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Synchronisation of contractile activity in giant unicellular organism *Physarum Polycephalum*

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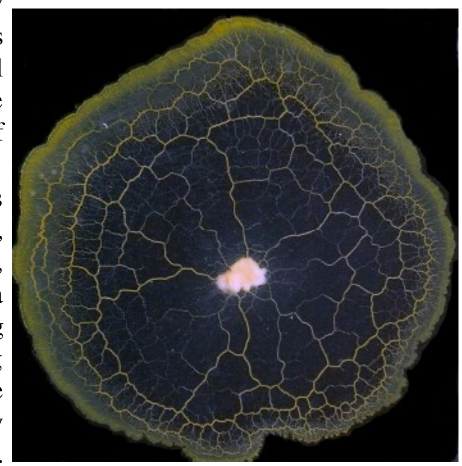
Summary

Like *E. Coli*, *C. Elegans* or *Drosophila*, *Physarum Polycephalum* is a model organism intensively studied by the scientific community. In its vegetative phase, called *plasmodium*, this organism is made of thousands of undifferentiated cells fusing in a single, multinuclear cell, and can reach macroscopic sizes (dozens of cm²). This organism then develops a tubular network in which oscillatory flows (with period ~ 1 minute) are generated by the contraction of the membranous layer surrounding the "veins". The role of this transport network is to supply the diffusive flows which are too slow to efficiently transport oxygen, nutrients, or waste through the whole cell. *Physarum Polycephalum* is likely the simplest organism with a vascular network.

The second function of this network is to efficiently transport the body mass during the growing stage or displacement of the cell. This requires from this organism, deprived from central nervous system, a local control of the sol-gel transition of the cytoplasm, and a synchronization of the contractile activity in the whole organism in order to generate a contractile wave traveling from one side of the cell to the other.



Example of P. Polycephalum in its plasmodium stage.

In spite of its apparent simplicity, the growth of the tubular network shares common features with the development of vascular systems in higher organisms, or with the mechanisms that take place in the irrigation of tumors. In particular, one can clearly identify two stages in the development of the plasmodium: a growing phase during which *P. Polycephalum* explores its environment covering all the plane with a very dense and ramified tubular network. Then a reorganizing phase during which the organism seems to follow an optimization scheme: the network is less and less reticulated. Eventually, the organism is then simply reduced to a few tubular elements directly connecting the different sources of food. Besides, separate plasmodia of same strain can merge together to create a larger plasmodium. Their networks connect to each other, allowing to exchange cytoplasm, nuclei, vesicles, etc.

From a physicist's perspective, the plasmodium is an **active gel** that is able, at short times, to generate and adapt contractile waves along the veins to generate peristaltic flows, and at long times to control actively its sol-gel transition to modify the network architecture.

During this internship, we will study the coupling between the contractile activity and the formation of the tubular network in the early stage of the plasmodium development, called microplasmodium. At this stage (size~200 µm), the plasmodium can be seen as an **active drop** with an erratic contractile activity at the beginning. This activity generates local heterogeneities of shear strain, leading to sol-gel transition locally within the cytoplasm, which in turn will affect the local contractile activity of the microplasmodium. Progressively, a primitive network of flowing material emerges within the gel.

In practice, we will measure simultaneously the thickness field of the microsplasmodium using transmitted light imaging, and the velocity field within the microplasmodium using standard velocimetry techniques, in order to highlight the feedback role of the flow in the contractile activity and the synchronization phenomena. We will also study how the addition of inhibitors of contractile activity affect the network developement.

At long term (PhD), we will identify the mechanisms involved in the network formation and evolution during the reorganization and optimization of the network, and during the merging of the networks of two plasmodia in contact.