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References

1. J. C. DeFries, J. Stevenson, J. J. Gillis, S. J. Wadsworth, *Reading Writing: An Interdisc. J.* **3**, 271 (1991); J. W. Gilger, B. F. Pennington, J. C. DeFries, *J. Am. Acad. Child Adolesc. Psychiatr.* **31**, 343 (1992); J. Stevenson, B. F. Pennington, J. W. Gilger, J. C. DeFries, J. J. Gillis, *J. Child Psychol. Psychiatr.* **34**, 1137 (1993).

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Amorphous Stability and Trehalose

The feature Frontiers in Materials Science (31 Mar., pp. 1918–1953) focusing on glasses and amorphous materials was informative. The News article by Karen Celia Fox, "Putting proteins under glass" (p. 1922), however, does not specify that the glassy state in Sea Monkeys or brine shrimps and many other such organisms is formed by a particular sugar, the simple disaccharide trehalose (α-D-glucopyranosyl α-D-glucopyranose) (*1*). Consistent with this observation, trehalose shows properties superior to those of other sugars in the stabilization of proteins and, in particular, during the long-term or high-temperature storage of dried formulations (*2*, *3*). For example, restriction enzymes dried in trehalose can be stored for months at 70°C with no detectable loss of activity (*3*). Finally, the efficacy of trehalose probably results from a combination of three properties, namely, the nature of glass formed (the glass transition temperature, T_g, for trehalose is 110°C), water replacement (greater flexibility because of the lack of direct hydrogen bonds between the two rings), and its chemical stability and inertness (*4*). The latter is a particularly important consideration in the use of glasses for stabilizing protein, as the poorly appreciated reactivity of reducing sugars with proteins, also known as the Maillard reaction, is accelerated both by the removal of water and at low water activities (*4*, *5*).

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References

1. M. J. Burke, in *Membranes, Metabolism and Dry Organisms*, A. C. Leopold, Ed. (Cornell Univ. Press, Ithaca, NY, 1985), pp. 358–363.
2. J. Crow *et al.*, *Biochem. J.* **242**, 1 (1987).
3. C. Colaco *et al.*, *Biotechnology* **10**, 1007 (1992).
4. C. Colaco *et al.*, in *Formulations and Delivery of Proteins and Peptides*, J. L. Cleland and R. Langer, Eds. (Symposia Series No. 567, American Chemical Society, Washington, DC, 1994), pp. 222–240.
5. P. A. Finot *et al.*, Eds., *The Maillard Reaction in Food Processing, Human Nutrition and Physiology* (Birkhauser, Basel, 1990).