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Albersheim P, Jones T M & English P D. Biochemistry of the cell wall in relation to infective processes. *Annu. Rev. Phytopathol.* 7:171-94, 1969.
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This review summarized the evidence available that the complex carbohydrates of plant cell walls and the enzymes of microbes that attack plant cell walls represented the key to understanding host-pathogen interactions in plant microbial systems. [The *SCI*® indicates that this paper has been cited in over 125 publications.]

Cell Walls—The Battleground of Plant-Microbe Interactions

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We presented the hypothesis that the interaction between enzymes secreted by microbes and the complex carbohydrates of plants determines whether a particular plant-microbe interaction will result in a sick, infected plant or in a healthy, resistant plant. After all these years, the validity of the hypothesis remains to be determined.

Tom Jones and Pat English, two graduate students, and I wrote the review when we were in the Department of Chemistry (now the Department of Chemistry and Biochemistry) at the University of Colorado in Boulder. Jones finished his PhD shortly after the article was written and went on to Cornell University where, unfortunately, he succumbed two years later to cancer. English later left science to become a housewife and mother.

A new review our laboratory now has in press on the same subject[1] begins with the following quote from the 1969 article,

> Pathogens find themselves most commonly in the presence of plants other than their hosts. Under such circumstances, a pathogen fails in its efforts to initiate infection. What is it that renders a plant's environment inhospitable to a pathogen except in that rare instance when the plant happens to be susceptible to the host? It is this question that we propose to answer by our hypothesis that, in many instances of pathogenesis by bacterial fungi, it is an interaction between the pathogen and the carbohydrates of the host that determines the pathogen's ability to produce enzymes capable of degrading the host's cell walls.

In 1989, despite logarithmic advances in this science, our review opens with the same statement! We did not realize in 1969 how completely and intricately cell walls are involved in defense against pathogens, but we were on the right track.

We knew that the cell wall was structurally complex, but had only begun studies that would define how complicated the wall polysaccharides are. We recognized, too, the high degree of specificity of polysaccharide-cleaving enzymes. We realized that cell wall polysaccharides possess exact structures, something not readily accepted at the time, and that a correlation exists between the inability of pathogen mutants to secrete certain wall-polysaccharide-degrading enzymes and the lack of virulence of the pathogens.

We now know that oligosaccharide fragments of plant cell wall polysaccharides, fragments released by enzymes secreted by microbes, can elicit defense responses by regulating gene expression in plants. We had no idea about such things 20 years ago. In our present review we write,

> The battleground between plants and the microorganisms that attempt to invade them are the...structurally complex plant and microbial cell wall polysaccharides that provide physical barriers and contain within their structures molecules—elicitors—that...signal the plant to act defensively....

So much has been learned since our first review.

Regulatory oligosaccharides ("oligosaccharins"), the enzymes that release them, and the proteins that modulate their release are critical, we firmly believe, to the interactions between plants and microbes and are likely to be determinants of cultivar-specific host-pathogen combinations. So, the hypothesis remains to be answered, and I am confident it will be well before the next 20 years have passed.

1. Hahn M G, Bucheli P, Cervone F, Doares S H, O'Neill R A, Darvill A & Albersheim P. Roles of cell wall constituents in plant-pathogen interactions. (Nester E & Kosuge T, eds.) *Plant-microbe interactions. Volume 3.* New York: McGraw-Hill. (In press.)