Chiropractic Update

Australian Spinal Research Foundation

Update 35

HOW STRUCTURAL NETWORKS INFLUENCE CELLULAR INFORMATION PROCESSING

Up until recently, biological and medical researchers have focused on identifying the molecular components that comprise life, with the hope that rigorous characterization of all the parts will lead to understanding of the whole. Of late, however, there has been a resurgence of interest in mechanical forces, rather than just chemical cues, as biological regulators.

Researchers have started to find that physical forces, when applied to the extra- cellular matrix and thereby resulting in cell distortion, can change chemical activities inside the cell and lead to changes in tissue development. The answer to how this happens appears to lie in molecular biophysics and can best be understood through a model, called cellular tensegrity, that helps give some understanding of cellular architecture.

Cellular tensegrity is a model of cell architecture in which microfilaments and intermediate filaments bear tensional forces and these are balanced by elements that resist compression, such as microtubules and matrix adhesions.

In part II of a two-part Commentary (1,2) on the subject, Donald Ingber from Harvard Medical School, not only discusses how mechanical stress can change chemical activity but that it might also provide a basis for biocomplexity by allowing cells to integrate physical and chemical signals into a network from which complex behaviours can emerge.

Ingber cites numerous recent studies that indicate that mechanical stress applied to the surface of cells can induce cytoskeletal reorganization, signal transduction and gene expression. Moreover, at the whole cell level, cell shape distortion is able to switch cells between gene programmes that lead to distinct cell fates – growth, differentiation or apoptosis.

Ingber contends that tensegrity may represent the `hardware' behind living systems, the signalling machinery being the software. In the context of this dynamic information-processing network, he proposes that cell fates can be viewed as `attractors' – stable states whose formation is an emergent property of the network.

Ingber concludes by stating,

"Perhaps the greatest impact of the tensegrity model is based on how it has helped to change the frame of reference in cell biology. In the past, we focused exclusively on the molecular components. In contrast, tensegrity describes how molecules function collectively as components of integrated, hierarchical systems in the physical context of living cells and tissues. It also further expands the frame of reference by adding `tone' (tension) and `architecture' (three-dimensional design) into the calculation. This shift in perspective has led to explanations for behaviours that could not be explained with conventional reductionist paradigms."

ASRF Chiropractic Update Editor - This growing body of research may provide a fertile model for chiropractic researchers interested in exploring whether, and how, vertebral subluxations and chiropractic adjustments might influence biochemical processes.

References -

Ingber DE. Tensegrity I. Cell structure and hierarchical systems biology J Cell Sci 2003; 116: 1157 - 1173. http://jcs.biologists.org/cgi/content/full/116/7/1157 (Full text article on-line)

Ingber DE. Tensegrity II. How structural networks influence cellular information processing networks. J Cell Sci 2003; 116:1397-1408. http://jcs.biologists.org/cgi/content/full/116/8/1397 (Full text article on-line)