Life without water: anhydrobiosis.

Jim Clegg, Bodega Marine Laboratory and Section on Molecular and Cellular Biology, University of California, Davis

Anhydrobiosis is the state of an organism when it shows no visible signs of life and when its metabolic activity is not measurable, or comes *reversibly* to a standstill, all due to dehydration. It has a long history, going back to 1702 when it was first described by Antony van Leeuwenhoek. A significant question concerns the mechanisms involved in achieving the anhydrobiotic state, as well as leaving it upon re-hydration, and I will summarize what we know about this topic. For example, there is evidence that non-reducing disaccharides, notably trehalose and sucrose, replace water as it is lost during dehydration, thereby preserving the hydration-dependent structure of things like membranes and macromolecules. These sugars can also vitrify, forming glasses at very low water contents, effectively embedding cellular structures in a fairly rigid matrix that minimizes damaging interactions. However……

In spite of the simple beauty of this general picture there is good evidence that anhydrobiosis can be achieved by some organisms in the absence of significant amounts of sugars of any kind, so the situation remains interesting. Also involved in dehydration tolerance are proteins belonging to the LEA (late embryogenesis abundant) category, first described in vascular plants, but similar proteins have recently been detected in several anhydrobiotic invertebrates. I will briefly describe these unusual proteins, and how they might function. The extent to which conventional heat shock (stress) proteins are involved in achieving the dried state is uncertain, although it seems likely that some of them are involved in damage-repair upon re-hydration.

Anhydrobiosis also tells us something fundamental about the basic nature of life – and about the roles played by cellular water. Organisms in anhydrobiosis lack the dynamic features that characterize living systems, a result of the lack of an ongoing metabolism and all that it generates. In that sense they are not Aliving,@ yet neither are they Adead@ since suitable re-hydration produces an obviously living organism. As a result, we may deduce that it is the *structural* organization of cells and organisms, rather than their dynamics, that represents the most fundamental feature of living systems and, importantly, that it is water that generates these dynamics.

Basic research in this area has resulted in recent practical applications, enhancing the stress resistance, including dehydration, of cultured mammalian cells, and I will describe that work. Finally, I note that anhydrobiotic cells provide useful models in which to study the properties of water in cells as a function of water content - but few (except me) have taken advantage of that.