Evolution and control of complexity: from butterfly proboscis to artificial probes for single cell analyses

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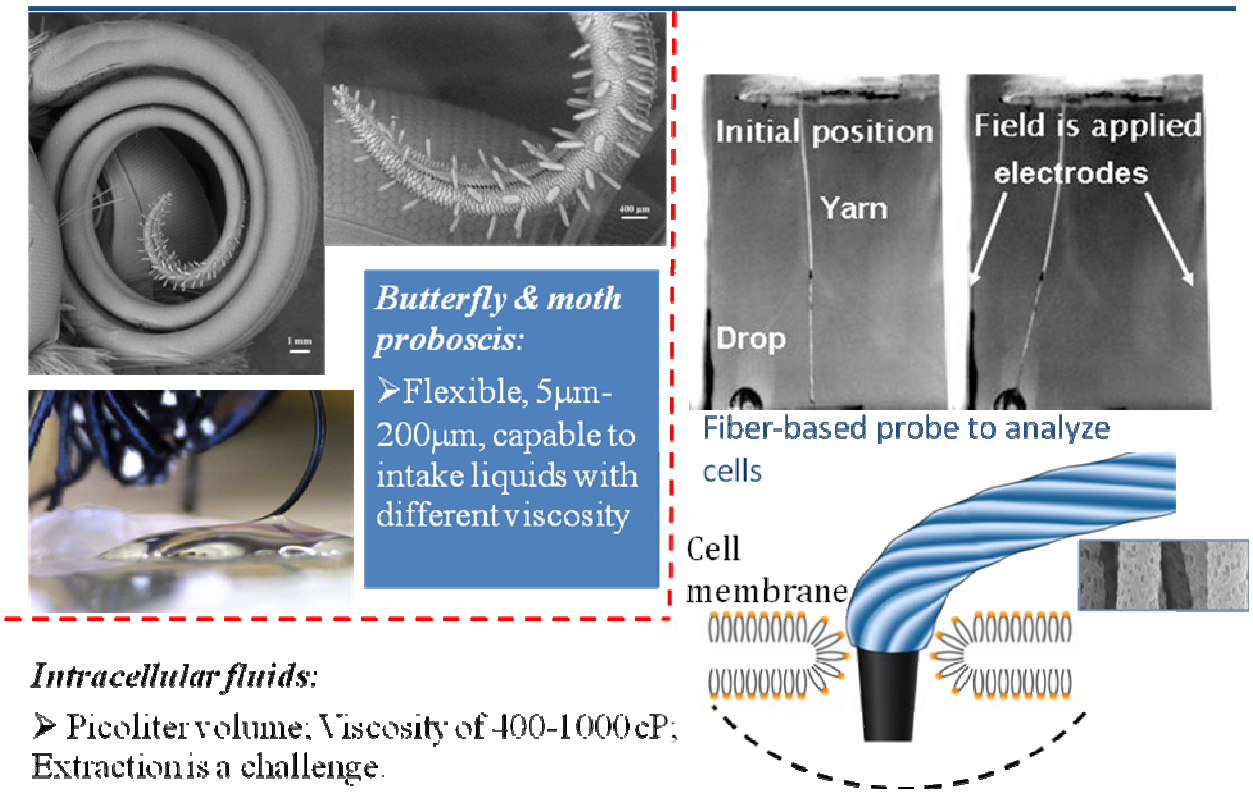
Almost 160,000 species of butterflies and moths have a coilable proboscis hypothesized to have evolved once. The food canal of the proboscis is formed from two semi-cylindrical halves, the maxillary galeae, that are linked together at their borders by cuticular linkage devices. Butterflies and moths not only imbibe floral nectar but also feed from rotten fruits and wet soil, suggesting that the suction pressure they produce is sufficiently high. The proboscis can be considered as flexible microfluidic device with extraordinary ability to probe, deliver, and sense different fluids. The proboscis evolution, organization and functionality are poorly understood, though its design is attractive for making artificial probes for single cell analyses. In this talk I will discuss recent results on the mechanisms of fluid absorption by butterflies. Using X-ray phase contrast imaging we were able to observe the process of fluid imbibitions into the food canal: the discovered mechanism drastically differs from the conventional. When the size of the proboscis decreases down to $5-10\mu m$, the flow imaging becomes a challenge. The problem of spanning the scales also arises when we study the liquid penetration into bioinspired probes made of nanofibers. All these problems constitute a new challenge for image analysis when one needs to bring nanofeatures in order to describe the flow at the microscale. I will discuss some key experiments.