1992.

value were discarded or were left to deteriorate under ambient conditions, the premise being that material could always be recollected, if needed. During the war many research programs were impacted as researchers were redirected or left their positions, resulting in loss of germplasm. After WW II, many countries closed their borders (e.g. China), and access to germplasm was greatly restricted. The need for a long-term storage facility was discussed by the National Research Council which had brought together leading agricultural representatives in 1944 to discuss the general problem of preservation of genetic stocks which resulted in the appointment of a standing committee to investigate the national need. Additional discussions were held in 1947/1948.

> "The idea was presented to a meeting of the National Coordinating Committee for New Crops in 1949 and action was taken to investigate the feasibility of a national storage. A standing subcommittee was appointed in 1950, and through its efforts support of the various agricultural societies and agencies was obtained. A brochure in support of a National Seed Storage Laboratory was presented to Congress and the Budget Bureau in 1955. Action by Congress was delayed until 1956, when funds were appropriated for the construction of the laboratory. Construction of the National

Figure 2. Dr. Edwin James served as the first Head of the National Seed Storage Laboratory from 1958 to 1970.

Seed Storage Laboratory was begun in 1957 and was essentially complete in September 1958." (James, 1961; pub. #3)

Dr. Edwin James was named the first Director (title later changed to "Head") and Dr. Louis N. Bass was hired to supervise the seed germination laboratory and to conduct research on seed germination and storage.

Although the primary mission of the NSSL was, and continues to be, to preserve seed germplasm for the future use of plant breeders and other scientists around the world, conducting a vigorous research program is an important complementary mission. In this paper, and the following papers in the symposium, we wish to highlight some of the research accomplishments of the staff and some of the new technologies developed at NSSL.

EDWIN JAMES – HEAD 1958–1970

Biography: Dr. Edwin James (Fig. 2) was born November 9, 1900, at St. Cleer, Cornwall, England. He emigrated with his mother in 1903 to Michigan, where he completed his secondary education. Following graduation from high school, he worked in automobile factories from 1919 to 1923. For a time he ran his own painting and decorating business until 1929, when he enrolled at Michigan State College. He graduated with high honors in 1934 and then taught vocational agriculture and earned a

Masters degree at Iowa State University in 1938. He taught agronomy at the University of Georgia for 10 years, and worked towards his Ph.D. at Michigan State University where he majored in agronomy. When the Regional Plant Introduction Station at Experiment (Griffin), Georgia was established in late 1949, Dr. James was chosen to be the first Coordinator of the regional project that served the 14 southern states. During this period he authored numerous papers on field and forage crops, and was co-author of two textbooks *Pastures* and *Pasture Science*. He served as Head of the NSSL from 1958 until his mandatory retirement, at age 70, in 1970. Ed lived in retirement in Fort Collins until his death on February 12, 1991.

CONTRIBUTIONS – EDWIN JAMES

Administrative: Upon assuming the duties of Head of NSSL, the first order of business was to assure that construction of the building met the original plans and specifications. Having just completed the addition and renovation of the NSSL, I think those of us here at the Laboratory can appreciate just how much work this involved. It was interesting and amusing to read some old correspondence in this regard. For example, in a letter dated July 27, 1959, Ed writes to his then Branch Chief, C.O. Erlanson:

> ...the equipment is not functioning according to specifications. In short, the way the system is supposed to operate is that the air is supposed to come off of the refrigeration coil at a low temperature and be reheated to the desired room temperature by reheating coils in the ducts. This procedure serves also to lower the relative humidity in the rooms. Up until the time that the...Company made some adjustments on the controls we were not able to have a low air delivery off of the coil and were not able to utilize the reheating coils. Nevertheless, we were able to maintain temperature of around 35–40° with an average relative humidity of about 50. After the adjustments were made...we set our air delivery temperature down in hopes that the reheat coils would lower the humidity. When this was done, we ran into another problem wherein the fans delivering the air into the rooms began frosting up as though someone had shoveled snow into them. Obviously, there was no air delivery to the rooms proper. The only way I could overcome the frosting of the fans was to raise the coil temperature again putting us right back where we were before the adjustments...

The struggle to get the new NSSL building operating according to specifications went on for at least another two years, before the building was finally accepted by GSA (General Services Administration). Fortunately, Ed James was very mechanically oriented and was always a "tinkerer" (as well as an inventor, see pub. #5, #6, #34) and his persistence led to the building operating relatively smoothly for the subsequent ten years.

