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"Theoretical Considerations for Modeling Viscoelastic Damage and Fatigue in Biological Soft Tissues"

One of the primary goals of soft tissue biomechanics is to estimate the conditions that might cause failure of these tissues under various physiological conditions. However, soft tissues typically exhibit viscoelasticity, so that their damage response becomes difficult to assess solely from experimental observations. Therefore, a theoretical framework that combines viscoelasticity and damage, using observable (thus, measurable) state variables, can provide fundamental insights into the phenomenon of viscoelastic damage. In this presentation we cover the topic of damage mechanics, nonlinear viscoelasticity, and viscoelastic damage, using the framework of constrained reactive mixtures. This framework is briefly compared to the more traditional internal variable theories available in the classical mechanics literature. Examples and illustrations are provided, based on experimental measurements performed on articular cartilage and tendon. Theoretical and experimental considerations of fatigue failure in soft tissues are also introduced.

Dr. Gerard Ateshian received his BS (1986), MS (1987), MPhil (1990) and PhD (1991) degrees in mechanical engineering from Columbia University. He is a Fellow of the American Society of Mechanical Engineers, the Biomedical Engineering Society, and the American Institute of Medical and Biological Engineers. He has been Professor of Mechanical Engineering and Biomedical Engineering at Columbia University since 2002 and the Andrew Walz Professor of Mechanical Engineering since 2013. Dr. Ateshian performs research in the field of soft tissue mechanics, with an emphasis on cartilage mechanics, lubrication, and tissue engineering, and the formulation of growth theories for biological tissues. A major component of his research focuses on understanding and treating osteoarthritis. Ateshian is particularly interested in formulating continuum mechanics theories that accommodate the complexities encountered in living biological tissues and cells, including mass transport, osmotic effects, and reactive mechanics in solid mixtures, needed to describe tissue growth and remodeling. Dr. Ateshian has received numerous prestigious awards, including the OARSI Basic Science Award (2013) and the H.R. Lissner Medal, ASME (2017).