Preface

Life and death decisions of plant cells!

This collection of reviews arises from the SEB Annual meeting held in Glasgow from 31 March - 4 April 2007 where a session was dedicated to ‘Programmed Cell Death in Plants and Fungi’. Examples of programmed cell death (PCD) in plants can be drawn from processes occurring throughout normal development starting with seed development through leaf remodelling, in some species, reproductive development, plant-plant interactions during reproduction, and organ or whole plant senescence. PCD can also be induced by a range of biotic and abiotic external factors and these same external stimuli can induce PCD in plant cell cultures which offer the advantage of a relatively uniform system free from developmental constraints. One key question yet to be resolved is whether we can find a common mechanism for PCD in these diverse systems or whether each system will turn out to have its own specific route to death. The reviews illustrate both the tremendous progress we have made in understanding PCD in plants, and also the many fundamental questions that remain to be answered.

A critical issue highlighted by Reape et al. is the importance of differentiating between the types of cell death occurring even within a relatively homogeneous population of cultured cells. Much has been said about the differences and similarities between cell death in animal and plant cells, with evidence in some systems pointing towards an autophagous type of mechanism while in others cytological features suggest the possibility of a mechanism more closely analogous to animal apoptosis. The timing of different markers of PCD is also crucial, and Reape et al. suggest that even within one PCD system different mechanisms may operate at different times.

Three reviews focus on different aspects of developmental PCD one vegetative and two reproductive: Gunawardena reviews the elegant lace plant model where waves of PCD result in the formation of an ordered arrangement of holes in the leaves, with parallels to endosperm development and perhaps also petal senescence. Petal senescence is the focus of the review by van Doorn and Woltering who offer us a comprehensive survey of research in this area. The emphasis of this review is on gene expression and protein function, regulation and signal transduction, leading ultimately to PCD in this organ. Bosch and Franklin-Tong describe recent exciting work on signalling during incompatible pollination, in Papaver where a complex signalling network is being uncovered. In both cases an involvement of the class of cysteine proteases known as caspases is implicated. A caspase cascade is a key feature of animal PCD and a question that has remained an intriguing puzzle in plant PCD is whether similar enzymes operate in plants as well. Bonneau et al. bring us up to date on the evidence for and against with some useful thoughts on how the animal and plant systems may have evolved. Crucially, the substrate or substrates for these enzyme activities remain an important piece of the puzzle yet to be put in place.

Cytochrome c release during PCD, is also a feature of animal PCD and has been reported in several plant PCD systems including the Papaver pollen system. Its importance is called into question, however, in the review by Mur et al. In this comprehensive review on PCD during the hypersensitive response, we discover that after a century of research on the hypersensitive response, we now have clues to many of the important signals regulating this process including calcium, reactive oxygen species (ROS), nitric oxide, salicylic acid, and now sphingolipids, but still lack a comprehensive molecular model.

Kingston-Smith et al. remind us that the agricultural importance of cell death does not stop at the point of harvest. Even after ingestion by livestock, plant cells attempt to regulate their fate, but in the rumen they are subjected to a barrage of death-inducing conditions including dark, anoxia, elevated temperatures, and microbial attack, any of which alone can induce PCD. Unravelling the cell responses in this complex system will provide a challenge for many years to come!

One of the key issues that has plagued this area of research has been the definition of the terms we use. Until we have a fuller understanding of the mechanisms involved, we will continue to have divergent views on the correct use of the terms PCD, apoptosis, and senescence. Clearly, there has been much progress in this field in the last 10 to 15 years and yet the precise molecular mechanisms elude us. Maybe a reason for the complexity that is being revealed lies in the sessile nature of plants and their fight with the onslaughts of a hostile environment which means they have to be resilient and adaptable unto death!

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