



John Bremner

1922–2007

BIOGRAPHICAL

Memiors

*A Biographical Memoir by
Dennis R. Keeney*

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NATIONAL ACADEMY OF SCIENCES

JOHN BREMNER

January 18, 1922–July 27, 2007

Elected to the NAS, 1984

John Bremner, who was known as “Jack” and was a distinguished professor emeritus at Iowa State University, died on July 27, 2007, at the age of 85 in his home in Palm Desert, California. He is survived by his wife of 57 years, Mary (Elanor Mary Williams); his son Stuart (b. 1954) and daughter-in-law Sarah Bremner; his daughter Carol (b. 1956) and son-in-law Mike Einsidler; and two grandchildren. He was buried at Iowa State University Cemetery.

Jack was born to Archie and Sarah Bremner on January 18, 1922, in Dumbarton, Scotland, a shipbuilding and whiskey-distilling town on the banks of the River Clyde. He was the youngest in a family of five boys and one girl. His father was a decorated veteran of World War I, during which he served the British Army in France and Belgium.

Jack received his primary and secondary education at Dumbarton Academy, one of the world’s oldest schools. He went on to get his advanced degrees from the University of Glasgow, which was founded in 1451. Jack had a remarkable memory and was an excellent athlete. His older brother Alex persuaded him to pursue an honors degree in chemistry, which he did, graduating in 1944 with a BSc degree in pure science and first class honors in chemistry. Jack received his DSc degree from the University of London in 1959.

Jack received many scholarships and awards, including the MacKay-Smith Award for the Most Distinguished Graduate in the Faculty of Science. As might be expected, he had numerous top job offers, but fate intervened and he was recruited by Sir William Ogg to the Rothamsted Experimental Station in Harpenden, England, which is the oldest and most famous agricultural experiment station in the world. Jack accepted the invitation and in 1945 began a program of research to characterize the organic substances in soil that contribute to soil fertility. He read all the material on organic matter in soils, taking advantage of the extensive science library at Rothamsted. He realized that little was known of the chemical nature of organic matter in soil, the main reason being that there



John Bremner

By Denis R. Keeney

were no good analytical techniques available. This fostered his career-long interest in improving methods of analysis, including the newly developed techniques of paper and gas chromatography, which is perhaps his best-known legacy.

Jack thrived at Rothamsted, soaking in the science and international culture. Rothamsted was affiliated with the University of London, and Jack got to know many young scientists from the Commonwealth who came to the station to do research toward advanced degrees. He met his future wife, Mary, while competing on the Rothamsted tennis and



Rothamsted group and dates. Jack Bremner is second from right in back row.

field hockey teams. Mary gave valuable assistance to Jack in the two-dimensional paper chromatography analysis of amino acids in soil hydrolysates. They married in 1950 and moved into a house on the lovely grounds of the Rothamsted Manor, where their two children were born.

Jack's Rothamsted work identified the alphaamino acids in 6N HCl hydrolysates using the Van Slyke ninhydrin-carbon dioxide method. This showed that 30 to 40 percent of the nitrogen in soils occurred as proteins or other combined forms of amino acids, and that another 5 to 10 percent of the nitrogen was in the form of the amino

sugars glucosamine and galactosamine. He also determined that a significant amount of nitrogen in mineral soils was trapped in the lattices of clay minerals. Jack had to develop new methods to determine all of these compounds.

By 1954 he was something of a celebrity, and by invitation, he toured universities in Europe, including Jack received his primary and secondary education at Dumbarton Academy, one of the world's oldest schools. He went on to get his advanced degrees from the University of Glasgow, which was founded in 1451. Jack had a remarkable memory and was an excellent athlete. His older brother Alex persuaded him to pursue an honors degree in chemistry, which he did, graduating in 1944 with a BSc degree in pure science and first class honors in chemistry. Jack received his DSc degree from the University of London in 1959. the laboratory of Professor Wolfgang Flaig at Braunschweig, West Germany. He continued his pursuit of reliable techniques for study of organic matter in

soils, expanding the Kjeldahl method to include soil nitrate, in collaboration with Ken Shaw. This helped to identify the role of organic matter in soil denitrification and led to the basis of our current understanding of this process. He and Shaw also developed microdiffusion methods to determine the amount of ammonium and nitrate in soil extracts, and Jack developed methods for organic and inorganic carbon.

By 1954, Jack had been promoted to principal scientific officer. In 1957 he received a Rockefeller Foundation Fellowship, enabling him to spend a year in the United States visiting research laboratories. His family sailed to the United States aboard the Queen Mary, a ship he had seen launched on the River Clyde in 1936. He spent five months at Iowa State University in Ames and four months at the University of Illinois, as well as short visits to many other campuses. Jack so impressed the faculty at Iowa State that Dr. W. H. Pierre, head of the Department of Agronomy, offered him a tenured position on his staff. At first Jack did not seriously consider the offer, but on returning to England in 1958, Jack and Mary had a change of heart and accepted it.



Rothamstead lab.

Iowa State University

When Jack arrived at Iowa State University in 1959, the Agronomy Department was undergoing a renaissance that included a fairly new building (built in 1952) and several new faculty members. The department had a mass spectrometer that had been purchased recently for stable isotope research, including N-15. But there were virtually no sensitive and specific methods for determination and isotope ratio analysis of the different forms of nitrogen available. Once again, Jack applied his innovative skills. By 1965, methods for the determination and isotope ratio analysis of soil total nitrogen, exchangeable ammonium nitrogen, clay-fixed ammonium nitrogen, nitrate nitrogen, nitrate nitrogen, urea nitrogen, amino acid nitrogen, hexosamine nitrogen, and mineralizable nitrogen were published. Authors included D. R. Keeney, Art Edwards, Jim Silva, H. H. Cheng,

and Darrell Nelson. These methods were also included in the first edition of the American Society of Agronomy Monograph series, *Methods of Soil Analysis*, which was an instant best seller. The second edition was published in 1982, and Jack was also a contributor to the third edition in 1996.

