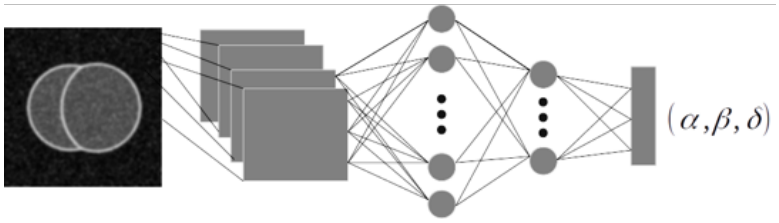
Master 2 Research internship

Physical inference from bio-images with deep learning



Keywords: deep learning, physical inference, biological microscopy images

Place: Collège de France
Center for Interdisciplinary Research in Biology
11, place Marcelin Berthelot, 75005 Paris

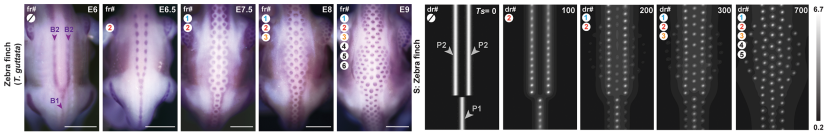
Team: *Multiscale Physics of Morphogenesis* www.virtual-embryo.com

Supervision: Hervé Turlier, team leader herve.turlier@college-de-france.fr
Phone: +33.1.44.27.14.10

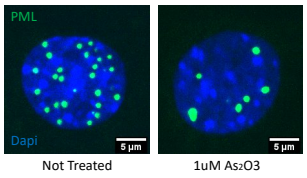
Duration: 4 to 6 months, starting Jan-Apr 2020
Benefits: ~500€/month, subsidized lunch and public transport (50%)

The goal of the research project is to develop new inference methods that use deep neural networks to extract physical information from time-lapse microscopy images of biological processes. The computational method will aim at inferring from images either the physical parameters of a predefined physical model, or to infer the best model to describe the observed dynamics. Here, we will build on recent *physics-informed* neural networks, that have proven their performance to solve complex inverse problems[1,2], but have not yet been applied to biological images. We will focus on two concrete biological processes, in collaboration with two biology teams at Collège de France:

1) Turing-like **advection-reaction-diffusion dynamics**, with application to the plumage patterning in bird embryos. Here we will focus on the discovery of optimal parameters with a predefined model that can fit observed biological patterns[3].



2) The **coarsening dynamics of nuclear bodies**, with application to the dynamics of PML nuclear bodies, which are membrane-less organelles that coarsen in a liquid-like fashion upon arsenic treatment[4]. Here we will focus on automatic model discovery to describe this biological phenomena involved in cancer.



The trainee will have access to a powerful **Nvidia DGX Station** to design and train deep learning models on GPU and to a laptop (Macbook Pro) during the internship period.

The research can be pursued with a PhD thesis in the team. The candidate will have to apply for funding through the physics doctoral school competition.

Candidates should be trained either in **computer science, physics** or **applied mathematics** and should demonstrate **excellent programming skills** (Python and/or C++) as well as a real desire to work in a highly interdisciplinary environment. Prior experience in machine learning and/or image analysis will be very valuable.

1. Tipireddy, R. et al., 2019. A comparative study of physics-informed neural network models for learning unknown dynamics and constitutive relations. arXiv, 1904.04058.

2. Lu, L. et al., 2019. DeepXDE: A deep learning library for solving differential equations. arXiv, 1907.04502.

3. Bailleul, R. et al., 2019. Symmetry breaking in the embryonic skin triggers directional and sequential plumage patterning C. S. Hill, ed. PLoS Biology, 17(10), pp.e3000448–27.

4. Lallemand-Breitenbach, V. (2010). PML nuclear bodies. Cold Spring Harbor perspectives in biology, 2(5), a000661.