

LIFE HISTORIES OF HONORARY IHSS MEMBERS

My Career in Research and Teaching at the University of Illinois (1953-1990)

Frank J. Stevenson



Early Years

I was born on August 2, 1922 at Logan, Utah, and received my early education in public schools near Salt Lake City, Utah. I attended the University of Utah for a brief period (1940-41), where I took courses in biology and geology, and became interested in the natural sciences. With war looming on the horizon (i.e., WW-II), I withdrew from the university and completed a course for machinists under a federal program designed to develop a pool of trained technicians for the mobilization effort. I subsequently worked as a machinist at Hill Air Force Base, near Ogden, Utah.

In the fall of 1942, I enlisted in the US Navy as an aviation cadet, and, in due course, obtained my “wings” at the air training center in Pensacola, Florida. This was followed by a tour of duty in the Pacific during the war with Japan, as a fighter pilot aboard an aircraft carrier. I was shot down by antiaircraft fire during the Iwo Jima campaign, survived a crash landing at sea, was rescued by the Navy, and returned to my carrier to fly another day.

Upon discharge from the Navy in the summer of 1946, I enrolled in the Brigham Young University and obtained my B.S. degree in Secondary Education (science option) in 1949. I continued my studies as a graduate student, first as a teaching assistant in chemistry at Brigham Young University and then as a research assistant in soil chemistry at the Ohio State University.

I was awarded the Ph.D. degree in December, 1952, and subsequently accepted the position of *Instructor of Soil Chemistry* at the University of Illinois. Over the years, I advanced through the various academic ranks: *Assistant Professor*, 1954; *Associate Professor*, 1958; *Professor*, 1962. I retired in 1990, and, as of this date, I am still listed on the faculty as *Professor Emeritus*.

In addition to research, I taught a course on the *Organic Chemistry of Soils*, and, for a time, taught a course entitled *Biochemical Processes in Soil and Water Environments*. During the school year 1962-63, I was on sabbatical to Australia, where I carried out joint research with soil scientists of the CSIRO, located at the Waite Institute in Adelaide.

Narrative of Research Activities

My research at the University of Illinois covered a wide range of subjects and spanned several scientific disciplines. A particularly rewarding aspect of my work was the opportunity to interact with graduate students, postdoctorate fellows, and visiting scientists – many of whom came from undeveloped countries to work with me under training grants from agencies of the United Nations. Throughout the years, I maintained a hands-on approach to research and worked actively in the laboratory, often using undergraduate students as laboratory helpers – many were inspired to pursue science careers on their own.

My Ph.D. thesis at the Ohio State University dealt with the physical and chemical properties of humic substances (the yellow- to black colored organic substances in soil) and I continued my interest on these important and mysterious substances throughout my career.

Together with my co-workers, I carried out research on the reactive functional groups in humic substances, including infrared studies of humic and fulvic acids and their methylated/acetylated derivatives – this work showed that the acidity of the different reactive groups overlapped, and that methods for determining functional groups based on acidity were not specific and could not be used as an absolute measure for functional group content. I also carried out research on the reactions of humic substances with micronutrient cations (e.g., copper and zinc) and toxic heavy metals (i.e., lead and cadmium). My initial calculations for stability constants of metal-humate complexes were made using unwieldy hand calculators and prototypes of modern-day computers, using “punch cards”. With development of the personal computer (PC), I became familiar with spread-sheets (i.e., Lotus 123) for analyzing experimental data. With the PC, I had the same computer capability in my office that previously required an entire room (and a large one at that).

My studies on metal-humate complexes led me to conclude that heavy metals introduced into agricultural soils as contaminants (and sediments as well) are complexed by humic substances, and that both soluble and insoluble complexes are formed. At low degrees of metal ion saturation, the complexes are soluble and humic substances act as transporting agents. On the other hand, when saturated with metal ions, these same complexes become insoluble and thus immobile, suggesting that humic substances can also function as a “sink” for heavy metals.

