

This Week's Citation Classic

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Beevers L & Hageman R H. Nitrate reduction in higher plants. *Annu. Rev. Plant Physiol.* **20**:495-522, 1969. [University Illinois, Urbana, IL]

The article provided a review of nitrate metabolism in higher plants. In addition to reviewing the properties of enzymes involved in nitrate and nitrite assimilation, the review discussed the factors regulating activity and level of the enzymes and the physiological consequences of an altered nitrate metabolism. [The SCi® indicates that this paper has been cited over 265 times since 1969.]

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"From 1961-1963 I had the good fortune to spend a two-year postdoctorate in the laboratory of R.H. Hageman at the University of Illinois. This was a stimulating experience both from the viewpoint of my introduction to nitrate reductase and plant biochemistry and to the contact with a dynamic group of graduate students and postdoctorates associated with the laboratory.

"Hageman's previous work had indicated that a reduced yield of grain in corn and nitrate accumulation could be associated with a decreased level of nitrate reductase. These relationships of field observations and physiological responses to a biochemical explanation have been key features to the research conducted in Hageman's lab. The research has been relevant.

"While I was in the department of horticulture at the University of Illinois I maintained a close association with Hageman's research group by instructing graduate students, serving on thesis committees, and attending seminars. Research was progressing rapidly in the area of nitrite metabolism. In 1960, with the group at Long Ashton, in England, Hageman had demonstrated the enzymatic conversion of nitrate to ammonia in the presence of the non-physiological electron donor reduced benzyl vologen.¹ This work stimulated a search for the endogenous reductant which was

characterized as ferredoxin providing support for the close association of photosynthesis and nitrite assimilation.

"In the 1960s it was recognized that nitrate availability influenced the tissue levels of nitrate reductase and it was suspected that the enzyme was substrate induced. This led to investigations of the molecular basis for the inductive process.

"The continued activities of several laboratories resulted in an accumulating literature on nitrate assimilation in the 1960s and it was appropriate, because of his pioneer role in many areas, that Hageman be asked to prepare an annual review of the rapidly developing subject. I was asked to join in the preparation because of my familiarity with some of the initial studies. After agreeing to prepare the review, Hageman and I departed on sabbatical leaves during which time the contents of the review gestated. The actual compilation of literature and writing were achieved in a flurried two months following our return.

"I consider that the frequency of citation is due to two reasons: a) the article provided a readable comprehensive review of the field which stressed the important interplay of physiological and biochemical studies and outlined the areas of deficiencies of our understanding of nitrate metabolisms; b) from 1969 to date, research in nitrate metabolism has been extremely active as indicated by the proliferation of publications. Biochemical research has been conducted on purification and characterization of the enzymes, the inductive process including involvement of nucleic acids, the role of substrate, reductant supply and light on nitrate assimilation, and the relationship of nitrogen metabolism to the physiological aspects of plant growth and grain yield. A similar proliferation of research on nitrate metabolism and its regulation in bacteria and fungi has also occurred. The review has provided a starting reference point for much of this ongoing research."

"[The reason that this article was a classic rests with Beevers. He has a photographic and encyclopedic mind, excellent scientific insight, organizational know-how, and an ability to write unambiguously." —R.H. Hageman]

REFERENCE

1. **Hageman R H, Cresswell C F & Hewitt E J.** Reduction of nitrate, nitrite and hydroxylamine to ammonia by enzymes extracted from higher plants. *Nature* **3193**:247-50. 1962