The Dynamics of Nacre Self Assembly

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Pearl and nacre, or mother of pearl, have been appreciated since antiquity for their beauty, and have been studied scientifically for at least the past 150 years [1]. As a result of these researches, it is now understood that nacre is not just of interest for its aesthetic qualities, but also as a material of exceptional performance compared to the properties of its component parts [2], and it has become a challenge to those engaged in fabricating biomimetic products to replicate the structure of this iconic biomineral [3, 4].

When the growth surface of nacre is viewed on the mesoscale, piles of crystals form a landscape of columns in gastropods, while steps or terraces of crystals are seen to give rise to arrangements of spirals, labyrinths, and target patterns in bivalves. The spirals and target patterns of the mesoscale structure of bivalve nacre have long been noted, and for decades attempts have been made to assimilate the phenomenon to other instances of similar patterning [5]. What was lacking in those attempts, however, was firstly the understanding that the most visible aspects of the patterning, the aragonite tablets, are merely elements adorning the underlying membranes, and secondly and more fundamentally, a means of linking any physicomathematical theory of the growth of the patterns — spirals, target patterns, and so on — to the underlying biology. In the intervening period it is not just our knowledge of molluscan biology that has improved; the fundamental understanding of crystallization, of liquid crystals, and of membrane and fluid physics has increased beyond all recognition, and has allowed us here to make the necessary connections between the physics and the biology.

We show how nacre and pearl construction in bivalve and gastropod molluscs can be understood in terms of successive processes of controlled self assembly from the molecular- to the macro-scale. This dynamics involves the physics of the formation of both solid and liquid crystals and of membranes and fluids to produce a nanostructured hierarchically constructed biological composite of polysaccharides, proteins, and mineral whose mechanical properties far surpass those of its component parts.

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