Man must go beyond all knowledge. What cherubs know sufficeth not: beyond their zone I fain would take my flight unto where nothing's known. Angelus Silesius, 1657

In Memory
Samuel J. Fomon, MD, 84, Professor Emeritus of the University of Iowa Department of Pediatrics, died December 18, 2007. He was born March 9, 1923 in Chicago, IL, the son of Drs. Samuel and Isabel (Sherman) Fomon. Sam graduated with honors in 1945 from Harvard College and received his medical degree from the University of Pennsylvania in 1947. Dr. Fomon was a resident in Pediatrics at the Children’s Hospital of Philadelphia and a research fellow at the Children’s Hospital Research Foundation in Cincinnati. He moved to the University of Iowa, College of Medicine in Iowa City in 1954 where he advanced from Assistant Professor to Professor in Pediatrics. He was the Director of the Infant Metabolic Unit from 1954 to 1993, which evolved into the Division of Nutrition, Department of Pediatrics in 1961. Fomon became the Director of the University of Iowa Graduate Program in Nutrition in 1980. In 1993, he became Professor Emeritus.

Infant Metabolic Unit
The Department of Pediatrics at the University of Iowa was organized in 1915 (1). In 1918 the Child Welfare Research Station was established at this location through state appropriations. By law, the research institute was devoted to the study of the normal child. The second Pediatric Chairman was Phillip C. Jeans, who had worked with William McKim Marriott at Washington University, St. Louis, from 1912-1924. Jeans further developed the infant metabolic studies begun under the Child Welfare Research Station. Babies typically stayed in his metabolic unit for 9–12 mo before adoption. The numerous publications from the unit reported on the nitrogen, calcium, and phosphorus balances of normal infants. Jeans recommended the fortification of milk with 400 IU of vitamin D in his edition of Marriott’s Infant Nutrition in 1947 (3). This recommended vitamin D fortification of milk persists today (Supplement S1).

Dr. Fomon was recruited to Iowa City by the third Chairman of Pediatrics, Charles D. May, in 1954. Sam had trained in renal physiology from 1950 to 1952 at the Cincinnati Children’s Hospital Research Foundation and was considered a “salt and water” investigator. Soon after his arrival, Dr. May requested that Sam assume responsibilities for the Metabolic Unit. Dr. Howard Meredith of the Child Welfare Research Station served as his mentor of anthropometrics and awakened his lifelong focus on nutritional needs for normal child growth. Meredith’s growth standards are known as the Iowa Growth Charts (1).

Fomon’s lifetime central hypothesis became that “growth during early infancy is the single most sensitive index of health and nutritional adequacy of the diet” (2). The quantitative definition of the external and internal dimensions of growth and the adequacy of the diet for normal growth were the primary objectives of his research in the Infant Metabolic Unit. The investigations in the unit came to involve a large number of infants living in the community and the scope included the investigations listed in Table 1. Studies in the Metabolic Unit have had national and international impacts on the policies developed by the Committee on Nutrition of the American Academy of Pediatrics and the WHO (Supplement S1). Manufacturers of infant formulas have been guided by his studies as a basis for formula modifications. Dr. Fomon wrote a report for the Academy of Pediatrics for the U.S. FDA in 1988 that became the present-day policy for infant formula selection and distributions in the Women, Infants and Children Feeding Program (Supplement S1).

Authorship
The physiological school of pediatrics was gradually transplanted to the English-speaking world, where authors such as Abraham Jacobi reported findings in Berlin, Breslau, and Vienna. The history of nutrition in American Pediatrics is traced from Jacobi through Emmett L. Holt and thence to John Howland, who had studied in Czerny’s clinic in Strasburg. One of Howland’s students was William M. Marriott, who dedicated the first edition of his book entitled Infant Nutrition published in 1930 to Howland. As previously mentioned, Jeans was coauthor of
the 4th edition of Marriott’s book (3). Howland described the first metabolic bed for infant balance studies reported in the American literature; all of Fomon’s books document his 1963 modifications of the infant balance study technique (4–6). With Jeans as the Chairman of Pediatrics in Iowa City, the metabolic balance study method created a centerpiece for infant nutrition research that continued under Fomon. The preceding balance studies by Jeans and growth studies by Meredith made Iowa City fertile soil for Fomon’s full development as scholar and investigator of infant nutrition and growth. He has 140 peer-reviewed publications listed online in PubMed.

The persistent need to integrate external nutrient balances with the dimensions of growth of internal body composition became Fomon’s central focus and most creative achievement (7). From 1966 until 2003, Sam proposed and refined the body composition of reference infants and concluded that one-half of the protein intake of infants goes to growth and 40% of energy intake is weight gained as fat (8). A statistically validated study of the Fomon reference infant and child appeared in 2002 from the ARS/USDA Children’s Nutrition Research Center that resulted in 20% decreased energy and 25% increased protein intake in the US and WHO feeding recommendations for children (9,10). The Fomon-inspired reference child growth-based factorial nutrition recommendations have modified the nutritional policies for all the world’s children.

Dr. Fomon authored several influential books, including *Infant Nutrition* [first edition in 1967 (4) and second edition in 1974 (5)] and *Nutrition of Normal Infants* in 1993 (6). The first edition was single authored and very similar to a syllabus of his week-long course on pediatric nutrition taught 81 times between 1968 and 2005 with 5693 attendees (1). The second edition included the subject of obesity and added micronutrient chapters by collaborating authors. In this edition, a chapter on nutritional status assessment appeared that described the physical examination used in nutritional surveys during the seventies (5). In the 3rd book, chapters on energy, human milk, and breastfeeding were introduced and chapters on obesity, failure to thrive, and nutritional status were deleted (6). These modifications reflected the explosion of new information on normal infant nutrition in this book.

