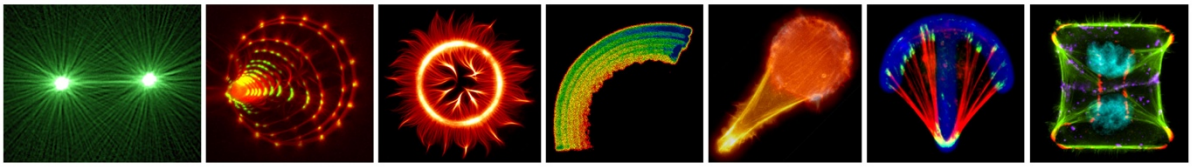
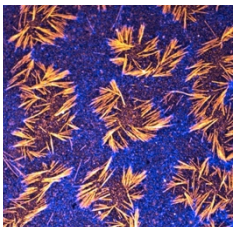


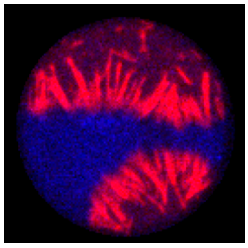
Master internship in the CytoMorphoLab in Paris, 2026-2027

Space partitioning by microtubules and molecular motors

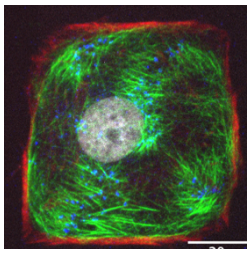
The architecture of the microtubule network orients intra-cellular transport, positions organelles, and segregate chromosomes during mitosis. However, despite their tremendous importance, the physical rules that organize the architectures of microtubule network are still unknown.

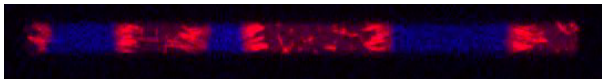


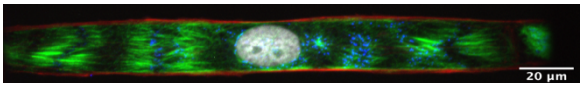
We recently managed to reconstitute in vitro the self-organization of microtubules by both plus-end and minus-end directed motors. We showed that microtubules and motors could self-pattern themselves into multiple domains, containing either plus-end or minus-end directed motors, separated by bundles of aligned microtubules (Utzschneider et al. PNAS, 2025). This could be modeled as a new mechanism of active phase separation by polar transport of motors of opposite directionality (Pattanak et al., Arxiv, 2026).



More recently, we confined this process on micropatterns and showed that this process can partition space into radial, polar, bipolar or multipolar domains, depending on motor ratio and microtubules length and number (left). We then showed that this mechanism is at play in living cells since similar bands of microtubules and separation domains could be observed upon stabilization of microtubules (right).







The aim of this internship is to further study the role of molecular motors and microtubule stability in this process of intra-cellular space partitioning and cell polarization. We propose to focus either on cells (in vivo) or on the reconstituted minimal system (in vitro). Students working in vivo will learn cell micropatterning and molecular biology strategies to modulate the activity of molecular motors. Students working in vitro will learn surface micropatterning, lipid handling, and the biochemistry of microtubules and motors. They both will be trained on first-class microscopes and deep-learning method for image analysis.

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Most recent publications of the CytoMorpho Lab on this topic:

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.

Contractile forces direct the chiral swirling of minimal cell collectives.
Badih G, ..., Blanchoin L, Théry M, Kurzawa L. PNAS. 122(47):e2415028122, 2025.

Microtubule-driven cell shape changes and actomyosin flow synergize to position the centrosome
Schaeffer A, ..., Blanchoin L*, Théry M*. The Journal of Cell Biology 224 (7), e202405126, 2025.

Compressive forces stabilise microtubules in living cells.
Li Y, ..., Akhmanova A, Blanchoin L*, Théry M*.Nature Materials, 22(7):913-924, 2023.

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