



3-to-6-month master internship in the [CytoMorphoLab](#) in Paris, 2025-2026

Active matter: self-organization of dynamic microtubule networks

The architecture of the microtubule network orients intra-cellular transport, positions organelles, and segregate chromosomes during mitosis. However, despite their tremendous importance, the physical rules that determine network architecture are still unknown.

The architecture of microtubule network depends on two main contributions: the templated growth and the self-organization of microtubules. The **templated growth** is determined by the amount and localization of microtubule nucleators, which imposes the localization of microtubule minus ends. The **self-organization of microtubules also depends on the action of molecular motors**, which not only move along microtubules but also transport microtubules. This process is known to contribute to the self-organization of the mitotic spindle, but is poorly characterized due to the structural and biochemical complexity these dynamic architectures.



We recently managed to reconstitute in vitro the self-organization of microtubules by both plus-end and minus-end directed motors. To our surprise, we found that microtubules and motors could self-pattern themselves into multiple domains, containing either plus-end or minus-end directed motors, separated by bundles of aligned microtubules (Utzschneider et al. PNAS, 2025). However, in these conditions, microtubules were stabilized in order to facilitate the transport of motors. We propose to further explore conditions closer to mitotic spindles by studying how motors of opposite polarities could self-organize dense arrays of short and dynamic microtubules.

Students will learn the use of purified tubulin and molecular motors to grow dynamic networks of microtubules in vitro. They will also learn various surface treatments and microfluidic methods to confine and encapsulate these networks. They will be trained on first-class microscopes to monitor network self-organization. An ongoing with Jean-François Joanny (Collège de France) will allow the design of a physical model of active phase separation in the self-organization of mitotic spindles.

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Most recent publications of the CytoMorpho Lab on reconstituted microtubule networks:

Force balance of opposing diffusive motors generates polarity-sorted microtubule patterns.

Utzschneider C, Suresh B, ..., Joanny JF*, Blanchoin L*, Théry M*. *PNAS* 121 (49), e2406985121, 2024.

Actin network architecture can ensure robust centering or sensitive decentering of the centrosome.

Yamamoto S, Gaillard J, ..., Blanchoin L*, Théry M*. *EMBO Journal*, 41(20):e111631, 2022.

Actin-microtubule dynamic composite forms responsive active matter with memory.

Kučera O, Gaillard J, Guérin C, Théry M*, Blanchoin L*. *PNAS* ;119(31):e2209522119, 2022.

Self-repair protects microtubules from their destruction by molecular motors.

Triclin S, Inoue D, SL, Blanchoin L*, Théry M*. *Nature Materials*, 20(6):883-891, 2021.

Other publications of the team : <http://cytomorpholab.com/index.php/publications/>