I maintained a long-time interest in chemical forms of nitrogen in humic substances and of the role of these constituents in nitrogen cycle processes. I cooperated with other members of our soil science staff on research on the mineralization-immobilization turnover of biologically and chemically fixed nitrogen, using the stable isotope nitrogen-15 as a tracer. This research was of importance in that as much as one-third of the nitrogen applied to soils as fertilizer is retained in stable organic forms after the growing season – to a large extent by incorporation into newly-formed substances. Calculations were made for mean-residence-times (MRT) of this immobilized nitrogen, information which was needed in models for predicting the soil’s ability to provide nitrogen for plant growth. Visiting scientists from Pakistan and China participated in this research.

Soon after my arrival at the University of Illinois, I initiated research on nitrogenous organic constituents in soils, which are of importance to soil fertility in that they serve as sources of nitrogen for plant growth. In my Ph.D. studies, I had become acquainted with chromatographic procedures for isolating and identifying biochemical compounds and I applied these techniques to studies on amino acids in soil. An interesting aspect of this research was that I found that soils contained far more amino acids than are normally found in plant and animal proteins (i.e., proteins contain about 26 amino acids whereas I found over 35 similar types of compounds in soil). I identified many of these unusual amino acids, which I believed to be remnants of microbial tissues (i.e., soils contain high numbers of bacteria, actinomyces, and fungi that are involved in the decay of plant and animal residues – my review of the literature showed that bacteria, in particular, synthesized exotic amino compounds of various types). I also detected several nitrogen-containing sugars (i.e., amino sugars), which occur in microorganisms but not in higher plants. I expanded this work to an examination of amino sugars in species of the *Rhizobium* (bacteria responsible for the fixation of atmospheric nitrogen in legumes). I believe that I was the first to detect and identify amino sugars in the rhizobia. I found that there were considerable differences in the kinds and amounts of amino sugars associated with the different *Rhizobium* species, from which I postulated that chromatography patterns for amino sugars might serve as a “finger-print” technique for classification purposes. I wanted to pursue this research further but never had the time to do so.

In my studies, I observed that some of the soil nitrogen (particularly in the subsoil) existed in forms that could not be regarded as “organic”, but that existed as ammonium held within the lattice structures of clay minerals (i.e., as “fixed ammonium”). Several other soil scientists, notably J.M. Bremner of the Rothamsted Experimental Station in England, had reached a similar conclusion. It had long been known that the C/N ratio narrows with increasing depth in the soil profile, and I was able to demonstrate that this decrease was due to clay-bound ammonium, rather than to an increase in N-rich organic compounds with depth, as had commonly been thought.

My attention at this time was directed to nitrogenous constituents in sedimentary rocks and marine sediments. From my research with soil, I was able to demonstrate that much of the nitrogen in these samples also occurred as fixed ammonium. Included in my studies were depth samples from the Experimental Mohole [a project of the National Science Foundation (NSF) to drill a hole through the earth's crust and into the mantle]. With these sediments, which I was able to obtain by virtue of a research project supported by NSF, I found that the disappearance of amino acids during diagenesis was due in part to abiotic (i.e., chemical) processes. On still another NSF project, I worked with deep-sea sediments from the Argentine Basin. I found that amino acid levels were correlated with climatic changes during Quaternary times, which I attributed to reduced microbial activity during the colder periods, with enhanced preservation of organic substances in the sedimentary material. From this work, I postulated that the levels of amino acids and other organics in sediments might provide a tool for stratigraphic correlations.

Ammonium is bound to certain clay minerals (e.g., illite) in much the same way as potassium (both have molecular dimensions that allow them to fit snugly within hexagonal voids of the minerals). From this, I concluded that those rocks and minerals that contained potassium-bearing primary minerals (e.g., feldspars and micas) would also contain ammonium, albeit in small amounts. My examination of a wide variety of primary rocks and silicate minerals showed this to be the case. From this work, I concluded that previous estimates for the amounts of nitrogen contained in primary rocks of the earth's crust and mantle were much too high (earlier estimates were based on an average value of 50 $\mu\text{g/g}$ for the nitrogen in rocks; my results suggested a value closer to 30 $\mu\text{g/g}$). My recalculated estimate for the geochemical distribution of nitrogen in the earth was, I believe, generally accepted by geochemists.

