BIOMATH SEMINAR
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Impact of kidney structural architecture on oxygen transport: A mathematical model

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The proper matching of oxygen supply to demand in a variety of tissues is necessary to preserve tissue viability. In the mammalian kidney, despite high bulk blood flow and oxygen delivery, oxygen concentrations are relatively low, especially in the deeper part of the kidney (called the medulla). Recent detailed anatomic studies of the rat medulla have revealed a highly organized structure, with oxygen-consuming tubules often found distant from oxygen-supplying blood vessels. In this talk, I will present a mathematical model of solute transport in the renal medulla of the rat kidney to study the impact of this structured 3D organization of tubules and vessels revealed in anatomic studies. Results from this model suggest that the functional role of the 3D medullary architecture may be to preserve oxygen delivery to the bottom tip of the kidney. The model was then extended to include the competing solutes nitric oxide and superoxide, which exert opposing effects on blood pressure and overall renal function, and which are dependent on oxygen concentration for their production. Model simulations including these solutes suggest a likely pathway for injury due to hypertension, as well as a clinical biomarker for acute kidney injury.