Conjecture on the lateral growth of Type I collagen fibrils

September 12 2014

Whatever the origin and condition of extraction of type I collagen fibrils, in vitro as well as in vivo, the radii of their circular circular cross sections stay distributed in a range going from 50 to 100 nm for the most part of them. Jean Charvolin and Jean-Francois Sadoc from the solid state physique laboratory at the Paris-Sud University propose therefore that, once the growth of the fibrils has been triggered by external biological factors, their lateral size be limited by internal physical stresses generated during the growth. Their conjecture is based on the remark that the assembly of the long triple helices building a fibril is a place of conflict between two incompatible requirements: (1) a double-twist around the fibril axis induced by the chirality of those molecules, and (2) a periodic layering normal to the fibril axis associated with their Hodge-Petrushka staggering.

If the initial planar configuration of the layering is kept unchanged as the growth proceeds, the stresses associated with this incompatibility increase and limit this growth rapidly. But if this configuration can switch to a helicoidal ones this increase can be limited and the growth pursued. However such changes require that the triple helices can slide along each other, i.e. their lateral cohesion must be weakened at the cylindrical surfaces along which the changes occurs.

The opportunity for this is contained in a recent model using the algorithm of phyllotaxis to build a dense organization of triple helices in fibrils with circular symmetry (see J. Charvolin and J.-F. Sadoc (2013), *Biophysical Reviews and Letters*, 8, 33-49 (2013). This organization shows indeed a succession of large rings or grains, in which each triple helices has six first neighbors and the cohesion is at its highest, separated by narrow rings of defects or grain boundaries in which this number is no longer maintained and the cohesion lowered.

Those grain boundaries can therefore be extended all along the cylindrical surfaces on which the configuration of the layering should change. However, as their radii follow the Fibonacci series, they are more and more spaced out when moving away from the center of the phyllotactic pattern: (1) they stay sufficiently close to each other not too far from the center so that the stresses can be relaxed before they become too important to prevent the growth, (2) they become too distant far from the center so that the stresses cannot be relaxed before they become sufficiently important and limit the growth.

The radius in the vicinity of which one situation changes to the other and the size limitation occurs compares well with those observed. The distribution of the grain boundaries in the phyllotactic pattern might therefore be determinant for the control of the lateral growth of type I collagen fibrils.

This conjecture relies upon a geometrical analysis of the structural distortions imposed by the very nature of the triple helices building the fibrils of type I collagen. Although crude at this level of development, the agreement obtained calls for an extension to similar systems of fibrils built by molecules different from the triple helices, as displayed by the wide variety of collagenic structures. Beyond its eventual interest for the conception of artificial tissues, such a program should also contribute to the most sensitive issue of the respective roles of genetics and physical chemistry in the building of morphologies needed for biological materials to fill their functions.

The study can be found in the upcoming issue of *Biophysical Reviews* *and Letters*.

More information: The full paper can be read at the following link, www.worldscientific.com/doi/pd … 42/S1793048014500027.

Provided by World Scientific Publishing

Citation: Conjecture on the lateral growth of Type I collagen fibrils (2014, September 12) retrieved 26 April 2024 from https://phys.org/news/2014-09-conjecture-lateral-growth-collagen-fibrils.html

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.