PN & G
2014 TOKYO JAPAN
Nov. 10-14, 2014
Ito International Research Center, Tokyo

Invited Keynote Lecture

SUPRAMOLECULAR ORGANIZATION AND FUNCTION OF CARTILAGE BIOPOLYMERS

Ferenc Horkay

Section on Tissue Biophysics and Biomimetics, National Institutes of Health, Bldg. 13, Room 3W16, 13 South Drive, Bethesda, MD 20892, USA, horkayf@helix.nih.gov

Cartilage is composed of a gel-like matrix containing collagen fibrils, proteoglycans (PGs), and glycosaminoglycans. In addition, the matrix also contains chondrocytes (cartilage cells), several low molecular weight components and ions. Collagen fibrils (mainly type II) forms a resilient network that restrains the osmotic forces caused by the charged PGs. The most abundant PG in cartilage is aggrecan, a bottlebrush shaped polyelectrolyte whose complexes with hyaluronic acid provide the osmotic resistance of cartilage. The negatively charged aggrecan molecules draw water into the tissue and create a large osmotic swelling pressure, which is balanced by the tensile stress generated in the collagen network. The load-bearing ability of cartilage arises from the highly charged PGs enmeshed in a collagenous matrix. The high swelling pressure of the PGs keeps the collagen network inflated.

Better understanding of the mechanism by which extracellular matrix components contribute to the load-bearing ability of cartilage requires knowledge of the physico-chemical interactions among the constituents. We have developed a multiscale experimental approach to study the structural organization and osmotic properties of the main macromolecular components in near physiological salt solutions. We combine scattering techniques (small angle neutron scattering, small angle X-ray scattering, static and dynamic light scattering) with macroscopic mechanical and osmotic pressure measurements. Results obtained for solutions of aggrecan, aggrecan-hyaluronic acid complex and collagen will be discussed. The osmotic modulus that defines the compressive resistance of the aggrecan-hyaluronic acid assemblies is estimated from the concentration dependence of the osmotic swelling pressure. Scattering techniques are used to determine the effect of the ionic environment on the structure of aggrecan assemblies in near physiological salt solutions. Our results demonstrate that aggrecan-hyaluronic acid assemblies exhibit microgel-like behavior and their supramolecular structure is remarkable insensitive to changes in the ionic environment, particularly to calcium ions. This finding is consistent with the role of aggrecan as an ion reservoir mediating calcium metabolism in cartilage and bone.

Understanding how cartilage responds to the environment is a critically important step in developing strategies to prevent and treat cartilage disorders and in designing implants for cartilage repair and regeneration.

ACKNOWLEDGEMENT
This research was supported by the Intramural Research Program of the NICHD, NIH.