IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Modeling and simulations of propulsion and swimming in microorganisms**	
Project Number	**IMURA0733**	
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Research Clusters:

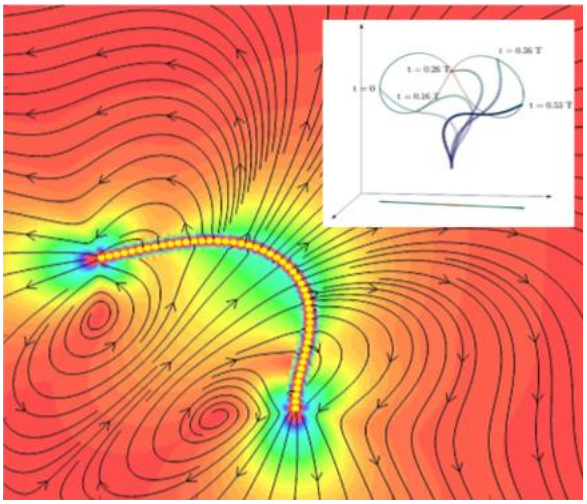
Highlight which of the Academy's CLUSTERS this project will address?
*(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*

1	*Material Science/Engineering (including Nano, Metallurgy)*
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*
3	*Math, CFD, Modelling, Manufacturing*
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*
8	*HSS, Design, Management*

Research Themes:

Highlight which of the Academy's Theme(s) this project will address?
(Feel free to nominate more than one. For more information, see www.iitbmonash.org)

1	*Advanced computational engineering, simulation and manufacture*
2	*Infrastructure Engineering*
3	*Clean Energy*
4	*Water*
5	*Nanotechnology*
6	*Biotechnology and Stem Cell Research*



An internally driven flexible microfilament can undergo unstable wavy motions (inset) driving complex flows in the surrounding fluid. (Image source: Laskar et al., Sci. Rep., 2013)

The Research Problem

The goal of microfluidic technology is to shrink fluid processes to achieve labs-on-chips. This problem has been solved by biology millions of years ago! Freely swimming cells are marvelous microfluidic machines. Any swimming cell effectively pumps fluid past itself to move forward. Microbes can also manipulate flows to more effectively transport nutrients towards themselves. By understanding the mechanisms behind such propulsion and steering, we might one-day be able to design a new generation of microfluidic devices that are well and truly labs-on-chips.

Project aims

Many cells swim by using flexible tails called flagella as propellers. These tails are driven by a complex internal engine. The propulsive thrust and swimming trajectory depend on the wavy pattern generated by the flagellum. We have two aims:

1. Use Computational Fluid Dynamics (CFD) to explore the complex three-dimensional flow that emerges from the fluid-structure interaction between internally-driven flexible filaments and its viscous fluid environment;
2. Use CFD to accurately calculate propulsive forces and power from experimental observations of high-speed, high-resolution videos of flagellar motion in microchannels.

Expected outcomes

The Project will deliver a detailed mathematical model of flagellar propulsion in cells.

How will the project address the Goals of the above Themes?

The Project involves mathematical modelling and aims to develop a sophisticated simulation tool that will enable exploring cell biology. It therefore satisfies the goals of the themes of “Advanced Computational Engineering, Simulation, and Manufacture” and “Biotechnology and Stem Cell Research”.

Capabilities and Degrees Required

Do you have a degree in mechanical or chemical engineering, or in physics? And are you interested in fluid mechanics, and in programming? If yes, this Project is a perfect springboard for an exciting research career in CFD and micro/ nano-fluidics. Fluid-structure problems are among the most complex problems in fluid dynamics. This project will train you in advanced numerical and computational techniques for studying such interactions. As a part of a larger collaboration between biologists and engineers at IITB and Monash, it is also an excellent opportunity to work in the emerging and exciting interdisciplinary area of biomicrofluidics.

Collaborators

The Project is a collaboration between Prof. Sameer Jadhav and Prof. Prabhakar Ranganathan.

Select up to **(4)** keywords from the Academy’s approved keyword list **(available at www.iitbmonash.org)** relating to this project to make it easier for the students to apply.

CFD, simulation, microfluidics