Formation and Organization of Biominerals in the Protein Ferritin and in the Radular Teeth of Chitons and Limpets

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Formation of mineral phases in biological systems is an ancient and widespread phenomenon that remains a distinctive feature of living organisms from mammals to microbes. Commonly, biominerals are formed in close association with an extended organic matrix containing organized arrays of acidic regions in proteins together with polysaccharides. The interactions of the organic and inorganic phases have attracted much current interest, stimulated in part by the search for biosignatures of life and in part by the search for fundamental principles underlying growth and morphologies of such a diverse range of inorganic phases. Several mechanisms have been proposed: biologically induced mineralization; biologically controlled mineralization; and facilitated assembly via emulsions and vesicles (Coord. Chem. Rev , 190-192, 1199-1215, 1999). The biosynthesis of biominerals will be illustrated using two exemplars: firstly, the ubiquitous protein ferritin that provides a constrained environment for the formation of the smallest biomineral known, a nanoscale particle of ferrihydrite ($5Fe_2O_3.9H_2O$) containing up to approx 4500 Fe atoms held within a hollow 7-8nm cavity created by protein macromolecules; secondly, the radular teeth of chitons and limpets, marine molluscs of wide distribution around the world. These teeth contain, variously, iron, calcium and silicon biominerals, synthesised within an organic matrix and organised in a complex microarchitecture. Recent results using vibrational spectroscopies (infrared and Raman) can map the distribution of the phases in these complex composite materials and delineate the sequence of synthesis of various phases. The role of the cellular environment around the emerging teeth will also be considered.