Internship: Adaptive microfluidic networks

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Whether in biological or in engineering contexts, fluids often have to flow through complex networks of tubes, from the vasculature of animals and plants to the random porous media making up batteries or packed-bed reactors, see Fig. 1. It has long been thought that biological network morphologies were minimising the energetic cost associated to viscous flow dissipation in their branches. However, another possibility, raised recently [1, 2], is for these networks to be optimal for mass exchange. We then need not only to have a network that covers space efficiently, but also whose morphology leads to an even flow of chemicals (catalysts, nutrients, oxygen,...) throughout all its tubes [2].

Such a uniform flow in all tubes of the network is in stark contrast with fluid flows in random porous media such as an engineered packed-bed reactor. There, most of the transport is essentially limited to a few very fast lanes [3], and mass exchange or chemical reactions cannot occur in most of the network. The current strategy to create artificial porous media that minimise viscous dissipation and enable efficient mass exchange, is to build, tube by tube, a prepatterned optimised network morphology [4].

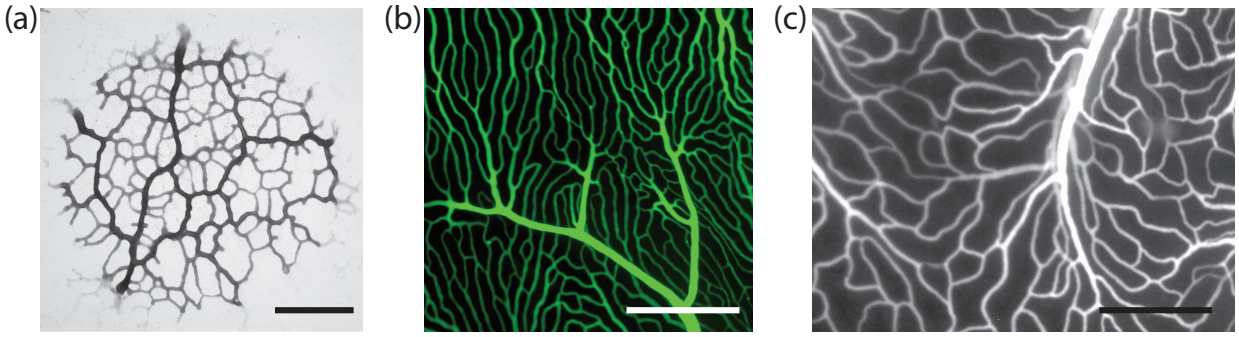

Figure 1: Vasculature of (a) the slime mould *Physarum polycephalum* (scale bar: 0.25 cm), (b) the rattle snake retina (scale bar: 500 μm) (c) and the rattle snake pit organ (scale bar: 250 μm).

The aim of this experimental internship is to build smart porous media, whose morphology self-organises to optimise perfusion throughout the network. Experimentally, we will make microfluidic devices that degrade in the presence of a chemical. The first step is to build upon an existing protocol in the lab to to make these degradable devices more efficiently. Then, we will monitor their degradation rate as a function of the concentration of chemical, and of the flow dynamics. The geometry of the device will be complexified, and depending on time, we will end up testing how a random network responds to pulses of chemical. There will be a constant interplay between experiments at LadHyX and our theoretician collaborators at TUM (Munich, Germany).

References

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[4] X. Zheng, G. Shen, C. Wang, Y. Li, D. Dunphy, T. Hasan, C. J. Brinker, and B. L. Su. *Nature Communications*, 8:1, 2017