



David H. Baker

1939–2009

BIOGRAPHICAL

Memoirs

A Biographical Memoir by

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NATIONAL ACADEMY OF SCIENCES

DAVID HIRAM BAKER

February 26, 1939–December 2, 2009

Elected to the NAS, 2005

David Baker was a powerful driver of improved understanding of nutrition, both the underlying biochemistry and the practical application. He took a decidedly comparative approach to nutrition, combining study of several non-ruminant animal species with a strong interest in human nutrition. He was remarkably disciplined and meticulous in his experiments, and extraordinarily productive. His colleagues across the globe recognized his scholarly contributions with an impressive array of awards, including election to the National Academy of Sciences in 2005.

Dave received his bachelor's, master's, and Ph.D. degrees from the University of Illinois and spent almost his entire career as an Illinois faculty member. But he was much more than a scientist. He was a family man, a friend, a mentor, a counselor, a father figure to many, and a man of God.

He died at peace after a battle with pancreatic cancer on December 2, 2009 at the age of 70.



DHBaker

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David Hiram Baker was born in the prairie village of Waterman, Illinois, on February 26, 1939, the son of Vernon and Lucille Baker. The rural background in which he grew up instilled values that were evident throughout his life, including integrity and self-discipline. He enrolled in 1957 at the University of Illinois at Champaign-Urbana, which was to be his professional home throughout most of his life. He received B.S., M.S. and Ph.D. degrees from Illinois, spent two years as a senior scientist with the Eli Lilly pharmaceutical company in Indianapolis, then returned to join the Illinois faculty for the remainder of his stellar career. His contributions to the advancement of science and to the people around him were immense.

The researcher

Dave made difficult tasks look easy, and that talent allowed him to be highly productive, publishing 510 peer-reviewed papers. He relied heavily on his encyclopedic knowledge of the scientific literature and of metabolic pathways. Bob Easter, one of his early Ph.D. students and later president of the University of Illinois, wrote:

Dr. Baker took justifiable pride in his skill as a writer...a skill that he attributed in significant part to an inspirational elementary teacher. Desk space was in short supply when I arrived here as a graduate student and that first semester my desk was in Dave's office. I could only marvel at the great efficiency with which he wrote...always with a Number 2 pencil on yellow legal pads...page upon page almost never pausing to use an eraser.

In the days before computers one could spend hours constructing the reference list for a manuscript...but not Dave. I watched him do it. He would write 'Literature Cited' at the top of the page then proceed to write each citation rarely pausing to look for a date, volume or page number. I once asked him how it did it and he just said, 'I just remember the reference.' I don't think many of us fully appreciated the extent to which he had virtually a photographic memory and the great advantage that was to him.

Dave himself said, "I actually enjoy writing. For me, it's pleasure rather than work. When we have exciting research findings, I can hardly wait to put pen to paper" (Zagorski, 2006).

Dave studied questions that were keys to both the advancement of the science of nutrition and the practical application of that knowledge to improve animal production and human health. His findings contributed heavily to the updates of the National Research Council Nutrient Requirement Series—swine, poultry, and companion animals. He was a translational scientist, bridging the almost insuperable barrier between theoretical research and applied science, before that term became popular.

Dave's effectiveness as a researcher depended also on his remarkable ability to design and conduct experiments to address directly the questions at hand. He thought carefully about the experimental treatments required and designed experiments that appeared complicated, with many treatments, but were conceptually straightforward and elegant.

It was rare, indeed, for his results to be difficult to interpret. He considered in advance every potential source of error and took appropriate and painstaking steps to eliminate or minimize it. To him, every detail was critical.

Perhaps the most widely recognized segment of Dave's voluminous research is his work on amino acid nutrition. Within that field, his detailed efforts to develop and popularize "ideal amino-acid ratios" has arguably had the most impact of any research on the way food-producing livestock is raised in commercial practice.

In order to produce proteins that support body functions and growth or for export in milk or eggs, livestock must have supplies of the component amino acids in their tissues. Animals can synthesize some of these amino acids, but not others, so those others must be supplied in their diets. These are called indispensable amino acids. Other researchers had identified the indispensable amino acids (numbering 8 to 11, depending on species) before Dave's time, but the difficult work of estimating how much of each of these amino acids was needed for each animal species at each stage of growth and in various conditions was just beginning. There evolved the notion that the ratios of amino acids in the proteins produced are constant, so their quantitative requirements rise and fall together. Therefore, the problem could be simplified by estimating the requirements of a single reference amino acid for a specific situation and basing ratios of the others on that reference.