In 1964, Jack was invited to install a mass spectrometer at the Institute for Application of Nuclear Energy in Vienna and to train the staff in its use. During this trip the U.S. Embassy in Belgrade discovered that the Bremner family could not return to the United States because they had stayed in a communist country while registered as U.S. alien residents. It took the intervention of the Iowa State University president and an Iowa Senator, but they eventually got back. They initiated the application process for citizenship of the United States immediately. In 1968, they gained U. S. citizenship and received a Guggenheim Foundation Fellowship and faculty improvement leave to travel in Japan and Australia and to work at the CSIRO Division of Plant Industry in Brisbane. This included return via Europe, completing a round-the-world trip, and it was their last trip with Stuart and Carol. Other memorable visits include the 10th International Congress of Soil Sciences in Russia in 1972 and a conference in the Vatican City on the role of organic matter in soil fertility. This conference was organized by the Pontifical Academy of Sciences and included an audience with the Pope.



Jack was a member of more than twenty scientific and honorary societies, a founding member of the British Society of Soil Science, and the first researcher on the chemistry and biochemistry of soils to be elected to the National Academy of Sciences (in 1984.) He authored or coauthored more than three hundred scientific publications, including thirty chapters in scientific monographs. His first publication was in *Nature* in 1946 on metal-organic matter complexes in soil, and his last publication was a review on nitrous oxide sources in soils in *Nutrient Cycling in Agroecosystems* in 1997. Several of Jack's papers were "Citation Classics" and he was one of the most frequently cited scientists for more than twenty years.

When he retired in 1992, a symposium titled "Contributions to soil nitrogen and soil organic matter research" was held at the American Society of Agronomy and Soil Science Society of America (ASA-SSSA) annual meeting in Minneapolis. A memorial symposium, "History of Nitrogen Research: The Bremner Factor," was held at the 2008 ASA-SSSA annual meeting in Houston.

After retirement, Jack continued to work at Iowa State University, completing manuscripts, reviewing journal articles, and reviewing proposals for federal agencies. Jack and Mary moved to California to be nearer to their children and grandchildren. Mary now resides in a rest home in San Diego, California, near her daughter Carol.

Personal reflections

To know Jack was to love him: the twinkle in his eye, his dry Scottish humor, his dedication to science, but not at the sacrifice of his family, and sometimes his naiveté about things worldly. I was Jack's second graduate student, and I worked with him closely from 1961 until 1966. I regard myself as lucky in the extreme to have had him as a professional and personal colleague.

What made Jack such a great scientist? His love of life, his attention to detail, and his ever-inquisitive mind, as well as his love of family, and a wide range of interests all factored into his success. Jack had a way of getting along with students and postdocs while still getting the best from them. He, like many soil scientists of his era, worked on the basics in an emerging field that had to be understood before soil biochemistry could advance to the level it has now reached. As Champ Tanner once said at a University of Wisconsin soils faculty meeting, "all the eccentrics are gone." Today's students and young faculty would do well to study Jack Bremner, what he stood for, and his work ethic. His legacy will be etched in the annals of nitrogen research forever.

I was one of several students and postdocs to develop appropriate methods and adapt them to mass spectrometer analysis. For this endeavor, Jack was the perfect major professor (sometimes taskmaster). He would work at home in the mornings and have office hours in the afternoon. He would look over results from yesterday's work and have marching orders for the next day's experiments. Methodology research, believe me, is not as fun as investigative research, but someone's got to do it. On the side, we did our true PhD thesis research.

My love of Jack comes from my association with him as a student, postdoc, professional colleague, and friend. One had to work with Jack to appreciate his devotion to the science and his attention to minutia in research while gathering data and writing. Sometimes a paragraph for a scientific publication would take days, with hours spent sweating out each sentence. Since everything was typed and had to be retyped again and again, secretaries would be driven to distraction. Research was much the same. Jack often thought by drawing up empty tables and having us provide the values through research.

It was a great way to think through a researchable question, although innovation often required slipping in extra work on the sly. He had a wonderful way of looking through you as you tried to explain a particular bit of research, asking just the right question, with a twinkle in his eye, which destroyed your hypothesis based on a week's work.

Larry

This paper requires a lot of guesswork about details. Note that they got nitrite accumulation even when ammonium level was NOT very high - nitrite accumulation seemed to be a pH story rather than a pH plus ammonium level story. They don't tell us much about the soils used or about methods (acid extraction for nitrite?). Do you share my view that experiments with one soil are now likely to be more fruitful than expts with a wide range of soils? All we are trying to do is to determine the factors affecting nitrite accumulation and see what promotes chemodenitrification (N deficit) and loss as NO_2 . Keep reading papers on nitrite accumulation and try to get background of previous findings so that we can decide on possibilities of a good story.

(CEC)

If texture is important, could study effect of adding sand to soil that accumulates nitrite. Have you read paper by Hauck in J. Agr. Food. Chem.

CaCO_3

pH

CEC (texture) ✓

Ammonium level ✓ Nitrate level ✓ *Keep simple*

Microbial population X

Water level ✓ → 40 60 80 ? of water

Temperature *Determine WHC*

NO_2

Could also add nitrite and see how fast it disappears under various conditions (pH, ammonium level, etc.)

What did James Hedlin find re nitrite accumulation?

