The algorithmic beauty of the starch granule

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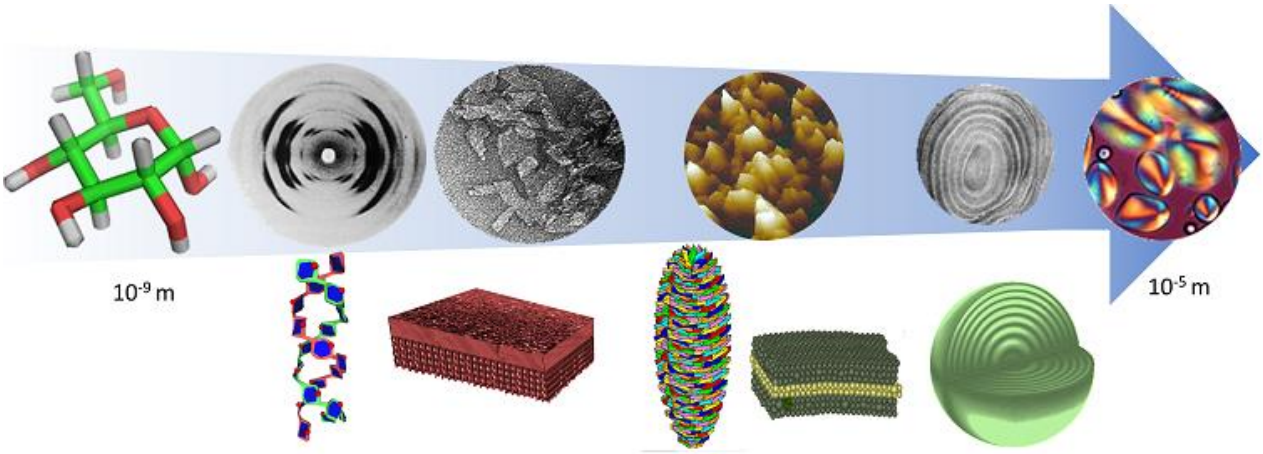
The starch granule is Nature's way of storing energy in green plants over long periods. It is an indispensable energy source for humans and animals and is extracted from the tuber of the potato and the seeds of corn, wheat and rice. Despite the apparently simple nature of its constituents (i.e. Amylose and Amylopectin), the highly complex hierarchical architecture of the starch granule remains to be totally deciphered. Irrespective of their origins, starches display distinct structural features observed individually and are the fingerprints of organisation levels over six orders of magnitude. We hypothesised that Nature retains hierarchical material structures at all levels and that some general rules control these structures' morphogenesis. We considered the occurrence of «phyllotaxis» like features that would develop at scales ranging from nano- to micro-meters. We also developed a novel geometric model capable of building complex structures from simple components. According to the Fibonacci Golden Angle, we applied it to form several Golden Spirals and derived theoretical models to simulate scattering patterns. The convergence between the experimental findings and the theoretical construction suggests that the «phyllotactic» model represents an amylopectin macromolecule with a rarely high molecular weight.



While establishing a viable model of a consistent hierarchical organisation, the present results offer a new 3-dimensional vision to reconsider previously experimentally reported data and extend our understanding of the structures' complexity and the underlying biosynthetic events.

F. Spinozzi, C. Ferrero & S. Perez, The architecture of starch blocklets follows phyllotaxic rules, Scientific Reports, (2020) 10-20093