The next challenge faced by the Laboratory was to persuade breeders, companies and even ARS scientists to deposit seeds for long-term storage. It was always assumed by the scientific community that worked to establish

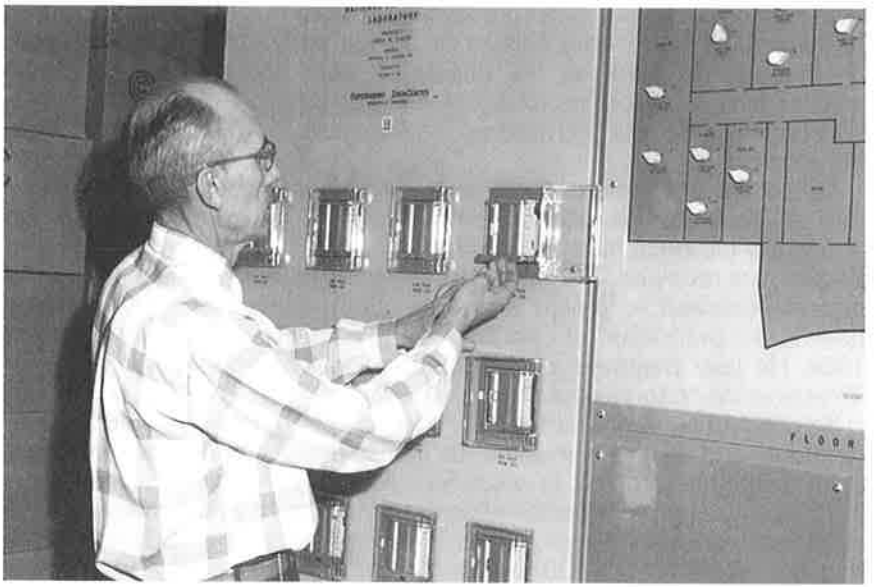

Figure 3. Dr. Edwin James checking the control panel for the seed storage vaults. Initially the storage vaults were maintained at 5°C and 40% relative humidity. The difficulties in maintaining RH and the storage studies conducted by Drs. Bass and James eventually led to lowering the storage temperature to –18°C and drying the seed before sealing in moisture proof bags, thus eliminating the need to control RH.

NSSL that, once open for business, seeds would flow into the Laboratory. This was not the case, and it soon became clear that persuasion would be needed to convince people to deposit their seed germplasm. Much of this reluctance to deposit seed hinged on the policy of NSSL that seed germplasm would become the property of the United States Government and would be freely available to any bona fide user. Seed companies were especially hesitant about depositing any inbred lines developed for their breeding programs. Development of a clear policy for operation of NSSL required cooperation among all potential users and benefactors, including the interest of the general public. Numerous drafts were prepared, edited, revised and finally an approved policy was adopted.

To spur interest in the seed storage program, Dr. James began a series of lectures and visitations to seed companies and various scientific societies and special interest groups, to explain the purpose and objectives of NSSL. Some of these included talks to the International Crop Improvement Association Meeting (Oct. 26, 1959); American Seed Trade Association, Farm Seed Research Conference (pub. #2); American Association for the Advancement of Science Germplasm Symposium (Pub. #3); and numerous other presentations. Seed receipts gradually increased in the early 1960's and soon the Laboratory was humming with activity involving germination testing and packaging seeds for long-term storage. By 1967, over

52,000 accessions had been processed for storage.

Research: I do not have a list of Dr. James' early publications, however, he did conduct work on the effects of plant arrangement on cross-pollination of muskmelons (pub. #1) with the objective of reducing contamination among the germplasm stocks held at the Regional Plant Introduction Station.

One of the first tasks undertaken by Dr. James was to review the literature on seed storage and longevity. This work was summarized in two annotated bibliographies. In the first (pub. #4) 492 papers, published in English, are reviewed. The second bibliography (pub. #11) summarized 149 papers published in foreign languages. Both of these papers appeared prior to the publication of Lela Barton's famous *Bibliography of Seeds* in 1964. He later prepared a review article for *Advances in Agronomy* on "Preservation of seed stocks" (pub. #27).

