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Supervised by
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*“Computational Fluid Dynamics
Analysis and Advanced Design of
Microbubble-Based
Microphysiological Systems”*

Seminar Abstract: Microphysiological systems (MPS) have emerged as promising alternatives to traditional *in vitro* models in recent years, enabling physiologically relevant studies of tissue function and drug response. Computational fluid dynamics (CFD) plays a critical role in understanding velocity profiles, flow patterns, nutrient transport, and shear stress distribution in such devices, which directly influence cellular behavior. Although prototypes of organ-on-a-chip devices utilizing microbubble (MB) array technologies have been developed, critical physiological characteristics including flow dynamics, shear stress, and mass transport remain insufficiently understood, limiting predictive insights into their performance and potential.

In this work, I employed COMSOL Multiphysics to simulate fluid flow and mass transport within the device, incorporating channel geometry, nanomembrane permeability, and practically relevant boundary conditions. The study investigated the effects of MB geometry, fluid flow, and microporous nanomembrane permeability on velocity profiles, shear stress, and nutrient distribution throughout the device. Results showed that the unique shape of the MB induces vortex flow in a single-side open configuration, enabling efficient mass transfer, whereas a rectilinear shape causes flow splitting. The simulation also demonstrated that velocity decoupling and shear damping occur inside the MB. Furthermore, the results showed that diffusion occurs throughout the device, which is suitable for efficient nutrient distribution.

Based on the simulation data of the single-sided open MB-based MPS device, I designed and simulated an advanced MPS architecture. Ultimately, this work provides a deeper understanding of computational modeling complementing experimental prototyping, offering a robust quantitative foundation for the future optimization of MPS devices.

Friday, April 17, 2026 | 10:00am EST | Adolph Aud (1-7619, Med Center)
<https://rochester.zoom.us/j/95878699783>

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