Bio-Inspired Microfluidic Platform for Biomechanical Analysis

Bio-Plan

Postdoc position: numerical modeling of artificial cilia

Overall project summary

This postdoc project is part of a larger ERC research project called "Bio-Plan", in which we envision the following research.

Biomechanical interactions between cells and their environment are essential in almost any biological process, from embryonic development to organ function to diseases. Hence, biomechanical interactions are crucial for health and disease. Examples are hydrodynamic interactions through fluid flow, and forces acting directly on cells. Existing methods to analyze and understand these interactions are limited however, since they do not offer the required combination of precisely controlled flow and accurate applying and sensing of forces. Also, they often lack a physiological environment. A breakthrough in biomechanical analysis is therefore highly needed.

We will realize a **novel microfluidic platform for biomechanical analysis** with unprecedented possibilities of controlling fluid flow and applying and sensing time-dependent forces at subcellular scales in controlled environments. The platform will be uniquely based on **bio-inspired magnetic artificial cilia,** rather than on conventional microfluidic valves and pumps. Cilia are microscopic hairs ubiquitously present in nature, acting both as actuators and sensors, essential for swimming of microorganisms, transport of dirt out of our airways, and sensing of sound, i.e. they exactly fulfill functions needed in biomechanical analysis.

We will develop **novel materials and fabrication methods** to realize microscopic polymeric artificial cilia, and integrate these in microfluidic devices. Magnetic actuation and optical readout systems complete the platform. We will **apply** the novel platform to address **three fundamental and unresolved biomechanical questions**: 1. How do hydrodynamic interactions with actuated cilia steer cellular and particle transport? 2. How do local and dynamic mechanical forces on cells fundamentally influence their motility and differentiation? 3. How do hydrodynamic interactions between cilia steer embryonic development? Complementary to the experimental work, we will develop numerical models and carry out simulations to guide the experimental design and to help answering the questions.

This unique platform will enable to address many other **future** biomechanical questions.

Activities of the postdoc

The postdoc will develop and apply numerical models to guide the experimental design, and to help interpreting the experimental results. This research will connect to all the work packages within the full project, and there will be a strong interaction with the experimental work. The starting point of the research will be the existing numerical artificial cilia models developed at the University of Groningen. These must be extended and applied to the following envisioned research activities:

- Study of the influence of the nature of magnetic actuation on fluid flow generation by the artificial cilia, e.g. 3D tilted conical actuation versus metachronal actuation in which individual cilia exhibit a 2D whip-like motion.
- Study of the influence of scaling and geometry on fluid flow generation and particle transportation: influence of artificial cilia size, shape, and surface coverage.
- Apply the models to study cilia-generated flow in the embryonic node, and investigate existing, but still unproven, hypotheses about how this flow results in the development of left-right body asymmetry during embryonic development.

Organization

The research is part of the ERC project Bio-Plan which runs at Eindhoven University of Technology, led by prof. Jaap den Toonder. The postdoc will be appointed at Eindhoven University of Technology, but the postdoc research will actually be carried out at the University of Groningen, under the direct supervision of prof. Patrick Onck, partner in Bio-Plan. The postdoc will thus be stationed in Groningen, and will pay frequent short visits to Eindhoven. The appointment will be for 2 years.

What we are looking for

We are looking for an ambitious candidate with affinity for computational modelling that has completed (or is in the process of completing) a PhD degree in the field of Mechanical Engineering, Aerospace Engineering, Applied Physics or Applied Mathematics. Candidates that have hands-on experience with Finite Element and/or Molecular Dynamics techniques are especially invited to apply.

Information

Please contact prof. Patrick Onck (p.r.onck@rug.nl) or prof. Jaap den Toonder (j.m.j.d.toonder@tue.nl) for more information.