To conduct research on the combined effects of different storage temperatures and relative humidities, Dr. James designed and built three constant temperature rooms, in which he placed three humidity cabinets, giving him a total of nine combinations of temperature and humidity. These were used for over 20 years for seed storage studies by NSSL scientists. In one such study (pub. #30), seeds of wheat, rye, soybeans and safflower were stored at five temperatures, including the three temperature rooms. In this case the seed moisture contents had been previously adjusted and the seeds sealed in glass bottles for storage. In another study (pub. #31), the temperature humidity cabinets are described in more detail. In this study varietal differences in longevity of several vegetable seeds were investigated. Louis Bass (and others, including me) made extensive use of these cabinets (for example see pub. #28, #29, and #33) and some of these studies will be detailed later. Eventually the rooms and cabinets were dismantled to provide additional laboratory and office space in the early 1980's.

In the fall of 1962, Dr. James obtained approximately 2000 lots of seed of several vegetable species which had been in uncontrolled storage in Cheyenne, Wyoming. The seeds had been stored in paper envelopes in metal drawers in an office. The age of each sample (15 to 30 years) was listed on the outside of the packet. The subsequent publication (#17) of the germination results became the oldest documented longevity for many of these species. I was able to continue and update this work in a subsequent paper (*HortScience* 27:393–396, 1992).

Dr. James was interested in rapid methods for determining storage potential and thus followed up on various reports of alternative tests. One such test involved using glutamic acid decarboxylase (GADA) as a viability test. The test requires only about an hour and previous reports had shown high correlation coefficients between germination and enzyme activity for wheat, corn, rice, and oats. Using garden beans, Dr. James found varying degrees of correlation (depending upon cultivar) between GADA and germination and thus reported on the limitations of this method for estimating viability (pub. #32).

One of the last research projects that Dr. James completed before his retirement was to examine the nature and performance of red cotyledon lettuce seedlings (pub. #35). His approach was to examine the pigments

in the necrotic tissue of germinating lettuce cotyledons to determine possible chlorophyll differences in necrotic and normal tissues. His results showed very obvious loss of chlorophyll, however, no anthocyanin or phenolics were detected in the necrotic tissue.

Dr. James last publication (#40) was a contribution to Eric Roberts' classic 1972 book, *Viability of Seeds*. Here he described the history, organization, and operation of the National Seed Storage Laboratory.

Personal Note: In 1966 ARS decided to transfer the Vegetable Seed Investigations Research Unit to the NSSL from Beltsville, Maryland. They would occupy space on the ground floor; however, their mission would remain separate from that of the NSSL. Dr. James lobbied hard to add a biochemist position. Little did I know that I was to be that scientist (although in actuality I did not join the NSSL officially until 1975). I first met Ed James when I joined ARS in 1967. He was extremely interested in the subject of seed aging and the biochemical and/or genetic reasons for deterioration. Although not trained as a biochemist, he still attempted to put a biochemical twist to seed investigations; I was very impressed. Long after his retirement I remember the day he came in the lab and started telling me about this idea he had dreamed up (literally). Why couldn't we just measure the entire electromagnetic spectrum of a seed and tell if it was alive or dead—no need for a germination test. It still sounds like a good idea to me. Ed never stopped thinking for a minute.

LOUIS N. BASS – HEAD 1970–1986

Biography: Dr. Louis Nelson Bass (Fig. 4) was born March 7, 1919 in Iola, Kansas, but moved to Fayette, Iowa at the age of six weeks. Except for a short period between the ages of 5 and 9, when the family lived in Willow Springs, Missouri, Louis spent his early years and college days in the State of Iowa. He received a B.S. degree in Biological Science from Upper Iowa University in 1940; an M.S. degree in Plant Taxonomy from the State University of Iowa in 1943; and a Ph.D. in Plant Physiology from Iowa State University in 1949. Positions held by Dr. Bass included the following: Biology and Chemistry Instructor, Upper Iowa University (1943); Plant Breeder, Associated Seed Growers (1944); Science and Mathematics Instructor, Ankeny, Iowa High School (1945); Seed Analyst and Assistant Professor, Iowa State University (1945-1958), and Plant Physiologist, National Seed Storage Laboratory (1958-1970). In 1970, Dr. Bass was named Head of the NSSL, a position he held until his untimely death on January 24, 1986.

