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INVITED REVIEW

Unifying perspectives of some mechanisms basic to desiccation tolerance across life forms

Patricia Berjak*

School of Biological and Conservation Sciences, University of KwaZulu-Natal, Durban, 4041 South Africa

Abstract

Desiccation-tolerant organisms, or life-cycle stages of particular taxa, occur among animals, higher and lower plants, terrestrial micro-algae, lichens and bacteria. Recent investigations have revealed that a number of mechanisms conferring desiccation tolerance appear to be common to the diversity of life forms able to survive extreme dehydration. In particular, parallel processes involving late embryogenic abundant (LEA) or LEA-like proteins, accumulation of sugars, aspects of active oxygen species (AOS) and non-enzymic and enzymic antioxidants have been the recent focus of attention, some across a diversity of organisms. The present contribution considers advances made from the study of these processes, particularly in enhancing current understanding of the composition of, and protection afforded by, the glassy state in desiccated organisms. Strong evidence that proteins, particularly LEAs, are implicated in glass formation is reviewed, and behaviour of such proteins upon dehydration is discussed in this context. The question of the ability of cells to survive complete water removal is considered in the context that it is unlikely, and that the basis of the deterioration of very dry seeds results from abstraction of water necessary to maintain the integrity of the intracellular glassy state. Finally, the revelation that desiccated seeds deteriorate with time, even under extremely good genebanking conditions, is discussed.

Keywords: active oxygen species, antioxidants, desiccation tolerance, intracellular glasses, LEA, localized reactivity, seed survival, sugars

*Correspondence
Email: berjak@ukzn.ac.za

Introduction

Desiccation tolerance, while a rare property of living organisms generally, is a remarkable survival mechanism that characterizes life-cycle stages of a surprising number of taxa. Although the phenomenon is presently recognized in species of only five phyla among animals, desiccation tolerance has been identified in one or more life-cycle stages in all the major plant taxa, and is a property *inter alia* found in bacteria, terrestrial micro-algae and lichens (Alpert, 2005). Emerging evidence is that there may be considerable commonality among the mechanisms facilitating desiccation tolerance across the spectrum of organisms that exhibit this trait, irrespective of their phylogeny. The present review seeks to extend the seed biologist's horizons beyond the realm of orthodox propagules of spermatophytes, by a consideration of the commonality of some of the characteristics of desiccation-tolerant resurrection plants, animals, lichens and micro-organisms. This is, however, not a wide-ranging review of all the features considered in the context of desiccation tolerance, but focuses particularly on the implication of proteins (generally late embryogenic abundant proteins, LEAs) with sugars in the intracellular glassy state; free radicals, particularly active oxygen species, and antioxidants; and the revelation that even under what are considered to be ideal conditions, stored seeds are not immortal. For an overview of life in the dry state, the reader is referred to Black and Pritchard (2002), and to papers emanating from a recent symposium, 'Drying without dying: The comparative mechanisms and evolution in animals, plants and microbes' published in the journal, *Integrative and Comparative Biology.*