Jack's editing style.

Mary was a full partner with Jack in his writing, speeches, and daily events. She ran his life and the household, planned everything from dinners to visiting the Pope, and she kept track of the kids and the dog and cat. Even when he was traveling, she called each morning to wake him up. Jack's parties were something to behold, especially when he got together with the University of Wisconsin's Gordon Chesters, another great British soil scientist and bragging rights competitor. I am sure many of their stories were greatly embellished. Jack and Mary loved hot toddies, golf, tennis, and especially their many friends worldwide. Their home life was warm and wonderful. Mary made great tea and English biscuits, and she was a fabulous cook. We cherished our times there, as I am sure others do also.

A dinner party at the Bremner's was something to savor, exquisite food and abundant scotch (my first hot toddy), and lively conversation. Inevitably the joke telling began. Jack had his favorite (often repeated) kilt jokes and toward the end of the evening he was calling for jokes by number, and of course we collapsed in laughter, especially at #12.

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was calling for jokes by number, and of course we collapsed in laughter, especially at #12. It was quite an education for an Iowa farm boy. Jack had a tendency to stutter (much like King James), a speech defect he acquired sometime in early life. He was also a chain smoker and came from a family of smokers. Sometimes he would have two cigarettes going in the ashtray and then light a third. Eventually the whole contents of an ashtray would explode, and we would have to run for a glass of water to put out the mini bonfire. When he finally quit smoking, which was a huge effort, his



Jack and Mary Bremner.

stuttering disappeared. He often wrote out the offending word when we were talking, and his organized talks usually were given via a tape recorder with Mary's voice. When he spoke at the Vatican conference, he wore an earpiece and spoke flawlessly from Mary's

recorded talk.

A side benefit for me was traveling with Jack to the grind-them-out small committee meetings around the country, and sometimes to Muscle Shoals, where we reported on research at the Tennessee Valley Authority laboratory (TVA) conferences. TVA was a strong financial supporter of the work and had excellent mass spectrometer facilities. TVA had gotten into the nitrogen fertilizer research and outreach area because the last large ammonium nitrate production facility for manufacture of explosives during World War II was there. Since nitrogen fertilizer production is very energy intensive, the plant used excess hydroelectric power from the series of Tennessee River dams. The war ended before the bomb making plant could be completed, and it was converted to a nitrogen fertilizer production facility. These meetings allowed me to intermingle with the best of the business, especially Dr. Roland Hauck, and to watch Jack work his charm and knowledge. At these and other meetings, I often represented Jack when he was travelling overseas.

There are of course hundreds if not thousands of times I have left out or forgotten. All of his students and postdoctoral students have stories that are as good as or better than any I could remember. He left the field of soil biochemistry far richer, and we will forever hold him in our debt, even if now at the Agronomy Department in Ames his name brings little or no recognition.

Epilogue

A little ditty Jack loved to recite when the parties gathered steam.

He did this without a stutter.

Glenlivet it has castles three,

Drumin, Blairfindy and Deskie,

And also one distillery,

Guid cheerio the nou Jack!

APPENDIX A

Below are four letters requested by a close colleague and special friend of Jack's, Ed Clapp, University of Minnesota, for the 2008 memorial symposium.

October 3, 2008

In Honor of Dr. Jack M. Bremner

I first met with Jack Bremner in the early 70s at an International meeting in Germany and continued to meet him over many years either at Conferences or Workshops or when he was a visiting scientist at one institution or another.

I first became acquainted with his scientific work some years earlier when I was studying for my PhD on the chemistry and structure of humic substances. This work quickly brought me into contact with his groundbreaking studies on the extraction and composition of soil organic matter that he carried out at Rothamsted Experimental Station. Subsequently, our scientific paths crossed again and again as I not only continued to work on soil organic matter but also on the forms and amounts of nitrogen and sulphur in soil and the cycling of these elements through soil organic matter.

The fundamental studies that Jack carried out in these areas, particularly the development of well founded and reliable analytical techniques, have made an enormous contribution to soil science and were pivotal to the rapid progress that was made in the succeeding decades. His work was always underpinned by a strong adherence to scientific principles and the rigorous application of good basic science. It is this characteristic which made his work so influential and of lasting value.

He leaves a towering legacy of achievement as a scientist that will serve as testament and memorial to him and et: sure that his many contributions will be recognised and remembered for many years to come. Even so, the lasting memory for those of us who knew him will be for his personality and humanity. His kindness, his wit, his intelligence, his encouragement and sound advice are the things that we will remember. In this context it is important to recognise the role and influence of his wife Mary. Jack and Mary worked as a team and travelled the world together. My fondest recollections are of convivial meals in restaurants around the world, after a long day in the lecture halls, with Jack and Mary holding court and Jack recounting some of his vast collection humorous stories. I may be wrong but it seemed to me that the words flowed more freely from him on these occasions.

At one conference I attended, Jack strode to the podium and announced in his usual faltering way that if he gave the paper it would take all day and he promptly switched on a portable tape

recorder and put it in front of the microphone. The recording was of Mary reading the paper and Jack's role was to change the slides. It turned out to be a first class presentation and exactly on time! A perfect example of team work. However, Jack did have to answer the questions.

Although we never worked together, I counted him as a friend and mentor and he supported me on several occasions throughout my career. For that I am very grateful but I am even more grateful for the lasting contributions that he made to soil science.

Roger Swift
President, International Union of Soil Science

September 29, 2008

In Honor of Dr. Jack M. Bremner:

Jack was a brilliant applied scientist. He took great pride in the precision and accuracy of his experimental results. Two of his innovations helped me. One was to extract soil organic matter using sodium salts and the other to break bonds between soil particles and organic matter by sonifying soil in water only. Jack was a modest man with a great sense of humour. At Rothamsted, he always started his talk with a joke. It was usually about a canny Scot and a mug Englishman!

