Victor Barocas

Professor
7-115 Hasselmo Hall
612/626-5572
baroc001@umn.edu
Personal Website

Computational Biomechanics and Transport

- B.S., Chemical Engineering, M.I.T., 1988
- M.S., Chemical Engineering Practice, M.I.T., 1989
- Ph.D., Chemical Engineering, University of Minnesota, 1996

Our group is primarily interested in understanding how mechanical, physical, and chemical phenomena interact to govern the behavior of biological and medical systems. Our goal is thus to use our engineering knowledge to explore, understand, and manipulate biological systems. At present, we are concentrating on three areas within the broad field of computational biomechanics and biotransport.

Ocular Biomechanics and Transport

Aqueous humor flows through the extreme anterior part of the eye, turning over the contents roughly every 1.5-2 hr. Although the iris engages in active deformation to control the amount of light passing through the pupil, it is also subject to passive deformation from the pressure in the aqueous humor. This is a relatively small effect in normal eyes but can be quite pronounced in certain pathological cases, and in some cases the iris even exhibits a confusing posterior deflection. We are developing finite element simulations of coupled AH flow and iris deformation to explore their interactions. In addition, we are interested in intravitreal flow and diffusion, particularly as they relate to drug delivery to the retina.

Tissue-Equivalent Mechanics

Tissue equivalents (TEs), formed from entrapping cells in a biopolymer matrix, provide insight into cell behavior and can be the basis for bioartificial tissues. Our Anisotropic Biphasic Theory of Tissue-Equivalent Mechanics (ABT) provides a quantitative tool for modeling and interpreting TE experiments, allowing cross-experiment comparisons of cell behavior and preliminary design of bioartificial tissues. We are currently pursuing various applications of the theory and also extension to account for the effect of microstructure on the macroscopic behavior of TEs.

Microelectromechanical Systems

The explosion of microtechnology has now reached the point where new designs for micro-scale pumping analysis is possible, but there are many questions that must be explored before the field can be considered "mature." Our particular interest is in developing design strategies for MEMS devices and systems, allowing us to answer questions like "how should a pump be fabricated to deliver X amount of fluid to a given location at a given rate with the least power required?" Fundamental design issues are in a sense scale-independent - we want to get the most for the least - but microsystems involve power limitations, heat removal, and surface interactions in ways that are rarely significant on the large scale of chemical production plants. Current research focuses on micropumps and on separation and analysis of solutions on small scales.

Selected Publications

- Heys, J. J. V. H. Barocas, and M. J. Taravella (2000). "Modeling Passive Mechanical Interaction between the Aqueous Humor and Iris." *J. Biomech. E.*, accepted.
- Xu, J., J. J. Heys, V. H. Barocas, and T. W. Randolph, "Permeability and Diffusion in Vitreous Humor: Implications for Drug Delivery." *Pharm. Res.*, 17 (6) : 664-669.
- Ohsumi, T. K., V.H. Barocas, J.E. Flaherty, S. Adjerid, and M. Aiffa (2000). "Adaptive Finite Element Analysis of Biphasic Equations." *Comp. Meth. Biomech. Biomed. Eng.*, 3 : 215-229.
- Knapp, D. M., V. H. Barocas, T. T. Tower and R. T. Tranquillo (1999). "Estimation of cell traction and migration in an isometric cell traction assay." *AIChE Journal* , 45 (12) : 2628-2640.
- Barocas, V. H., T. S. Girton, and R. T. Tranquillo (1998). "Engineered Alignment in Media-Equivalents: Consequences of Cell Induced Compaction on Magnetic Prealignment." *J Biomech E.*, 120 (5) : 660-666.
- Barocas, V. H. and R. T. Tranquillo (1997). "An anisotropic biphasic theory of tissue-equivalent mechanics: the interplay among cell traction, fibril network deformation, and contact guidance." *J Biomech Eng*, 119 (2) : 135-147.
- Barocas, V. H. and R. T. Tranquillo (1997). "A finite element solution for the anisotropic biphasic theory of tissue-equivalent mechanics: the effect of contact guidance on isometric cell traction measurement." *J Biomech Eng*, 119 (3) : 261-269.
- Knapp, D. M., V. H. Barocas, K. Yoo, L. R. Petzold, and R. T. Tranquillo (1997). "Rheology of reconstituted type I collagen gel in confined compression." *J Rheol.*, 41 (5) : 971-993.