CC/NUMBER 1
JANUARY 5, 1981

This Week's Citation Classic

Antonovics J, Bradshaw A D & Turner R G. Heavy metal tolerance in plants.
Advctn. Ecol. Res. **7**:1-85, 1971.
[Dept. Biol., Univ. Stirling, Stirling, Scotland; Dept. Botany, Univ. Liverpool, Liverpool, England; and Sch. Plant Biol., Univ. Coll. North Wales, Bangor, Caernarvonshire, Wales]

This paper reviews the ecology, evolution, and physiology of plants capable of growing in situations of abnormally high heavy metal concentrations. [The *SCI*® indicates that this paper has been cited over 150 times since 1971.]

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November 4, 1980

"This review was first conceived when I was a graduate student at the University College of North Wales, Bangor, UK. During graduate school I had very little direct interest in the effects of metal ions on plants. Instead, my major interest lay in the study of evolution, particularly in how genetic differences could arise among closely adjacent populations connected by gene flow. Tony Bradshaw, my major professor, had been studying metal tolerance in populations of grasses growing across the boundaries of old metal mine dumps and normal uncontaminated pasture. Detailing the evolutionary processes occurring at these boundaries was therefore the major thrust of my thesis.

"At that time, as a result of several summers in Austria with relatives, I had a strong interest in learning German. I quickly discovered that much of the literature on metal tolerance was in this language. So chasing this literature provided me with both a challenge to keep up my German and an opportunity to get some general background to my research. There was also the challenge of some detective work, since many of the studies were in rather old, obscure journals.

"I did not want to bog down the introduction of my thesis with a review of these papers, since I felt metal effects *per se* were only tangential to the evolutionary questions I was addressing. I therefore decided to relegate the review to the appendix. I remember well Bradshaw rejecting my first ill-formed draft, and if it had not been for his encouraging remarks that I could do better, perhaps I would have abandoned the review altogether. It still nevertheless remained a low priority. The other coauthor, Roger Turner, was a fellow graduate student and housemate, but it was not till we had both left Wales that we thought to incorporate his work on the biochemical basis of tolerance into a larger, more general article.

"The review has been successful for two reasons. Firstly, metal tolerance has become a classical example of natural selection in plants. Secondly, the review came at a time when there was increasing concern about metal pollution (particularly from lead compounds in car exhaust) and revegetation of toxic mine wastes. Here, ready and waiting, was a review pertaining directly to these concerns. I have always enjoyed contrasting our review with that of the National Research Council report[1] on the effects of lead in the environment. Whereas the report concluded that there was very little evidence that lead could be toxic to plants in nature, our review provided overwhelming evidence of such harmful effects. One can but conclude that apparently outdated articles in obscure foreign journals still have a role to play in scientific understanding."

1. **National Research Council. Committee on Biological Effects of Atmospheric Pollutants.** *Lead: airborne lead in perspective.* Washington, DC: National Academy of Sciences, 1972. 330 p.