Jack had a slight tendency to stammer. He overcame this brilliantly by having an overhead projector to hand so that he could write the offending word out. He was also an excellent sportsman by far and away the best tennis player at the lab, until Jim Quirk arrived. Jack was also blessed with a charming and understanding wife.

Best wishes,

Bill Emerson
Retired CSIRO Adelaide, Australia

October 2, 2008

In Honor of Dr. Jack M. Bremner:

It is indeed an honor for me to prepare a letter in honor of one of the giants of Soil Science, our friend and colleague, Dr. J. M. Bremner. He had an outgoing personality and was always willing to help others.

Jack was well-known for his monumental achievements in /Soil Chemistry/Soil Biochemistry/. His basic research in these areas had practical significance for soil management and for the use of agricultural chemicals for maximizing crop yields while at the same time protecting the environment. A particularly strong point of his career was the development of analytical methods for determining the different forms of soil nitrogen: methods which have been used in research laboratories world-wide.

I admired Jack not only for his scientific achievements but also for his tenacity in solving a long-time problem he had with oral expression. When I first met Jack, I had difficulty communicating with him because of his speech impediment. Over the years he overcame this problem, or at least partially so, but only after persistence and hard work. Jack never let this handicap detract him from interacting with others, and, in fact, he was often the center of attention during scientific discussions.

Whereas Jack was a perfectionist in the development of scientific methods, he was somewhat less than perfect behind the wheel of an automobile. As time went on, I soon found out why his good wife Mary always did the driving. On one occasion, while at the University of Illinois, Jack insisted on getting behind the wheel (undoubtedly under Mary's objection) for a social function at our home. I had given him detailed road instructions and he was successful in finding his way over.

When it came to return, I could see that Jack was puzzled as to which direction to go. I took him to his car and pointed out the way-- straight ahead for three blocks to a deadend, left turn to a second deadend (another three blocks), right turn and he would be in familiar territory.

I stood at the side-walk to see if Jack made the proper first turn, and guess what, he turned the wrong way (right instead of left). It took some time for him to get his bearings and even longer to find his way home.

For obvious reasons, Jack was late getting to the lab the next day.
Respectfully submitted,

Frank Stevenson
Professor Emeritus, University of Illinois

Jack Bremner

By Johnny Johnson

July 10, 2012

Rothamsted Experimental Station (retired)

Jack joined a somewhat “war-weary” Rothamsted Experimental Station in 1945 where effort throughout the war was concentrated on special investigations and advisory work in connection with food production. With the end of the war in sight and relaxation of the requirement for young people for war service, all the Departments at Rothamsted were ready to recruit staff to resume or start more fundamental research on crop production. Two new graduates joined the Chemistry Department, Jack was given responsibility for “soil organic matter,” and his life-long friend Peter Arnold had responsibility for “basic calcium-phosphate equilibria.”

The Rothamsted that Jack joined, with its increasing numbers of young people, was something of a marriage bureau. In Soil Microbiology Department on the floor above Chemistry was the young, vivacious Eleanor M. Williams (always known as Mary) and it was not long before Mary and Jack were married, setting up their first home in one of the flats created in the buildings attached to the Rothamsted Manor House and starting a long and supportive life together. Harpenden at this time was in many ways still affected by war time shortages and restrictions. Consequently, the social life of the staff was centered on the facilities that were available at Rothamsted for tennis, hockey, football and cricket, there was also the Dramatic Society and the annual Christmas Party to which all contributed. Buoyed by hope for a better future, the new members of the “Rothamsted family” lived by the ethic hard work and hard play and Mary and Jack were one of the most well-liked couples, generous with their time to help and encourage others to enjoy the benefits of working at Rothamsted.

In 1957, Jack was awarded a Rockefeller Foundation Fellowship tenable at Iowa State College and at the University of Illinois, and Mary and Jack set out to spend a year in America. Returning to fulfill his agreement with the Director that he would come back to Rothamsted for at least one year, both Mary and Jack had been impressed with what they had seen in America. For me a lasting memory when chatting one day was Jack commenting that in the quite stillness of a warm summer evening it was possible to sit and hear the corn growing, something that was never going to happen in Harpenden! Appreciating that the opportunities for a family were most probably better in America, Jack resigned from Rothamsted in August 1959.

Other comments received by Dr Clapp for the symposium:

Jack inspired those around him to admire his "uncompromising commitment to a clarity of thought few can achieve."

Charles A. Black described Bremner as "the soil man's Bureau of Standards."

Another colleague (unknown) wrote, "His research contributions in soil nitrogen and sulfur chemistry, the nature of soil organic matter, and development of analytical methods are legendary."

APPENDIX B**Graduate Students and postdocs of Jack Bremner (Compiled by M. Ali Tabatabai)**

James Anthony Silva, PhD 1964. Determination of fixed ammonium in soils.

Dennis Raymond Keeney, PhD 1965. Identification and estimation of readily mineralizable nitrogen in soils.

Darrell Wayne Nelson, PhD 1967. Chemical transformation of nitrite in soils.

Lyle Angus Douglas, PhD 1971. Inhibition of urease activity in soils.

Donald Allen Genrich, PhD 1972. Isolation and characterization of sand, silt, and clay, sized fractions in soils.

Larry Gene Bundy, PhD 1973. Control of nitrogen transformations in soils.

Wayne Lee Banwart, PhD 1975. Volatilization of sulfur from soils and animal manures.

