Flexible slender structures in flow are everywhere. While a great deal is known about individual flexible fibers interacting with fluids, considerably less work has been done on fiber ensembles — such as fur or hair — in flow. These hairy surfaces are abundant in nature and perform multiple functions from thermal regulation to water harvesting to sensing. Motivated by these biological systems, we consider three examples of hairy surfaces interacting with flow: (1) air entrainment in the fur of diving mammals, (2) viscous entrainment in drinking bats, and (3) symmetry breaking in hairy micro-channels. In the first example, we take inspiration from semi-aquatic mammals (such as fur seals, otters, and beavers) which have specially adapted fur that serves as an effective insulator both above and below water. Many of these animals have evolved pelts that naturally entrap air when they dive. In this study we investigate diving conditions and fur properties which amplify air entrainment. In the second example we consider viscous dipping, a feeding method utilized by many nectar drinking animals, whereby fluid is viscously entrained on the surface of a tongue. This mechanism is reminiscent of Landau-Levich-Derjaguin (LLD) dip coating, and has been analyzed through this framework in previous studies. However, many viscous dippers have hairy structures on their tongues that enhance fluid uptake. Here we investigate the impact of mesoscale hairy structures on feeding efficiency. Finally, we consider a fundamental component in hydraulic systems, the flow rectifier. In particular we propose a design that allows the operator to modulate the relative resistances in the rectifier and that can be achieved using only solid state components (i.e. no moving parts).

Bio: Peko Hosoi is the Neil and Jane Pappalardo Professor of Mechanical Engineering and professor of Mathematics at MIT. Her research contributions lie at the junction of nonlinear hydrodynamics, biomechanics, and bio-inspired design. A common theme in her work is the fundamental study of shape, kinematic, and rheological optimization of biological systems with applications to the emergent field of “soft robotics.” Her work is internationally respected by physicists, biologists, roboticists, applied mathematicians, and engineers alike, and is used to guide the engineering design of robotic swimmers, crawlers, burrowers, and other mechanisms. More recently, she has turned her attention to problems that lie intersection of biomechanics, applied mathematics, and sports. She is the co-founder of MIT 3-Sigma Sports which aims to solve engineering challenges in the sports domain. The program connects students and faculty with alumni and industry partners who work together to improve athletic performance using engineering to elevate endurance, speed, accuracy, and agility. Peko has received numerous awards including the Ruth and Joel Spira Award for Distinguished Teaching, the Bose Award for Excellence in Teaching, and the Jacob P. Den Hartog Distinguished Educator Award. She is a Fellow of the American Physical Society (APS), a Radcliffe Institute Fellow, and a MacVicar Faculty Fellow. Peko joined the Department of Mechanical Engineering in 2002 as an assistant professor after receiving an AB in physics from Princeton University and an MA and PhD in physics from the University of Chicago. She was promoted to full professor in 2013.