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# Microscopic Characterization of Cartilage Load-bearing Properties

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Cartilage is composed of a gel-like matrix and cells (chondrocytes) that produce the matrix. The matrix consists of a collagen network and of large bottle-brush shaped proteoglycan molecules. The latter molecules play important role in cartilage function because of electrical and steric interactions between the brush 'bristles'. It is not fully understood how these molecules behave in cartilage, how do they deform under external load, how their properties at different length scales vary with age and in different disease conditions.

Osmotic pressure plays a central role in the physiology of cartilage. Physiological processes are accompanied by changes in the balance of water and ions between the fluid compartments within the body. The driving force of the swelling process is the osmotic pressure that contains contributions from a variety of interactions, such as electrostatic interactions, hydration forces, hydrophobic interactions, etc. Each of these interactions has its characteristic length scale over which the interaction is effective. Knowledge of the length scale that controls the osmotic properties is essential in understanding the behavior of biological tissues.

In general, and particularly in the context of cartilage, ions play significant role in defining tissue structure and function. Typically, in polyelectrolyte gels addition of salts containing multivalent ions tends to cause phase separation, owing to the reduction in the repulsive interactions among the polyelectrolyte chains. Although numerous biophysical and bio-mechanical studies have been made on solutions of cartilage polymers, these investigations have not addressed the relationship between structure and interactions that govern the thermodynamic properties at physiologically relevant ion concentrations. The aim of this study is to explore the structure and dynamic properties of cartilage polymers in nearly physiological solutions at length scales intermediate to the macroscopic and the short-range atomic structure of the molecule, i.e., between 1 μm and 1 nm. To investigate structures in this spatial range, small angle neutron scattering, static and dynamic light scattering, and atomic force microscopy are ideally suited and are used in conjunction. These techniques provide quantitative information on the dynamic behavior of the matrix that governs the movement of the molecules, as well as on the ordering of the constituent chains within the domains.