Manuel Ibarbia Zantua, PhD 1976. Urease activity in soils.

Richard Lesley Mulvaney, MS 1977. Retardation of urea hydrolysis in soils.

Alfred Merrill Blackmer, PhD 1977. Emission and sorption of nitrous oxide by soils.

Larry Joseph Cihacek, PhD 1979. Sorption of sulfur dioxide and hydrogen sulfide by soils.

Charlene Steele Mulvaney, MS 1979. Sorption of nitrogen dioxide by soils.

Susan Gatter Robins, MS 1981. Diurnal and seasonal variability in emission of nitrous oxide from soil.

Dean Allen Martens, MS 1983. Effectiveness of phosphoroamides for retardation of urea hydrolysis in soils.

Gary A. Breintenbeck, PhD 1984. Emission of nitrous oxide from soils fertilized with anhydrous ammonia.

Polly Jo Gross, MS 1984. Evaluation of the acetylene blockage method of measuring denitrification in soils.

Clesio Gianello, PhD 1985. Chemical methods of assessing potentially available organic nitrogen in soils.

Gregory William McCarty, MS 1985. Inhibition of nitrification in soils.

Hornng-Shyang Chai, PhD 1986. Effects of phosphoroamides on transformations of urea nitrogen in soil.

Jane Catherine Yeomans, PhD 1986. Effects of urease inhibitors, nitrification inhibitors and pesticides on denitrification in soil.

Dean Allen Martens, PhD 1987. Effect of pesticides on transformations of urea nitrogen in soil.
Michael J. Krogmeier, MS 1988. Effects of organic acids on seed germination and seedling growth in soil
Gregory William McCarty PhD 1989. Evaluation of soil urease and nitrification inhibitors.

Post-doctoral Scientists

H. H. Cheng 1962	D. A. Genrich 1972	Jia Wang 1982
Dennis Keeney 1966	B. B. Singh 1975	Gary A. Breitenbeck 1985
Darrell Nelson 1968	Y. M. Chae 1978	Jane C. Yeomans 1986
M. A. Tabatabai 1969	Diane Stott 1982	Dean Martens 1987

SELECTED BIBLIOGRAPHY

- 1946 With S. G. Heintze, P. J. G. Mann, and H. Lees. Metalloorganic complexes in soil. *Nature* 158:770.
- 1949 Studies on soil organic matter. I. The chemical nature of soil organic nitrogen. *J. Agr. Sci.* 39:183–193.
- With H. Lees. Studies on soil organic matter. II. The extraction of organic matter from soil by neutral reagents. *J. Agr. Sci.* 39:274–279.
- Studies on soil organic matter. III. The extraction of organic carbon and nitrogen from soil. *J. Agr. Sci.* 39:280–282.
- 1950 Some observations on the oxidation of soil organic matter in the presence of alkali. *J. Soil Sci.* 1:198–204.
- Amino acids in soil. *Nature* 165:367.
- The amino-acid composition of the protein material in soil. *Biochem. J.* 47:538–542.
- 1951 A review of recent work on soil organic matter. I. *J. Soil Sci.* 2:67–82.
- 1952 The nature of soil-nitrogen complexes. *J. Sci. Food Agr.* 3:497–500.
- 1954 A review of recent work on soil organic matter. I. *J. Soil Sci.* 5:214–232.
- With K. Shaw. Studies on the estimation and decomposition of amino sugars in soil. *J. Agr. Sci.* 44:152–159.
- 1955 Recent work on soil organic matter at Rothamsted. *Zeitschrift für Pflanzenernährung, Düngung, Bodenkunde* 69:32–38.
- Studies on soil humic acids. I. The chemical nature of humic nitrogen. *J. Agr. Sci.* 46:247–256.
- With K. Shaw. Determination of ammonia and nitrate in soil. *J. Agr. Sci.* 46:320–328.
- With W. Flaig and E. Kuster. Zur Kenntnis der Huminsäuren. IX. Mitteilung. Der Gehalt an Aminosäuren in Steptomyceten-Huminsäuren. *Zeitschrift für Pflanzenernährung, Düngung, Bodenkunde.* 71:58–63.
- Nitrogen distribution and amino-acid composition of fractions of a humic acid from a chernozem soil. (Hildesheimer Schwarzerde). *Zeitschrift für Pflanzenernährung, Düngung, Bodenkunde.* 71:63–66.
- With K. Shaw. Reduction of nitrate by ferrous hydroxide under various conditions of alkalinity. *Analyst* 80:626–627.

- 1956 Some soil organic-matter problems. *Soils and Fertilizers* 19:115-123.
- Alkaline decomposition of p-hydroxy-o-amino acids. *Biochim. Biophys. Acta* 20:579-581.
- 1957 Studies on soil humic acids. II. Observations on the estimation of free amino groups. Reactions of humic acid and lignin preparations with nitrous acid. *J. Agr. Sci.* 48:352-360.
- With K. Shaw. The mineralization of some nitrogenous materials in soil. *J. Sci. Food Agr.* 8:341-347.
- 1958 With K. Shaw. Denitrification in soil. I. Methods of investigation. *J. Agr. Sci.* 51:22-39.
- With K. Shaw. Denitrification in soil. II. Factors affecting denitrification. *J. Agr. Sci.* 51:40-52.
- Amino sugars in soil. *J. Sci. Food Agr.* 9:528-532.
- 1959 Determination of fixed ammonium in soil. *J. Agr. Sci.* 52:147-160.
- 1960 Determination of nitrogen in soil by the Kjeldahl method. *J. Agr. Sci.* 55:11-33.
- With D. S. Jenkinson. Determination of organic carbon in soil. I. Oxidation by dichromate of organic matter in soil and plant materials. *J. Soil Sci.* 11:394-402.
- With D. S. Jenkinson. Determination of organic carbon in soil. II. Effect of carbonized materials. *J. Soil Sci.* 11:403-408.