I published my work on nitrogen in rocks and minerals in *Science* 130, 221-222 (1959), and this work was widely quoted, including newspapers (both locally and elsewhere). Some sources credited me with discovering nitrogen in rocks, but this was not the case. Rocks had been known to contain nitrogen since the work of Raleigh in 1910. My work dealt with the *chemical form* of this nitrogen. I also postulated that the nitrogen in *stony* meteorites existed as ammonium held within the structures of silicate minerals, which I found to be the case (work unpublished).

By virtue of my research with organics in sediments, I became affiliated with the relatively new scientific discipline of organic geochemistry. I became personally acquainted with world-renowned scientists in this field, many of whom worked on organics in extraterrestrial samples (e.g., carbonaceous meteorites) and in developing methods for detecting life (i.e., microorganisms) on other planets. I assisted in these endeavors in that I evaluated some of the approaches that were being considered to determine if life existed (or ever existed) on Mars (i.e., initial landings were to be unmanned). For a brief time, I was a consultant to a commercial company that was developing hardware for this purpose.

I was indirectly involved in allied disciplines in which humic substances were of interest. For example, numerous studies had shown that organic matter was a key component on the retention of pesticides and various xenobiotics in soil. I was often asked to participate in symposia on this subject and to offer expert advice on the nature of the binding, etc. Based on my other research, I predicted that pesticide residues can become stabilized, and thereby inactivated, by conjugation with components of soil humic substances, and this hypothesis was subsequently confirmed.

During my career, I gave over 50 symposium, workshop and seminar presentations in 10 countries throughout the world: Australia (1962, 1984); Canada (1963, 1965, 1978); England (1966, 1984); France (1973); India (1982); Pakistan (1984); Germany (1987); Israel (1985); Italy (1973), and the USA (over 20).

In addition to my research, I published 4 books, edited 2 books of major importance, and published about 150 research articles and book chapters. I served on many university and scientific society committees and received a number of awards, including Fellows of the American Association of Science, the American Society of Agronomy (ASA), and the Soil Science Society of America (SSSA). I was a recipient of the Agronomic Research Award (ASA), Soil Science Research Award

(SSSA), Bouyoucos Soil Science Distinguished Service Award (SSSA), Paul A. Funk Recognition Award (University of Illinois), and the prestigious Wolf Prize in Agriculture, awarded jointly with Dr. Morris Schnitzer for our “outstanding contributions to our understanding of the chemistry of soil organic matter, and its application to agriculture”.

Memberships included: Phi Lambda Upsilon, Phi Kappa Phi (honorary member), Gamma Sigma Delta, Sigma Xi, American Association for the Advancement of Science, American Society of Agronomy, International Humic Substances Society (honorary, life-time member), Soil Science Society of America, International Soil Science Society.

I retired from the University of Illinois in 1990 after 37 years of service and continued to be active professionally (as professor emeritus) for several years thereafter. Along with my wife and companion of over 50 years (Leda), I now reside in a retirement community in Arizona, where I relax in the sunshine, enjoy the fantastic scenery of the American southwest, frolic with four grandchildren living nearby, and, as health permits, engage in such worthwhile activities as the game of golf.

For a time following retirement, I continued to attend national and international conferences, usually to give an invitational paper. My last paper was presented at annual meetings of the *Soil Science Society of America* in St. Paul, Minnesota, in November 1994, at which time I decided that it was time to step down and let younger scientists take over.

To paraphrase the words of one of our famous generals (General Douglas MacArthur) -
Old scientists never die, they just fade away.