During his career, Dr. Bass authored over 100 publications, including *Principles and Practices of Seed Storage*, which he coauthored with O.L. Justice; also six book chapters, over 50 scientific journal articles, plus numerous technical bulletins, reports, as well as popular and semi-popular articles on seed storage. Several scientific societies and organizations benefitted from his service and he received many honors and awards: Association of Official Seed Analysts (AOSA), held all of the elected offices including President (1971-72) and was a recipient of the AOSA Award of Merit (1975); American Society for Horticultural Science, Chair of Genetics and Germplasm Working Group; American Society of

Figure 4. Dr. Louis N. Bass joined the staff of the National Seed Storage Laboratory in 1958 and was named Head in 1970, a position he held until his untimely death in 1986.

Agronomy, elected Division C-4 Board Representative and served as Associate Editor of *Agronomv Journal*, and was elected a Fellow (1982); Crop Science Society of America, elected Division C-4 Chair, elected Division C-4 Board Representative, Fellow (1985); International Seed Testing Association, Chair of Seed Storage Committee, Associate Editor of *Seed Science and Technology*; Society of Commercial Seed Technologists, elected Honorary Member; also a member of Sigma Xi, Phi Kappa Phi, Gamma Sigma Delta, and Epsilon Sigma Phi.

CONTRIBUTIONS – LOUIS N. BASS

Administrative: By 1970 the NSSL was running smoothly, however, Dr. Bass was soon to be faced with many new challenges including the total reorganization of ARS which occurred in 1972. Branches and Divisions were abolished and replaced by Areas and Regions. Fort Collins became the Area Office for the new Colorado-Wyoming Area. The old Vegetable Seed Investigations Unit (of which I was a member) was assigned under Dr. Bass' supervision, although we continued our previous research agenda. The number of new seed accessions began to accelerate and finally in 1975 increased funding was provided by Congress which allowed a much needed expansion of the staff. At this time, my research technician, Joe Manalo, and I were reassigned to the germplasm work of NSSL, and, after nearly five years, a replacement for Dr. Bass' old position was hired in the person of Phillip Stanwood, who took over as supervisor of the germination laboratory (Fig. 5).

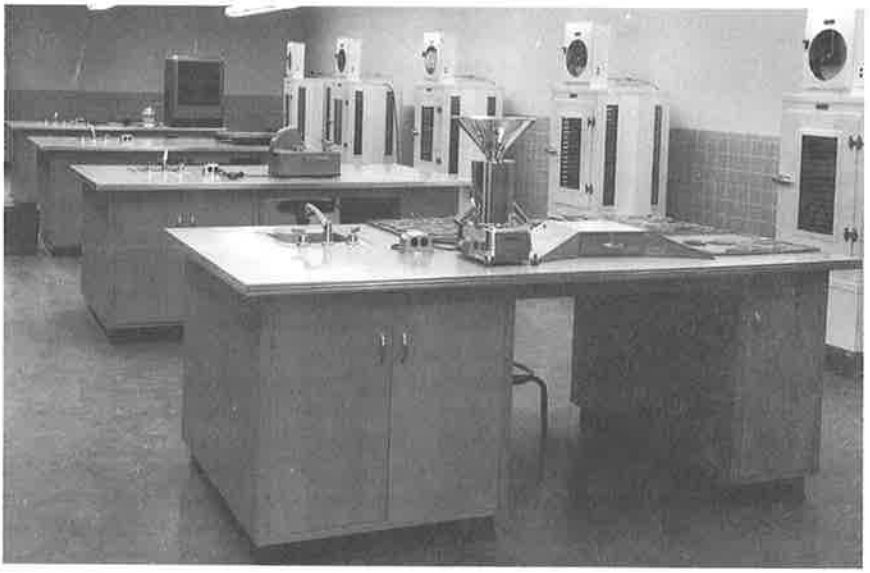

Figure 5. View of the seed germination laboratory. Each center island had a small sink and provided space for two analysts with a vacuum line for each to plant seeds. Two walk-in germinators (not shown) were available as well as small germinators located along the back wall.

In the mid 1970's a dramatic shift was taking place in how we stored our seeds. Based mostly on the research of Dr. Bass, it was decided to lower the storage temperature to –18°C, seal the seeds in moisture proof containers, and eliminate the costly humidity control of the storage vaults. This did not occur overnight, but required several years and special funding from the Regional Office to renovate each of the ten storage vaults. The old screw top cans were gradually replaced with laminated, heat-sealable, foil-paper-polyethylene bags, as each sample came up for its 5-year germination test.