- 1964 With L. R. Frederick. Laboratory evaluation of new nitrogen fertilizers. *Proceedings of Nitrogen Research Symposium, Tennessee Valley Authority, Wilson Dam*. pp. 58–63.
- With S. A. Waring. Some problems in the development of incubation techniques for the estimation of nitrogen availability in soils. *Australian Plant Nutrition Conference 1964*, Section B(d), pp. 10–11. Melbourne: CSIRO.
- With S. A. Waring. A rapid method for the estimation of nitrogen availability in soils. *Australian Plant Nutrition Conference 1964*, Section B(d), pp. 11–12. Melbourne: CSIRO.
- With F. Fuhr. Untersuchungen Zur Fixierung des Nitrit-Stickstoffs durch die organische Masse des Bodens. *Landw. Forsch.* 18:43–51.
- With R. D. Hauck. The methodology of N¹⁵ research. *Proceedings of Nitrogen Research Symposium, Tennessee Valley Authority, Wilson Dam*. pp. 97–110.
- With D. R. Keeney. Effect of cultivation on the nitrogen distribution in soils. *Proc. Soil Sci. Soc. Am.* 28:653–656.
- With S. A. Waring. Ammonium production in soil under waterlogged conditions as an index of nitrogen availability. *Nature* 201:951–952.
- With H. H. Cheng and A. P. Edwards. Variations of nitrogen-15 abundance in soils. *Science* 146:1574–1575.

- 1965 With D. R. Keeney. Steam distillation methods for determination of ammonium, nitrate, and nitrite. *Anal. Chim. Acta* 32:485–495.
- Total nitrogen. In *Methods of Soil Analysis*, edited by C. A. Black Part 2, pp. 1149–1178. Madison: American Society of Agronomy.
- Inorganic forms of nitrogen. In *Methods of Soil Analysis*, edited by C. A. Black, Part 2, pp. 1179–1237. Madison: American Society of Agronomy.
- Organic forms of nitrogen. In *Methods of Soil Analysis*, edited by C. A. Black, Part 2, pp. 1238–1255. Madison: American Society of Agronomy.
- Nitrogen availability indexes. In *Methods of Soil Analysis*, edited by C. A. Black, Part 2, pp. 1324–1345. Madison: American Society of Agronomy.
- Organic nitrogen in soils. In *Soil Nitrogen*, edited by W. V. Bartholomew and F. E. Clark, pp. 93–149. Madison: American Society of Agronomy.
- With A. P. Edwards. Determination and isotope-ratio analysis of different forms of nitrogen in soils. 1. Apparatus and procedure for distillation and determination of ammonium. *Proc. Soil Sci. Soc. Am.* 29:504–507.
- 1966 With H. H. Cheng and A. P. Edwards. Assumptions and errors in N-15 tracer research. In *The Use of Isotopes In Soil Organic Matter Studies (Report of FAOIAEA Technical Meeting, Brunswick-Volkenrode, 1963)*, pp. 429–445. New York: Pergamon Press.
- With H. H. Cheng. Determination and isotope-ratio analysis of different forms of nitrogen in soils. 2. A simplified procedure for isotope-ratio analysis of soil nitrogen. *Proc. Soil Sci. Soc. Am.* 30:450–453.
- With D. R. Keeney. Determination and isotope-ratio analysis of different forms of nitrogen in soils. 3. Exchangeable ammonium, nitrate, and nitrite by extraction-distillation methods. *Proc. Soil Sci. Soc. Am.* 30:577–582.
- With D. W. Nelson. An evaluation of Mogilevkina's method of estimating fixed ammonium in soils. *Proc. Soil Sci. Soc. Am.* 30:409–411.
- With D. R. Keeney. Characterization of mineralizable nitrogen in soils. *Proc. Soil Sci. Soc. Am.* 30:714–719.
- With J. A. Silva. Determination and isotope-ratio analysis of different forms of nitrogen in soils. 5. Fixed ammonium. *Proc. Soil Sci. Soc. Am.* 30:587–594.

- 1967 Nitrogenous compounds. In *Soil Biochemistry*, edited by A. D. McLaren and G. H. Peterson, pp. 19-66. New York: Marcel Dekker.
- With A. P. Edwards. Microaggregate formation in soils. *J. Soil Sci.* 18:64-73.
- With D. R. Keeney. A simple steam distillation method of estimating Betahydroxy-alpha-amino acids. *Anal. Biochem.* 18:274-285.
- With D. R. Keeney. Use of the Coleman Model 29A Analyzer for total nitrogen analysis of soils. *Soil Sci.* 104:358-363.
- 1968 The nitrogenous constituents of soil organic matter and their role in soil fertility. In *Organic Matter and Soil Fertility*, pp. 143-158. Vatican City: Pontifical Academy of Sciences.
- 1969 With R. D. Hauck. Significance of the nitrification reaction in nitrogen balances. In *Biology and Ecology of Nitrogen*, pp. 31-39. Washington, DC: National Academy of Sciences.
- With M. A. Tabatabai. Use of p-nitrophenyl phosphate for assay of soil phosphatase activity. *Soil Biol. Biochem.* 1:301-307.
- 1970 With H. A. Tabatabai. Comparison of some methods for determination of total sulfur in soils. *Proc. Soil Sci. Soc. Am.* 34:417-420.
- With D. W. Nelson. Role of soil minerals and metallic cations in nitrite decomposition and chemo denitrification in soils. *Soil Biol. Biochem.* 2:1-8.
- With L. A. Douglas. Colorimetric determination of microgram quantities of urea. *Anal. Letters* 3:79-87.
- With D. W. Nelson. Gaseous products of nitrite decomposition in soils. *Soil Biol. Biochem.* 2:203-215.

