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BIOMINERALIZATION: AN INSOLUBLE OR A SOLUBILITY PROBLEM?

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Evidence from previous work has led to the assumption (probably correct) that the serum (and extracellular fluid) is supersaturated in relation to bone mineral for calcium and phosphate ions but not in relation to the nucleation of the first mineral deposit. There is, therefore a barrier to nucleation which must be overcome either by an increase in calcium and/or phosphate ions (homogeneous nucleation) or by some interaction whith matrix-molecules (heterogeneous nucleation). Several theories have been proposed to explain the exclusive deposition of mineral in hard tissues, and in the last twenty years the concept of matrix-vesicles mediated calcification has emerged.

Matrix-vesicles are membrane-bound bodies which are present in the extracellular space of calcifiable collagenous matrices (bone, dentine, cartilage). They derive from the cells of calcifying tissues and appear to be sites of initial calcium phosphate (biological apatite) nucleation. They appear in the matrices of hard tissues soon after deposition of collagen and soon acquire crystal-like inclusions which have been shown to contain calcium and phosphorus in a variety of specimens (Energy dispersive-X-ray-microanalysis). It seems therefore that matrix-vesicles are the initiators of mineralization. Recent work conducted by us at the London Hospital Medical College using electron opaque tracers (lanthanum nitrate) has shown that early bone matrix is in continuity with the rest of the extracellular space. This suggest that there is probably free access of certain materials to the early matrix. At this stage, the matrix contains numerous matrix-vesicles.

In later stages, when matrix-vesicles cease to appear, the matrix becomes compartmentalized (tracer fails penetrate). It is likely, therefore, that matrix-vesicles provide a microcompartment in which the necessary conditions for crystal nucleation may be reached.

Whether mineralization "spreads" from the vesicles to collagen remains a matter of great controversy. It is well established that collagen and/or associated molecules (phosphoprotein, for example) are capable of providing the three dimensional stereochemical geometry and electrical charge distribution required for apatite nucleation.

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