The challenge that Dave tackled was to estimate those ratios, generally called ideal amino acid ratios. Through painstaking research he did that for pigs (Chung and Baker, 1992) and chicks (Baker and Han, 1994) for several stages of growth. His ratios were more widely accepted than any others in the field, because practicing nutritionists in the commercial animal and feed industries recognized his broad understanding of the subject matter and his meticulous work. He also contributed to those ratios' wide acceptance through his direct communication with the industry. The latest pork chop, chicken breast, or slice of bacon most people in the world have consumed probably came from animals fed diets formulated on the basis of Dave's ideal amino acid ratios.

Early in his career Dave identified a need for well-defined diets that could be manipulated for use in his experiments, and that was impossible with existing technology, which relied on diets containing intact protein sources. Through an extensive series of meticulous experiments with young chicks he estimated the quantitative dietary requirement for each of the indispensable amino acids, which ultimately enabled him to formulate an efficacious chick diet based on crystalline amino acids devoid of intact protein (Velu, et

al., 1971). He later developed additional crystalline amino acid diets for pigs, rats, mice, dogs, and cats. This information has been used worldwide to formulate purified diets for use in a diverse array of biological experiments.

Biochemistry of the sulfur amino acids, namely methionine and cysteine, represented one of Dave's most prolific areas of research, with findings extending from agricultural species to humans. He was particularly fascinated with the bioefficacy of different chemical forms or precursors of these amino acids and their toxicity when fed to animals, manifested in the publication of more than 100 peer-reviewed articles and book chapters he wrote on the topic. He worked with every known precursor and analog of the sulfur amino acids in pigs and chickens and produced some of the first evidence regarding their efficacy and safety when fed to animals. One of his most heavily cited references, compiled as part of the International Council of Amino Acid Science (ICAAS) 5th Amino Acid Assessment Workshop, captures the breadth of interest Dave showed in sulfur amino acid toxicity (Baker, 2006).

Dave was intrigued with the beautiful complexity of nutrients involved with intermediary or so-called "1-carbon" metabolism, and he would spend significant time sketching pathways and pondering the profound implications of sulfur amino acid biochemistry. Considering he was trained by Dr. D. E. Becker, a superb swine nutritionist who helped to pioneer amino acid chemistry himself, Dave came by this fascination naturally, but it was his uncanny ability to design and interpret precision growth assays that allowed him to unravel complex metabolic pathways before the advent of modern analytical techniques. Toward this end, he established the proportion of the total dietary sulfur amino acid requirement that could be met using cysteine, which has proved to be a critical finding now taken for granted by swine and poultry nutritionists around the globe.

Dave's investigation of metabolic interactions of sulfur amino acids with vitamins and minerals also led him to the discovery of a wealth of fundamental nutrition concepts. Proving that excess methionine elicits vitamin B6 deficiency, that S-methylmethionine could spare the need for choline in chicks, or that administering L-cysteine exacerbates the noxious effects of pentavalent organic arsenic toxicity were all concepts advanced by Dave's research. Always keeping current with the literature, Dave had an astounding ability to assimilate findings published from myriad research perspectives in order to elucidate nutrient interactions with broad implications for animals and humans.

In concept, the task of the practicing animal nutritionist is to use feed ingredients in appropriate combinations to meet the nutrient requirements of livestock. Although this

sounds simple, it requires quantitative knowledge of both the amount of each nutrient required by the animal and the contribution of each nutrient by each ingredient. As noted above, Dave made key gains in the science of estimating nutrient requirements, but he also refined the estimates of the quantitative nutrient contributions of ingredients. It is often simple enough to measure nutrient concentrations in feed ingredients, but not all of each nutrient is bioavailable—that is, usable—by the animal. Dave optimized the slope-ratio method for estimating the amount of bioavailable nutrients in ingredients (Burns and Baker, 1976), and he used that method more extensively and more productively than anyone before him.

Given his emphasis on amino acid nutrition, it is not surprising that he estimated amino acid bioavailability in a variety of feedstuffs, including heat-damaged materials (Lowry, et al., 1990). However, he also measured bioavailability of minerals and of vitamins. His original research demonstrating that the bioavailability of zinc from zinc sulfate varies widely depending on the background diet (Wedekind, et al., 1992) is of special note, and speaks to unexpected complications that often arise in nutrition. In addition, he determined, to the surprise of many, that a common form of copper used in human nutrition supplements provided no copper value at all (Aoyagi and Baker, 1993).