- 1971 With L. A. Douglas. Decomposition of urea phosphate in soils. *Proc. Soil Sci. Soc. Am.* 35:575-578.
- With L. A. Douglas. A rapid method of evaluating different compounds as inhibitors of urease activity in soils. *Soil Biol. Biochem.* 3:309-315.
- With L. A. Douglas. Use of plastic films for aeration in soil incubation experiments. *Soil Biol. Biochem.* 3:289-296.
- With L. A. Douglas. Inhibition of urease activity in soils. *Soil Biol. Biochem.* 3:297-307.
- With M. A. Tabatabai. Michaelis constants of soil enzymes. *Soil Biol. Biochem.* 3:317-324.
- 1972 With M. A. Tabatabai. Sulphur in Iowa soils. *Sulphur Inst. J.* 8:10-13.
- With M. A. Tabatabai. Assay of urease activity in soils. *Soil Biol. Biochem.* 4:479-487.
- With R. D. Hauck, et al. Use of variations in natural nitrogen isotope abundance for environmental studies: a questionable approach. *Science* 177:453-454.
- With M. A. Tabatabai. Forms of sulfur, and carbon, nitrogen, and sulfur relationships in Iowa soils. *Soil Sci.* 114:380-386.
- 1973 With M. A. Tabatabai. Nitrogen-15 enrichment of soils and soil-derived nitrate. *J. Environ. Qual.* 2:363-365.
- With L. G. Bundy. Inhibition of nitrification in soils. *Proc. Soil Sci. Soc. Am.* 37:396-398.
- 1974 With W. L. Banwart. Gas chromatographic identification of sulfur gases in soil atmospheres. *Soil Biol. Biochem.* 6:113-115.
- With R. D. Hauck. Perspectives in soil and fertilizer nitrogen research. *Trans. 10th Internat. Cong. Soil Sci., Moscow* 9:13-29.
- 1975 With M. I. Zantua. Comparison of methods of assaying urease activity in soils. *Soil Biol. Biochem.* 7:291-295.
- With M. I. Zantua. Enzyme activity in soils at subzero temperatures. *Soil Biol. Biochem.* 7:383-387.
- With W. L. Banwart. Identification of sulfur gases evolved from animal manures. *J. Environ. Qual.* 4:363-366.

- 1976 With W. L. Banwart. Volatilization of sulfur from unamended and sulfate-treated soils. *Soil Biol. Biochem.* 8:19–22.
- With L. G. Bundy. Effects of potassium azide on transformations of urea nitrogen in soils. *Soil Biol. Biochem.* 8:131–133.
- With R. D. Hauck. Use of tracers for soil and fertilizer nitrogen research. *Adv. Agron.* 28:219–266.
- With M. I. Zantua. Production and persistence of urease activity in soils. *Soil Biol. Biochem.* 8:369–374.
- With A. M. Blackmer. Potential of soil as a sink for atmospheric nitrous oxide. *Geophys. Res. Letters* 3:739–742.
- 1977 With A. M. Blackmer. Nitrogen isotope discrimination in denitrification of nitrate in soils. *Soil Biol. Biochem.* 9:73–77.
- With A. M. Blackmer. Gas chromatographic analysis of soil atmospheres. *Soil Sci. Soc. Am. J.* 41:908–912.
- With M. I. Zantua and L. C. Dumenil. Relationships between soil urease activity and other soil properties. *Soil Sci. Soc. Am. J.* 41:350–352.
- Role of organic matter in volatilization of sulfur and nitrogen from soils. In *Proceedings of International Symposium on Soil Organic Matter Studies, Braunschweig, September 1976*, Vol. II, pp. 229–240. Vienna: International Atomic Energy Agency.

- 1978 With A. M. Blackmer. The nitrogen fertilizer-ozone connection. In *Proceedings of the 30th Annual Fertilizer and AG Chemical Dealers Conference, Des Moines*, EC 1270. Ames: Iowa State University.
- With A. M. Blackmer. Nitrous oxide: Emission from soils during nitrification of fertilizer nitrogen. *Science* 199:295–296.
- Use of nitrogen-tracer techniques for research on nitrogen fixation. In *Biological Nitrogen Fixation in Farming Systems of the Tropics*, edited by A. Ayanaba and P. J. Dart, pp. 335–352. New York: Wiley & Sons.
- Effects of soil processes on the atmospheric concentration of nitrous oxide. In *Nitrogen in the Environment*, edited by D. R. Nielsen and J. G. McDonald, Vol. 1, pp. 477–491. New York: Academic Press.
- With R. L. Mulvaney. Use of p-benzoquinone and hydroquinone for retardation of urea hydrolysis in soils. *Soil Biol. Biochem.* 10:297–302.
- With R. L. Mulvaney. Urease activity. In *Soil Enzymes* (R. G. Burns, ed.) pp. 149–196. New York: Academic Press.
- With C. G. Steele. Role of microorganisms in the atmospheric sulfur cycle. In *Advances in Microbial Ecology*, Vol. 2, pp. 155–201. New York: Plenum Press.
- 1980 With G. A. Breitenbeck and A. M. Blackmer. Effects of different nitrogen fertilizers on emission of nitrous oxide from soil. *Geophys. Res. Lett.* 7:85–88.
- With A. M. Blackmer. Mechanisms of nitrous oxide production in soils. In *Biochemistry of Ancient and Modern Environments*, edited by P.A. Trudinger, M.R. Walter, and R.J. Ralph, pp. 279–291. Canberra: Australian Academy of Science.
- With A. M. Blackmer and S. A. Waring. Formation of nitrous oxide and dinitrogen by chemical decomposition of hydroxylamine in soils. *Soil Biol. Biochem.* 12:263–269.
- With A. M. Blackmer. Natural and fertilizer-induced emissions of nitrous oxide from soils. In *Biogenic Emissions of Sulfur, Hydrocarbons, and Nitrogen Gases into the Atmosphere*, pp. 1–12. APCA Special Publication. Pittsburgh: Air Pollution Control Association.
- With R. D. Hauck. Advances in methodology for research on nitrogen transformations in soils. In *Nitrogen in Agricultural Soils*, edited by F. J. Stevenson, p. 467. Madison, WI: American Society of Agronomy.

