Flowing through confined geometries

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Background Suspensions of rigid and/or deformable particles in viscous fluids flowing through confined geometries are ubiquitous in natural and engineering systems and the shapes of these confined geometries are notoriously complex. For example, the spermatozoa need to navigate the female reproductive tract (and do it efficiently) to reach the ovum cell; carefully designed micro-fluidic chips can be used to sort and separate cells based on their mechanical properties (size, shape, rigidity etc.).

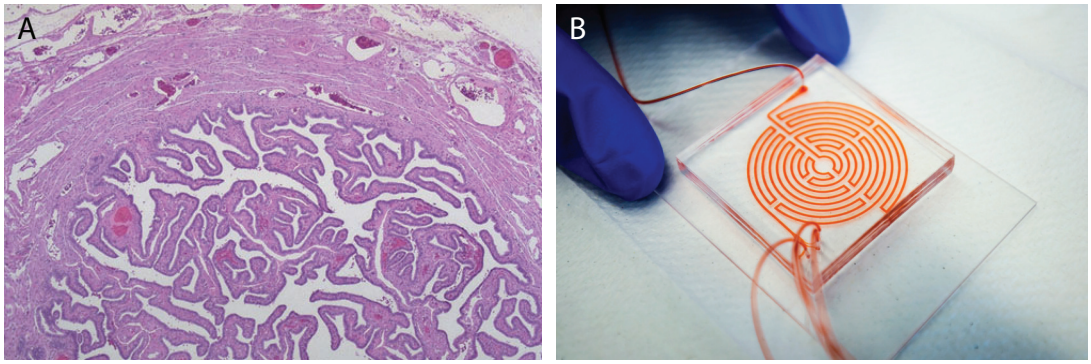

Figure 1: A: The microscopic image of a cross section of the Fallopian tube. B: Blood samples run through a microfluidic chip. (cr: https://news.engin.umich.edu/photography/labyrinth-chip/)

Goals In this project, we will numerically study the shape effects of the confined geometry on the motions of the suspensions. In particular, we will start with existing computer programs to investigate the flows of suspensions in pressure-driven pipes with different geometries (sample result shown in Fig. 2); we will then modify the programs to implement different boundary conditions to emulate different biological scenarios (e.g., slip boundary conditions for cilia-driven flows). You will be writing your own codes (simple and challenging), working with cutting-edge computational programs, and get a flavor of the University's supercomputer (Great Lakes).

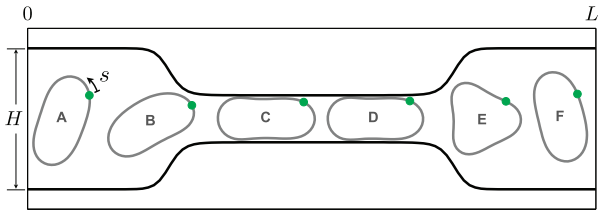

Figure 2: Dynamics of a 2D vesicle through a channel with a constriction. [O. Pak *et al.* PNAS (2015)]

Prerequisite Linear algebra (Math 214 or equivalent) and Differential equations (Math 216 or equivalent). Experience with scientific computing (Math 371 or equivalent) and/or Matlab will be nice.