CADMIUM-INDUCED NUCLEOLAR RINGS IN PHYSARUM POLYCEPHALUM

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Our laboratory has been studying cellular aspects of cadmium toxicity in the model system Physarum polycephalum, a single celled organism containing many naturally synchronous nuclei in a common cytoplasm. Exposure of the organism to cadmium ion elicits a continuum of ultrastructural damage in the nucleus, depending on concentration of Cd^{++} and duration of exposure. Figure 1a shows the ultrastructure of a control cell with microchannels, intracellular vacuoles, and mitochondria with characteristic fibrous bodies. Each nucleus contains a centrally located, nearly spherical, uniformly dense nucleolus. 3.5 hr after a 30 min exposure to 5×10^{-4}M Cd^{++} is initiated at the beginning of DNA synthesis (early S), extranuclear ultrastructure appears to be normal; however, subtle nucleolar lesions occur--nucleoli are eccentrically located, and approximately 8% of the nuclei contain multiple nucleolar bodies (Fig. 1b). When the Cd^{++} exposure is increased to 1.5×10^{-3}M for 4 hr, eccentricity becomes more pronounced; but the incidence of multiple nucleolar bodies does not increase. A more prominent lesion is seen--ring-shaped nucleoli (Fig. 1c). These structures appear in 70-90% of nuclei as electron dense rings of nucleolar material, enclosing less intensely staining central zones. The basic ring shape does not degrade further after a lethal 4 hr exposure to 10^{-2}M Cd^{++}, although the ring of nucleolar material appears to lose cohesiveness, projecting into the nucleoplasm (Fig. 1d).

Closer examination of ring nucleoli shows that nucleolar components are segregated into discrete groupings, similar in appearance to segregation induced by actinomycin D (Shinozuka, 1972). Furthermore, three dimensional reconstructions (wax models and drawings) made from 1 μm thick serial sections show that the "ring" is a sphere of nucleolar material completely surrounding the central zone, with no apparent continuity between the nucleoplasm and the central zone.

We conclude that ring nucleoli are an ultrastructural manifestation of cadmium toxicity. The absence of uranyl acetate staining in the central zone of ring nucleoli indicates an absence of RNA in this area. These observations suggest that cadmium interferes with synthesis, organization, or stability of nucleolar components.

Shinozuka, H., 1972. In: The Biochemistry of Disease, Farber, E. (ed.), M. Dekker, Inc., New York, Vol. 2, 73.

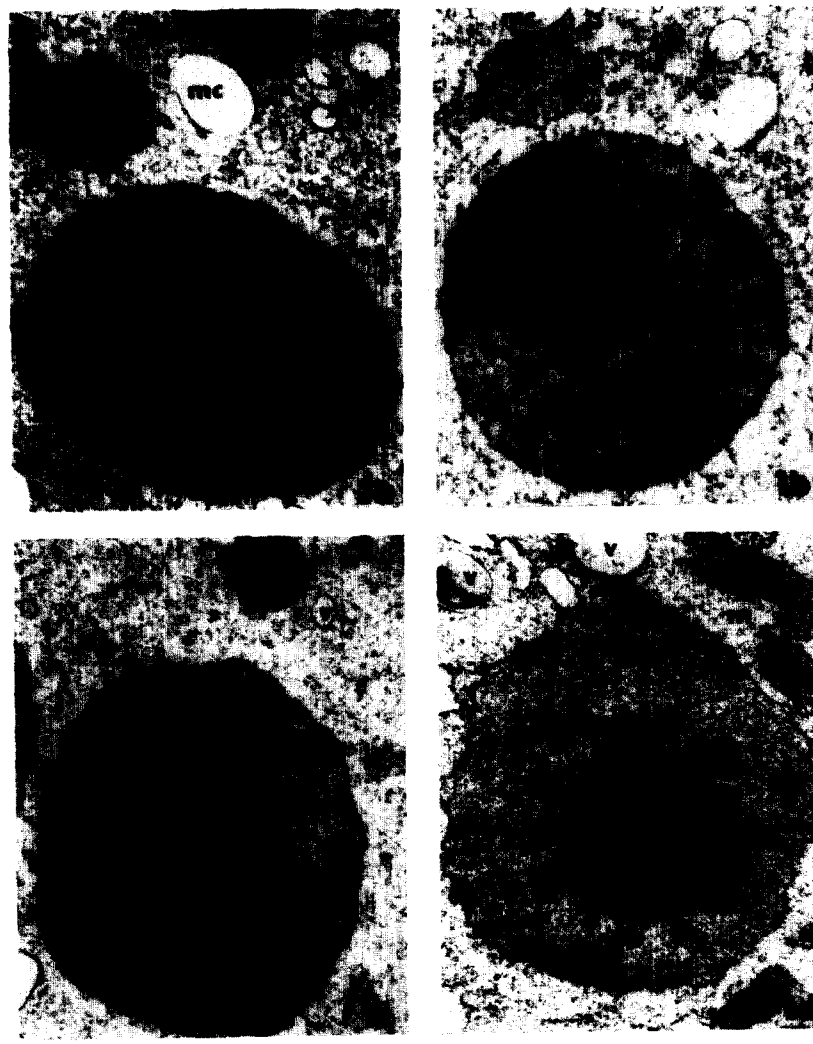

Figure 1: Electron micrographs of Physarum polycephalum after varied exposures to Cd^{++}: (a) no cadmium exposure; (b) 5 x 10^{-4}M for 30 min; (c) 1.5 x 10^{-3}M for 4 hr [note segregation of fibrillar (f) and granular (g) components]; (d) 10^{-2}M for 4 hr. microchannels (mc); vacuoles (v); mitochondria (m) with fibrous body (fb); nucleus (N); nucleolus (nu); central zone (cz). x15,000.