Growth of an animal fed a diet limited in indispensable amino acids will improve only if the diet is supplemented with the most-severely-deficient amino acid; addition of any other amino acid will provide no benefit. If two amino acids are equally deficient, both must be added to produce a benefit. Dave demonstrated late in his career that a similar relationship does not hold for minerals and vitamins. He found benefits from adding a vitamin or mineral, even though another nutrient was equally deficient (Baker, et al., 1999).

Dave not only produced new information, he also promoted its use in practice. He gave more than 300 talks, often to feed-industry groups, about how to use this new knowledge in feeding animals. His consulting work with key companies has also ensured that his research results are used in practice, and used correctly.

Some nutritional scientists spend their lifetimes working on one pathway or a single or small group of nutrients. David published important papers on numerous nutrients—amino acids, minerals, and vitamins—each requiring the development of an extensive knowledge base and unique, carefully designed experimental studies. His accomplishments in nutritional science may be unparalleled.

The towering figure

Dave's contributions to the advancement of science were far broader than just his productive research program. He served on the editorial boards of six different scientific journals, on the Board of Directors of the Federation of American Societies of Experimental Biology, and on the International Council of Amino Acid Science. Especially noteworthy are his contributions to the work of the National Research Council (NRC) of the National Academy of Sciences. He was a member of four expert panels that produced four NRC Reports commissioned by the Board on Agriculture relating to nutrient bioavailability and the nutrient requirements of swine and felines, and a fifth that addressed dietary reference intakes by humans. Dave served on the NRC Board of Agriculture and Natural Resources from 1998 through 2000, during which period the Board commissioned a total of 15 reports covering timely scientific issues ranging from nutrient requirements of animals to food safety, genetically modified crops, the role of agriculture in education of children, and funding for agricultural research.

Dave's contributions were recognized by a remarkable series of awards including six from the American Society of Animal Science, five from the Poultry Science Association, and three from the American Society for Nutrition. Each of these organizations made him a Fellow. He was named a University Scholar by the University of Illinois, and he received the USDA Distinguished Service Award in Research and the Frontiers in Animal Nutrition Award from the Federation of Animal Science Societies. In 2005 David Baker was elected to the National Academy of Sciences.

The teacher and mentor

Dave taught nutrition to undergraduate Animal Sciences students at Illinois for many years, and often to veterinary students. As a teacher he was clear and organized, and he expected much the same from his students. He was exceptional at simplifying complicated information and teaching it so students could easily understand the material being presented. One of his favorite words for teaching was "inculcation," or teaching by repetition. He strongly believed that a good teacher should be able to emphasize and get across the most important points or aspects of the information being taught, then repeatedly emphasize these points throughout the rest of the class period.

His teaching style was not high tech. He generally taught classes using an overhead projector containing a roll of transparency film. As he lectured, he would write the material on the film with a marker and then roll the film forward to fill the screen. He actually owned a projector that he rolled to class each day. Using this method, he never

had to turn his back to the class, which he believed kept his lectures more informal and prevented him from going too fast and trying to cover too much material. Undergrads liked his teaching style, and Dave was repeatedly rated as one of the best teachers they had ever had.

However, Dave may have been even more effective in teaching graduate students, to whom he offered courses in protein and amino acid nutrition, minerals, and the classical nutrition literature. One of his favorite graduate courses was “Concepts in Nonruminant Nutrition.” It covered a broad range of important topics in nutrition, with particular emphasis on the fundamentals and most important concepts in these areas. These fundamentals were things Dave believed to be very important that may not have been covered or emphasized in other classes the students would have taken.

The course also emphasized vocabulary and history. Dave was an excellent writer, and he believed that students should have a good command of vocabulary, which was particularly important in writing research papers involving nutrition research. He always began the course by giving the students a list of vocabulary words and definitions to memorize. These included words such as plethora, ephemeral, mellifluous, exacerbate, ameliorate, and of course, inculcate. He gave a quiz every week, and most quizzes would involve a question or two from the vocabulary list. Dave also was a great believer in his students’ knowing and appreciating the importance of history in nutrition. For example, the first topic in the course was the classical debate between two renowned University of Illinois faculty members, H. H. Mitchell and W. C. Rose, on the topic “Does the Amount of Food Consumed Influence the Growth of an Animal,” which was a series of three articles published in *Science* in 1927 and 1928.

Weekly lab meetings gave Dave a further opportunity for teaching research philosophy, experimental design, the conduct of experiments, metabolic pathways, basic concepts in nutrition, current literature, application of nutritional knowledge to animals and people, and other topics. He required all of his graduate students who conducted chick and pig experiments to prepare reports when their experiments were finished. The students would then present their reports at the weekly lab meetings, and the group would discuss the interpretation of the results of the experiments, how the experimental design/treatments could have been improved, and how the next experiment, if warranted, should be conducted and designed.

