

A possible coordinate system in the 3D coiling of molluscan shells

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A vast variety of forms have evolved in the molluscan shells since the Cambrian, all basing on the single and simple rules of growth, or the logarithmic spiral. Yet the biological realities underlying this mathematical regularity remained elusive except that the signal transduction protein Dpp has been demonstrated to be involved at least in the two-dimensional coiling of the shells. Here we show that another signal transduction protein is involved in the shell coiling, based on the results obtained from chemical treatments of the embryos of the pond snail *Lymnaea stagnalis*. We argue that those two 'morphogens' may form a coordinate system, which grows like a moving frame of the theoretical 'growing tube', enabling the mantle epithelial cells to form secretory three-dimensionally coiled structures.