In 1974, the establishment of the International Board for Plant Genetic Resources in Rome brought new focus to the world of the necessity for preserving our plant genetic resources. The NSSL was one of a few genebanks worldwide and served as a model for other countries attempting to set up their own long-term seed banks. NSSL entered into an agreement to hold world collections for various crops and became a keystone in the international network of genebanks. Over the years almost every person involved in genetic resources conservation has found their way to Fort Collins. This continues to be the case today. Dr. Bass provided advice on seed storage to these individuals and even spent a month in Bangalore, India advising them on the design of a seed storage facility.

One of the last efforts by Dr. Bass was the push to upgrade the NSSL and increase the capacity of the seed storage vaults. This effort began in earnest about 1984 when he was finally advised to proceed with prelimi-

Figure 6. Dr. Louis Bass (c. 1960) checking seed samples in the storage vault. Seeds were stored in screw-top cans placed in metal trays on fixed shelves in one of the ten storage units.

nary discussions with Colorado State University to obtain the land for the expansion. What followed was an interminable series of meetings with all concerned to build the political support for a new building. Unfortunately, Louis did not live to see the fulfillment of his dream.

Research: Prior to joining the NSSL, Dr. Bass conducted research on seed germination and vigor, and the effects of different packaging materials on seed storage (pub. #8) . He was probably the world expert on germination of Kentucky bluegrass seed (pub. #18). I have not included this stage of Louis' career in this review.

As already mentioned, the first two or three years the Laboratory was open saw only a limited number of samples received for storage. This

enabled Dr. Bass, Dr. James, and Mr. Dorris Clark (who had joined the Laboratory in 1959 as a laboratory technician) to initiate numerous storage studies, some of which continue to the present day. Of singular importance were the numerous studies on the effects of different storage temperatures, relative humidities, and packaging materials on seed viability and vigor of many diverse species including: hemp and kenaf (pub. #16); *Dimorphotheca sinuata* and *Osteospermum ecklonis* (pub. #28, #60); reed canarygrass (pub. #29); peanut (pub. #33); lima bean (pub. #36); lettuce (pub. #37); cantaloupe (pub. #43, #86); crambe (pub. #46); safflower (pub. #47); papaya (pub. #48); crimson clover (pub. #49); numerous flower species (pub. #75); and seeds of tropical legumes (pub. #88).

Dr. Bass supervised the work of a young graduate student (Richard L. Sayers) who examined the germination requirements for some potential new crops: crambe (pub. #19) and *Lesquerella* (pub. #21). Dr. Bass also examined germination requirements for many other seeds such as: Indian ricegrass (pub. #38); *Vernonia anthelmintica* (pub. #39); *Lesquerella* (pub. #44); and true mountain-mahogany (pub. #45).

An experiment was initiated in 1959 to study the effects of vacuum and inert gases on longevity of crimson clover, lettuce, safflower, sesame, and sorghum seed (pub. #10, #12, #13, #63, #65). Remnant samples from this experiment are still in storage. This experiment remains the most important work and legacy of Dr. Bass, in my humble opinion.

A major contribution of Dr. Bass was the work he did in compiling seed storage literature. I have already mentioned the book he coauthored with O.L Justice (pub. #61). However, he also wrote several other review papers on various aspects of seed storage (pub. #42, #70, #72, #77, #89, #90 #91).

Personal Note: When the word of Louis' death came to the Laboratory, we were, of course, in a complete state of shock as he had been at work in the morning and had returned home for lunch when he collapsed and died. He was a robust man, full of life, and was always very active in his many organizations such as bridge club, bottle collectors, and others. I saw in Louis a very successful man, one who had achieved the highest recognition within his chosen profession. He was a kind person, well-liked by his friends and colleagues. When I first came to the NSSL in 1967, most of my interaction with Louis came during the mid-morning coffee break. We were a much smaller group then and perhaps a little closer. In 1972, he became my supervisor and we enjoyed a good relationship throughout this period. He was always supportive and tried to provide the necessary resources for my work, which was not easy with the limited budgets in those days. When I was named acting Research Leader in 1984, he was again very supportive and provided me with the necessary guidance for this new role. We all should be grateful for having had the chance to know Louis Bass.

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