Once a student's experiment was completed, Dave expected the progress report to be completed FAST! He was always eager to see the results. These weekly lab meetings were a tremendous teaching asset not only for the graduate students but also for other faculty who attended. After he retired, some of his colleagues asked him to join monthly meetings focused on non-ruminant nutrition research so their students could be exposed to the mind of David Baker.

Probably the highest testimony to Dave as a graduate teacher/mentor is the great number of students—57—who earned a Master's or Ph.D. degree under his advisement. Thirty-seven of these were Ph.D.s. These students have gone on to highly successful careers, holding leadership positions in academia, industry, and the government. In recognition of his influence as a mentor to students, postdoctoral fellows, and young faculty, Dave became the second recipient of the Dannon Institute Mentorship Award from the American Society for Nutrition in 2003. Several of his former mentees commented on his impact on their professional and personal development, including the following examples:

Dr. Kevin Halpin, a former Ph.D. student, wrote:

Dr. Baker's mentoring went well beyond academic achievements, emphasizing issues such as ethics and integrity in research, the importance of my professional reputation, development of writing and presentation skills and the value of cooperation amongst my scientific peers.

Dr. Jack Odle, the William Neal Reynolds Professor of Nutritional Biochemistry at North Carolina State University, stated:

They say that imitation is the highest form of flattery. In this regard, let me [say] that it has been my desire to replicate the qualities possessed by this gifted man. I feel very privileged to have had my early perspectives of science shaped by such an outstanding mentor." He went on to conclude that "Dr. David H. Baker is a world-class educator that makes all around him better. He is indeed a mentor's mentor, and he is worthy of your highest accolade."

The man

Dave Baker was passionate about his research, his teaching and his students, but he was more than that. He was also passionate about his family and his faith. His wife, Norraine, was by his side for 26 years. Their children are Barbara Becker, Michael Baker, Susan Shunk, Deborah Ruh, Luann Voss, and Beth Limberg, and there are 16 grandchildren and 5 great-grandchildren. He is also survived by Norraine, his older brother Roger, and his sister Diana.

Dave's parents had introduced him and Roger to the joys and challenges of fishing. For 55 consecutive years the boys fished together in the Lake of the Woods, near Kenora, Ontario. They also frequently fished the Boundary Waters in Minnesota. Dave and Roger were meticulous and competitive fishermen, whether it came to the preparation of their equipment, the boat, setting up favorite spots on their GPS devices, or specific fishing plans for the day.

In the last decade and a half of Dave's life the yearly fishing trips included spouses and colleagues from the university. Often the group occupied several cabins. Usually groups would venture out two or three times daily. These were wonderful extended family events, often joined by children and grandchildren as well as Illinois friends. Abundant food and drink were available, along with joyous stories and laughter. Of course, bragging about the largest or most walleyes or Northern pike caught was continuously debated, as most fish caught, and all the large ones, were released back into the lake. Truth be told, Norraine and Roger's wife, Sue, often held their own against their spouses.

Dave liked to work with his hands and with tools and extended his home-repair skills beyond his own home to relatives and neighbors. On one occasion, one of this article's authors had just moved into his neighborhood, and one Saturday morning awoke hearing banging in his garage. Dave was there, installing shelves that he was sure would be needed (and were).

He enthusiastically followed Fighting Illini athletic teams, and served as a nutritional advisor to them. However, he was an even more passionate fan of the Chicago Cubs, and followed them from his "Cubs room" in the basement of his house.

A dramatic event occurred just a few days before Dave died. Many of his former students and a few others who considered him a mentor congregated on the Illinois campus, and others joined by phone. They included Bob Easter, later president of the University, and many leaders of the nutritional sciences community from both academia and industry.

Much of the event consisted of comments from each of the attendees, including descriptions of their career paths and their current responsibilities. These former students also talked of the experience of working closely with Dave. They talked of what they learned from him of science, hard work, faith, family, the complete life, and self-confidence. Scattered among the humorous anecdotes were emotional descriptions of Dave's counsel that substantially changed their lives for the better. It was a powerful experience for all who attended, and laid clear the power of this one man to change many lives.

Dave and Bob Easter talked after this event. Near the end of the conversation, Dave said: "We've had a good life at the University of Illinois." It was, indeed, a good life for David Baker, and for those he touched.

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