Stability of high-density lipoprotein particles

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The packaging and transport of cholesterol in the bloodstream are mediated by nanoparticles called lipoproteins. In a process known as reverse cholesterol transport (RCT), high-density lipoprotein (HDL) particles scavenge cholesterol from tissues and other lipoproteins and thereafter deliver it to the liver for excretion. During RCT, HDL particles change shape from discoidal to spheroidal. The functional properties of HDL are thought to be closely tied to shape. A discoidal HDL particle consists of an open lipid bilayer bound by an apolipoprotein apo A-I chain. Motivated by experimental and numerical studies revealing that discoidal high-density lipoprotein (HDL) particles may adopt flat elliptical and nonplanar saddle-like configurations, a variational description is developed to explore the stability of a flat circular discoidal HDL particle. While the lipid bilayer is modeled as two-dimensional fluid film endowed with surface tension and bending elasticity, the apo A-I chain is modeled as a one-dimensional inextensible twist-free rod endowed with bending elasticity. Stability is investigated using the second variation of the energy functional. Various planar and nonplanar instability modes are predicted and corresponding critical values of the salient dimensionless parameters are obtained. The results predict that the first planar and nonplanar unstable modes occur due to in-plane elliptical and transverse saddle-like perturbations. Using available data, detailed stability diagrams indicate the range of input parameters for which a flat circular discoidal HDL particle is linearly stable or unstable. The equations governing the equilibrium of an HDL particle consist of the shape equation familiar form the theory of lipid bilayers supplemented by boundary conditions expressing force balance and moment balance. Like the highly nonlinear shape equation, the boundary conditions are nonlinear and involve fourth-order derivatives. As such, these equations present interesting mathematical challenges.

The lecture will take place in Thackeray 704 at 3:30pm.

Refreshments will start at 3:00pm.