### Leadership

Dr. Fomon was respected as a leader in nutritional sciences. Sam was an active member of the American Academy of Pediatrics’ influential Committee on Nutrition from 1958 to 1963 and chairman from 1960 to 1963. He was an active member of the American Society for Clinical Nutrition and its president from 1961 to 1982. He was a member of the American Institute of Nutrition (now ASN) and the president from 1989 to 1990. He served on NIH Child Health and Human development committees from 1966 to 1970 and was a member of the Nutrition Study section from 1978 to 1981. Dr. Fomon was a Consultant and Expert in Nutrition for DHEW from 1965 to 1981. He was the Director of the University of Iowa Graduate Program in Nutrition from 1980 to 1990 (Supplement S2).

### Honors

Dr. Fomon received many honors during his career, of which the following are noted. He received the Borden Award of the American Academy of Pediatrics in 1966. The McCollum Award was presented by the American Society for Clinical Nutrition in 1978. The Conrad A. Elvehjem Award was given to Dr. Fomon by the American Institute of Nutrition in 1990. The North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition presented him with the Shwachman Award in 1992 (Supplement S2).

### Industrial consultant

Manufacturers of infant formulas respected the nutritional expertise of Dr. Fomon. In addition to the published results reported from the Infant Metabolic Unit (Supplements S1, S2), he was a respected consultant on the continuing evolution of infant formulas as described in Chapter 3 of his 3rd book (6). His exchange with these important infant food industries is evidenced by his collaborators and former Fellows; Dr. Lloyd J. Filer Jr. joined the Iowa City group from Ross Laboratories in 1965; Dr. Thomas A. Anderson came from the H.J. Heinz Co. in 1970. His former Fellows Dr. George M. Owen became Medical Director of Bristol-Myers in 1965 and Dr. Ferdinand Haschke became Vice-President of Nestec, Ltd. and Chairman of the Nestle Nutrition Institute in 2005. Much of the work of the Infant Metabolic Unit was funded by grants from the infant food industry, a measure of their full confidence in Fomon’s research (Supplement S1).

### Enduring legacy

At his retirement in 1993 the Department of Pediatrics, University of Iowa Infant Metabolic Unit was named the Samuel J. Fomon Infant Nutrition Unit, which is continuing under direction of his former Fellow Ekhard E. Ziegler, MD. The Committee on Nutrition of the American Academy of Pediatrics has given a Nutrition Award since 1944 that recognizes outstanding achievement in research on infant and child nutrition. The annual award is funded by a grant from the International Formula Council. Dr. Fomon received this award in 2004 and it was renamed the American Academy of Pediatrics Samuel J. Fomon Award. The Children’s Nutrition Research Center (CNRC) at Baylor College of Medicine and Texas Children’s Hospital is one of the Human Nutrition Centers of the Agricultural Research Service of the USDA. Dr. Fomon was the center’s inspiration for its studies of nutritional needs for normal child growth and served as chairman of the center’s Council of Scientific Advisors from 1994 to 2002. His contributions to the center were recognized by naming its main conference room the Samuel J. Fomon Conference Room. The drawing that hangs in the CNRC Samuel J. Fomon Conference Room is reproduced as Figure 1.

### Enduring paradoxes

Dr. Fomon was fully aware of the historical evolution of infant feeding practices (8). One persistent paradox was the definition of normal infant growth and the well-documented difference between growth of young infants fed at the breast compared

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Dr. Fomon was fully aware of the historical evolution of infant feeding practices (8). One persistent paradox was the definition of normal infant growth and the well-documented difference between growth of young infants fed at the breast compared
with those fed formulas. He reported “growth of the breast-fed infant does not conform with the most commonly used reference data” (2). This led to his speculation that some “breastfed infants fail to meet their potential for growth because of marginal intakes” (8). The cited evidence is that the fat-free mass is larger in formula-fed infants. He questioned the desirability of using growth of breast-fed infants as a reference standard for infants fed formula (8). This is a persistent paradox for future investigations, but Fomon never argued that “bigger is better” (2). As investigators in the field of infant nutrition, we stand today on Sam’s massive scientific shoulders and continue the reach to understand the significance of the nutritional and functional differences between human milk and infant formula feedings and infant growth.

A more fundamental paradox was the lack of agreement between the metabolic balances of macronutrients and the actual retentions in growth of body composition. In 1966, he first constructed, from limited data, estimates of increases in body tissues of reference infants during growth (7). This model was then used to estimate the nutrient requirements for growth by the factorial method. Thus, growth of body composition became the index of nutritional adequacy. This conceptual advance was followed by Fomon’s 6 published updates of reference infant and child body compositions (1967–2007) that are discussed in a scientific eulogy by the title Samuel J. Fomon, MD - Champion of Growth (7). Fomon used the factor of growth in body nutrient composition to correct the estimates based upon balance retentions; are these factorial calculations adequate for estimating childhood food needs? It can be predicted that the Fomon reference infant and child body composition models will be refined by future advances in body composition measurement techniques, because his compartmental dissections of body composition growth are not congruent with individual cell and tissue chemical and functional maturations.

**Literature Cited**