- 1982 Nitrogen—Urea. In *Methods of Soil Analysis* (second edition), edited by A. L. Page, Part 2, pp. 699–709. Madison: American Society of Agronomy.
- With C. S. Mulvaney. Nitrogen—Total. In *Methods of Soil Analysis* (second edition), edited by A. L. Page et al., Part 2, pp. 595–624. Madison: American Society of Agronomy.
- With A. M. Blackmer. Composition of soil atmospheres. In *Methods of Soil Analysis* (second edition), edited by A. L. Page et al., Part 2, pp. 873–901. Madison: American Society of Agronomy.
- 1984 With D. A. Martens. Effectiveness of phosphoroamides for retardation of urea hydrolysis in soils. *Soil Sci. Soc. Am. J.* 48:302–305.
- With D. A. Martens. Urea hydrolysis in soil: Factors influencing the effectiveness of phenylphosphorodiamidate as a retardant. *Soil Biol. Biochem.* 16:481–489.
- 1985 Method of inhibiting nitrification of ammonium nitrogen. U.S. Patent No. 4,552,581.
- 1986 With C. Gianello. Comparison of chemical methods of assessing potentially available organic nitrogen in soil. *Commun. Soil Sci. Plant Anal.* 17:215–236.
- With G. W. McCarty, J. C. Yeomans, and H. S. Chai. Effects of phosphoroamides on nitrification, denitrification, and mineralization of organic nitrogen in soil. *Commun. Soil Sci. Plant Anal.* 17:369–384.
- With G. A. Breitenbeck. Effects of various nitrogen fertilizers on emission of nitrous oxide from soils. *Biol. Fert. Soils* 2:195–199.
- Inhibition of nitrogen transformations in soil. *Trans. Fourth International Symposium on Microbial Ecology, Ljubljana, Yugoslavia*, pp. 337–342.
- With G. W. McCarty. *Inhibition of nitrification in soil. Trans. 13th Cong. Internat. Soc. Soil Sci., Hamburg, Germany, Vol. 2*, pp. 251–252.
- 1988 With J. C. Yeomans. Advances in nitrogen methodology: Laboratory techniques for determination of different forms of nitrogen. In *Advances in Nitrogen Cycling in Agricultural Ecosystems 77*, edited by R. Wilson, pp. 399–414. Wallingford, UK: C.A.B. International.
- With L. J. Cihacek. Capacity of soils for sorption of sulfur dioxide. *Commun. Sol Sci. Plant Anal.* 19:1945–1964.
- With G. W. McCarty. Effects of terpenoids on nitrification in soil. *Soil Sci. Soc. Am. J.* 52:1630–1633

- 1989 With J. C. Yeomans. Effects of organic solvents on denitrification in soil. *Biol. Fert. Soils* 7:336–340.
- With Y. K. Joo and N. E. Christians. Effectiveness of urease inhibitors and cationic materials for reduction of ammonia volatilization from turfgrass treated with urea. In *Proc. 6th International Turfgrass Research Conference, Tokyo*, chapter 30, pp. 209–211.
- With M. J. Krogmeier. Effects of nitrification inhibitors on germination of various seeds in soil. *Biol. Fert. Soils* 8:369–372.
- With M. J. Krogmeier and G. W. McCarty. Phytotoxicity of foliar-applied urea. *Proc. Natl. Acad. Sci. U.S.A.* 86:8189–8191.
- With G. W. McCarty. Inhibition of nitrification in soil by heterocyclic nitrogen compounds. *Biol. Fert. Soils*. 8:204–211.
- 1991 With G. W. McCarty. Inhibition of nitrification in soil by gaseous hydrocarbons. *Biol. Fert. Soils*. 11:231–234.
- With G. W. McCarty. Production of urease by microbial activity in soils under aerobic and anaerobic conditions. *Biol. Fert. Soil*. 11:228–230.
- 1992 With J. C. Yeomans and G. W. McCarty. Denitrification capacity and denitrification potential of subsurface soils. *Commun. Soil Sci. Plant Anal.* 23:919–927.
- 1993 With G. W. McCarty. Factors affecting the availability of organic carbon for denitrification of nitrate in subsoils. *Biol. Fert. Soils*. 15:132–136.
- 1995 Recent research on problems in the use of urea as a nitrogen fertilizer. *Fert. Res.* 42:321–329.
- 1996 Nitrogen—Total. In *Methods of Soil Analysis, Part 3, Chemical Methods* (third edition), pp. 1035–1122. SSSA Book Ser. 5. Madison: Soil Science Society of America and American Society of Agronomy.
- 1997 Sources of nitrous oxide in soils. *Nutrient Cycling in Agroecosystems* 49:7–16.

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