

From blood-sucking mosquitoes to embryonic hearts: how do we pump at low Reynolds number?

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Subject

To remain unnoticed, mosquitoes have to pump blood as efficiently as possible from their preys. Some mosquitoes have evolved a minimal and robust valveless pumping system [1], relying on two in-line active reservoirs. At the lengthscales at play, all dynamics are dominated by the fluid's viscosity and are thus time-reversal invariant [2]. This should prevent any net flow from occurring in the absence of a mean pressure gradient. A similar fluidic system is found in human hearts at the embryonic stage. During prenatal development, the heart must evolve continuously from a low Reynolds to a high Reynolds regime, the physics of which is still to be disentangled.



Figure 1: Typical blood-sucking mosquito

The internship, consisting in unravelling the mechanisms of valveless pumping at low Reynolds number, will have both experimental and theoretical components. The experiments will consist in fabricating bio-inspired microfluidic devices that reproduce – and why not, outperform – the mosquito's feat. In parallel, we will develop a theoretical framework to address this problem and compute the associated net flows. In particular, we will build on the minimal system with 2 active pumps and study the effect of N consecutive pumps. As $N \rightarrow \infty$, we expect to recover the physics of peristaltic pumping.

References

- [1] S. CHATTERJEE, J. SOCHA, AND M. STREMLER, *Mosquito drinking with a burst in reserve: explaining behavior with a fluid mechanics model*, in APS Meeting Abstracts, Mar. 2014.
- [2] E. E. PURCELL, *Life at low Reynolds number*, American Journal of Physics, 45 (1977), p. 11.