ERC-funded post-doc position

Active surface and finite-element models of embryo & tissue dynamics

<u>Job application portal</u>: https://bit.ly/3BaYpx8 **<u>Deadline</u>: Sept 20th 2021**

<u>Possible starting date</u>: Oct 15th 2021

<u>Place</u>: <u>Collège de France</u>
Center for Interdisciplinary Research in Biology
11, place Marcelin Berthelot, 75005 Paris, FRANCE

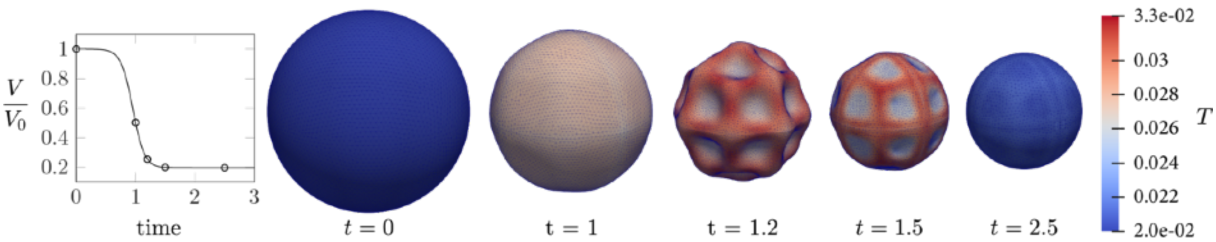
<u>Team</u>: *Multiscale Physics of Morphogenesis* <u>www.turlierlab.com</u>

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

<u>Duration</u>: 24 months, starting October 2021 - possibility to extend to 36 months

<u>Salary</u>: between € 2,200 and € 2,500 net monthly depending on experience

<u>Mission:</u> Cells are highly dynamic structures, that divide, change shape and rearrange to build complex embryo and tissue structures. This is done primarily by actively tuning the mechanical properties of their surface, called the actomyosin cortex. In the last years, we - and others - have been working on viscous-active physical and numerical models of the actomyosin cortex, the main component of cell surface mechanics (Turlier et al. 2014, Borja et al. 2021). Recently, we derived and simulated with finite-elements a novel active thin shell theory of the cortex, that notably accounts for surface buckling and material turnover (Fig. 1). The aim of this project is to generalise such theoretical and numerical framework to now tackle the dynamics of multicellular dynamics. Building on the The project is part of the ERC DeepEmbryo project led by Hervé Turlier, whose goal is to reverse-engineer the development of embryos by combining biophysical and machine learning methods, in collaboration with several biologists.



<u>Figure 1</u>: Viscous-active thin shell simulation of an hyper-osmotic shock on a single cell

<u>Activities:</u> The successful candidate will develop physical and numerical models of embryo and tissue dynamics (Fig. 2). Its role will be to design a generic computational framework for multicellular dynamics in 3D, based on active surface constitutive laws and finite-element implementations on surface meshes (Turlier et al. 2014, Borja-da-Rocha et al. 2021). These models will be applied in particular to model early embryo development in 3D+time (Maître, Turlier et al. 2016, Dumortier et al. 2019). She/he will have to work with the other members of the team and will work closely with several biologists. She/he will have to present her/his results at scientific conferences, to write scientific articles and to actively participate in the scientific life of the team and host Institute.

<u>Expected profile:</u> The candidate should hold a PhD in **mechanical engineering** or **applied mathematics** or **computer graphics** (a theoretical physics background may also be considered). She/he should demonstrate **excellent computer skills** (C++ & python), and expertise or prior experience in **finite-element modeling**. Knowledge of the libraries FEniCS &/or MFEM (or equivalent) will be a strong asset, as well basic knowledge of triangular surface mesh-based modeling. She/he should have already demonstrated the ability to publish in international peer-reviewed scientific journals. Prior experience in modeling of biological structures and in collaborating with biologists will be appreciated but is not mandatory. In addition, a strong desire to acquire new skills in deep-learning, which will be associated to this project, is necessary. The work will be largely interdisciplinary, mixing concepts of soft-biological physics, classical mechanics, computational modeling and data science. A great autonomy in work, curiosity, initiative, and proficiency in English as well as good communication skills are therefore expected.

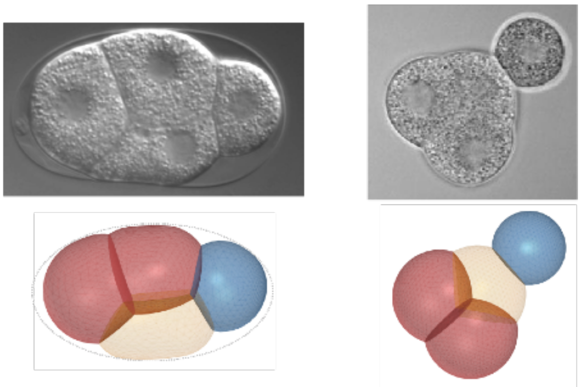


Figure 2: Microscopy snapshots and multicellular (quasi-static) simulations of the *C elegans* worm embryo at 4-cell stage, with or deprived of its eggshell.

Working environment: The successful candidate will work in the interdisciplinary team "Multiscale physics of morphogenesis" led by Hervé Turlier composed of 10 scientists from various backgrounds (physics, applied mathematics, computer science, biology). The team is located at the Collège de France, in the heart of the Latin Quarter in Paris. Integrated within the PSL University, and close to other major institutions such as Ecole Normale Supérieure and Institut Curie, the Collège de France constitutes an exceptional and unique scientific environment in the world. The successful candidate will be provided an individual workstation in renovated premises, a powerful laptop and will have access to a high performance computing cluster (CPU+GPU) fully dedicated to the team.

1. H. Turlier*, B. Audoly, J. Prost, J-F. Joanny. (2014) Furrow Constriction in Animal Cell Cytokinesis. ***Biophysical Journal*** 106(1): 114-123.
2. H. Borja-da-Rocha, J. Bleyer, H. Turlier. (2021) *In preparation*.
3. J-L. Maître, H. Turlier, R. Illukkumbura, B. Eismann, R. Niwayama, F. Nédélec, T. Hiiragi. (2016) Asymmetric division of contractile domains couples cell positioning and specification. ***Nature*** 536: 344-348.
4. J.G. Dumortier, M. Le Verge-Serandour, A.F. Tortorelli, A. Mielke, L. de Plater, H. Turlier*,& J.L. Maître*. (2019) Hydraulic fracturing and active coarsening position the lumen of the mouse blastocyst. ***Science***, 365: 465-468.