Turing Centre for Living Systems Marseille, France

Applications: http://centuri-livingsystems.org/recruitment/

Dead line : April 15th, 2018

PhD Project: Fluid-induced self-organization of ciliated-cell activity in human lungs

Project abstract:

Mucociliary clearance is a biomechanical mechanism of airway protection. It consists of the active transport along the bronchial tree of the mucus, a fluid propelled by the coordinated beating of a myriad of cilia on the bronchial epithelial surface. The purpose of this PhD is to study and characterize the role of hydrodynamical forces on the self-organization of ciliated cells and the coordination of the ciliary beats in human lungs and, conversely, to understand how the ciliary dynamics drives mucus transport. It is a joint numerical-experimental study which couples the active response of these cells to the multiphase fluid environment where they are immersed. The biophysical mechanisms to be studied involve long-range hydrodynamic interactions among distant beating cilia, the non-linear rheology of mucus, and the collective modes of ciliary beats. To elucidate the role of these biophysical mechanisms in the cell response, the project relies on the physical analysis of ciliary activity and mucus transport using :

- an in-vitro approach on human bronchial cultures at Air Liquid Interface, based on optical, confocal and fluorescence video-microscopy experiments.
- an in-silico approach based on Lattice Boltzmann simulations coupled to immersed boundary method in a multiphase context.

The focus will be placed on the quantitative understanding of the coupled relations between the mucus flow and the spatial and dynamic organization of ciliated cells, including individual ciliary beat frequencies and directions, and their collective behavior. The role of hydrodynamics in the emergence of metachronal ciliary beat waves and spatial flow patterns will be unraveled. This will also shed light on mechanotransductive effects involved in ciliogenesis and wound healing, including changes in ciliated cell polarity and potential transdifferentiation.

Expected profil of the candidates:

A crucial aspect of the work will be obtaining and analyzing numerical and experimental results, and thus the candidate with have a solid background in either physics of complex systems/active matter, biophysics or mechanics. He will have the appropriate skills in at least experimental biophysics or computation, and demonstrate it through its resume and experience. In addition, having a taste for health issues and quantitative biology is required in the interdisciplinary context of the PhD.

Supervisors

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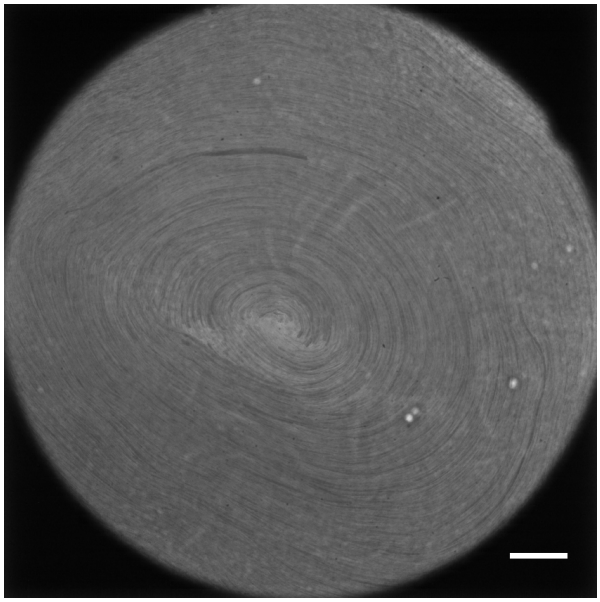

Figure 1. Experimental observation of a swirl of mucus (top view).

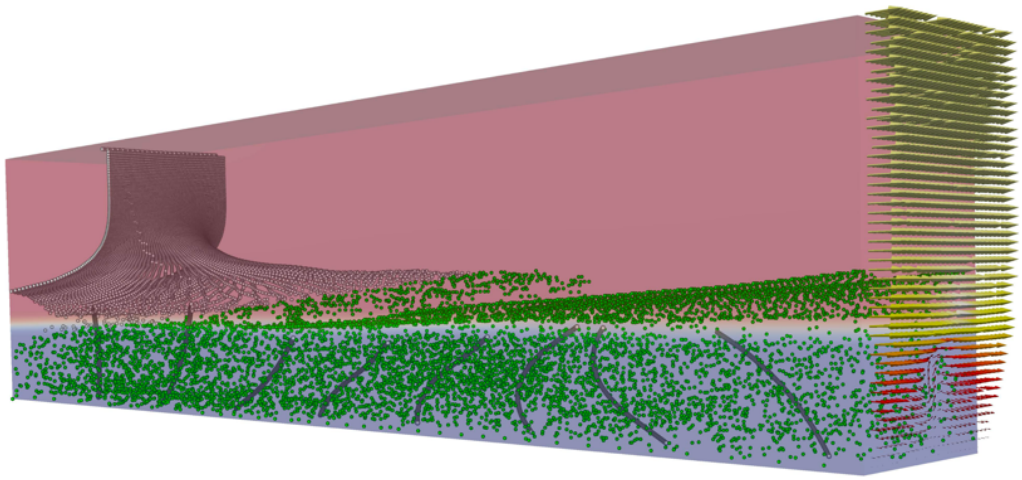

Figure 2. Numerical simulation of the transport of passive tracers by the beating of a metachronal wave (side view).