# Simulation and Physics of Drosophila Larva Body Dynamics

## Introduction

The "STRETCHED" project aims to develop a robust, physics-based 3D simulation platform to replicate the motor control dynamics observed in Drosophila larvae. This interdisciplinary project combines biology, neuroscience, and computational modelling to understand how the larva's body's physical properties influence its motor control and neural computation. By leveraging the rich data repository on the larva's neural connectome and muscular structure, the project seeks to create accurate simulations that can inform biological research and soft robotics development.

## PhD project

The PhD project will focus on the technical aspects of simulating the physics of the Drosophila larva body. The primary objectives include:

Developing a Finite Element Model of the Larva Body:

- Utilise existing Drosophila larva CT-scan data to segment components such as the cuticle, muscles, and mouth hook.
- Implement finite element simulations within the SOFA framework to model the larva's body dynamics.
- Create a mesh model of the larva with the main organs required for simulation and develop plugins to control muscle and body properties.

Modelling Muscle Dynamics:

- Approximate muscles as "cables" with Hill model dynamics within the SOFA framework.
- Simulate muscle contraction patterns and their interaction with the larva's environment, including friction models.

Integrating Experimental Data:

- Collaborate with experimental teams to incorporate data from calcium imaging, confocal microscopy, and high-resolution video recordings.
- Use experimental data to constrain the free parameters of the simulated model and validate the simulation against real-world observations.

Exploring Motor Control Policies:

- Develop and test motor control policies to mimic larva behaviour using computational approaches such as Bayesian program synthesis and inverse reinforcement learning.
- Investigate the diversity of motor commands that could implement observed behaviours and explore their neural implementation.

## Profile of the Expected Candidate

We are seeking a highly motivated and qualified candidate with the following profile:

- Master's degree in Computer Science, Engineering, Physics, Applied Mathematics, or a related field.
- Strong foundation in computational modelling & numerical simulations

**The laboratory**

The Decision and Bayesian Computation (DBC) – Epiméthée (EPI) laboratory, situated within the Institut Pasteur, is a collaborative unit involving Pasteur, INRIA, CNRS, and UPC. Led by a Principal Investigator (PI), Jean-Baptiste Masson, who is a theoretical physicist, the lab is co-managed by two deputies: Christian Vestergaard, a theoretical physicist, and François Laurent, an applied mathematician and software engineer.

The laboratory's research is centred on uncovering the organising principles of biological information processing, focusing on the underlying physics of computations and sensory environments. This exploration has led to developing models and advanced statistical frameworks, successfully describing phenomena such as bacteria chemotaxis, olfactory search strategies in insects, and synaptic variability in the random walk dynamics of synaptic receptors.

The lab's theoretical research is focused on embodied neuroAI, recognising that the body influences biological neural networks, the continuity of actions, and sensory inputs. Leveraging advancements in Drosophila genetic manipulation, neural connectomics, and amortised inference, the lab studies small neural circuits' organisation, structure, and function. The goal is to identify the biological and physical "cost" functions that shape the design of these circuits.

The lab is dedicated to medical algorithmics on the applied research front, emphasising technologies implementable within hospitals. Notably, the lab's medical image rendering and analysis project, DIVA (and Genuage), has evolved into Avatar Medical, which provides DIVA-derived solutions globally. Current initiatives include developing parametric conditional generative models for fetal imaging data and ICU patient phenotyping from EEG data.

Please send your application with a CV at **dbc-epi-recrutement@pasteur.fr**