The algorithmic beauty of the starch granule

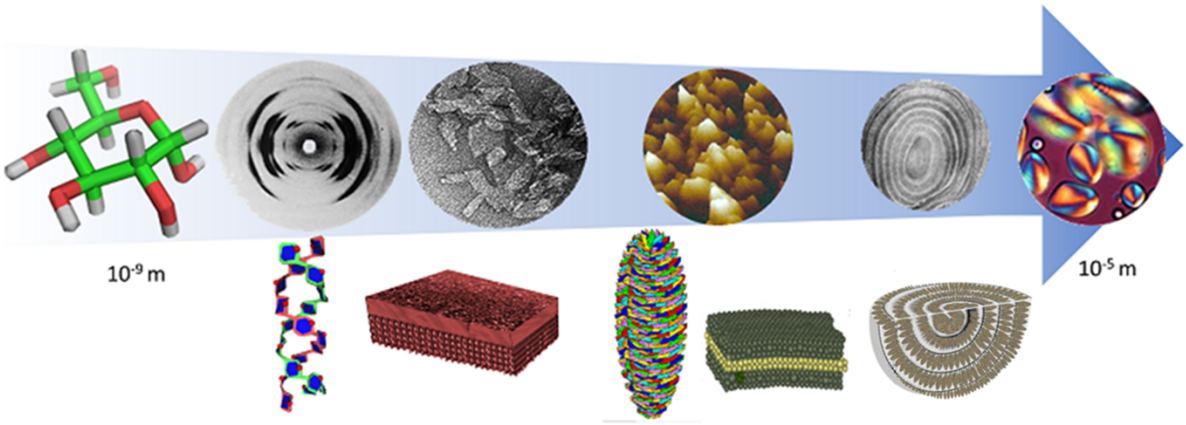
Serge PEREZ [1]

[1] University of Grenoble Alpes, CNRS, Centre de Recherches sur les Macromolécules Végétales

serge.perez@cermav.cnrs.fr

The starch granule is Nature's way of storing energy in green plants over long periods. Irrespective of their botanical origin and diversity, it is remarkable that the internal structures of starch granules share universal features, as indicated by the land-marked appearance of the Maltese cross when observed in polarized light. The construction requires the organization of structural elements over five orders of magnitude from the constituting glucose units to the complete granule. To reach a complete molecular description and understanding of such an architecture, we hypothesized 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 micrometres and developed a novel geometric model to build complex structures from simple components. One among these structures is a golden spiral ellipsoid constructed with elements made up of parallel-stranded double-helices. Its shapes, sizes and high compactness would account for a macromolecular organization of about 10^8 Da, representing an amylopectin macromolecule.

While establishing a viable model of a consistent hierarchical organization, these results offer a new 3-dimensional vision to reconsider previously experimentally reported data and extend our understanding of the structures' complexity, where the underlying biosynthetic events are only the first steps of the construction which obey more general principles of spatial organization.



The structural levels of starch granule architecture

Bibliographic references:

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