Genetic – cell biological – structural aspects of biomineralization: Sponge biosilica formation an exceptional model.

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Biomineralization processes are characterized by controlled deposition of inorganic polymers/minerals mediated by functional groups linked to organic templates. One metazoan taxon, the siliceous sponges (phylum Porifera: classes of Demospongiae and Hexactinellida), have utilized these principles and even gained the property to form these polymers/minerals by an enzymatic mechanism using the silicateins. Silicateins are the dominant protein species present in the axial filament,which is the enzyme as well as the template of biomineralization, of the skeletal elements of the siliceous sponges, the spicules. Silicateins also present as a major part of the organic components in the silica lamellae which are cylindrically arranged around the axial canal, and exists also as a 33 kDa precursor in the extra-spicular space. In the spicules, only the processed, functionally active enzymes with sizes of 24 to 30 kDa are found. cDNAs coding for these enzymes, which belong to the cathepsin family of proteases, have been cloned both from demosponges and deep-sea hexactinellids. The proteins which are biocatalytically active when expressed in a recombinant way have been attributed to bio-silica formation in nature that proceeds at orthosilicate concentrations significantly lower than those required for silica synthesis in sol-gel chemistry. Using the demosponge *Suberites domuncula* as a model, quantitative enzymatic studies revealed that the native as well as the recombinant enzyme displays *in vitro* (almost) the same bio-silica forming activity as the enzyme involved in spicule formation *in vivo*. Monomeric silicatein molecules assemble to filaments via fractal intermediates which are stabilized by the silicatein-interacting protein, silintaphin-1. This silicatein interactor associates in a 1:4 stoichiometric ratio with silicatein, and thereby augments the enzymatic activity of the protein. Besides of the silicateins, and complementing those anabolic enzymes, a silica-degrading silicase acting as a catabolic enzyme has been identified. Growth of spicules proceeds *in vivo* in two directions. First, by axial growth, a process that is controlled by evagination of cell protrusions and mediated by the axial filament-associated silicateins. And second, by appositional growth that is driven by the extra-spicular silicateins, a process that provides the spicules with the final size and morphology. This radial layer-by-layer accretion is directed by organic cylinders which are formed around the growing spicule and consist of galectin and silicatein. Within those cylinders the siliceous lamellae are formed. Ca^{2+} ions which are required for the assembly of the silicatein/galectin cylinders are supplied by the Ca^{2+}-binding protein, silintaphin-2. The cellular interplay that controls these morphogenetic processes during spiculogenesis is outlined.

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