Science and Technology Group
Annual Report FY2025

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1 Introduction

Vertebrate zygotes and embryonic blastomeres divide symmetrically during early cleavage for clonal expansion. To achieve symmetrical cleavage, early embryonic cells grow large microtubule meshworks called “asters” from each centrosome in anaphase, and position centrosomes at the center of each blastomere during cytokinesis. Previous research indicates that dynein, a conserved microtubule-based motor, generates aster-pulling forces in bulk cytoplasm. However, it remains unclear how the localization and activity of dynein are spatiotemporally regulated in cytoplasm to promote centrosome centering in large vertebrate embryos (Figure 1).

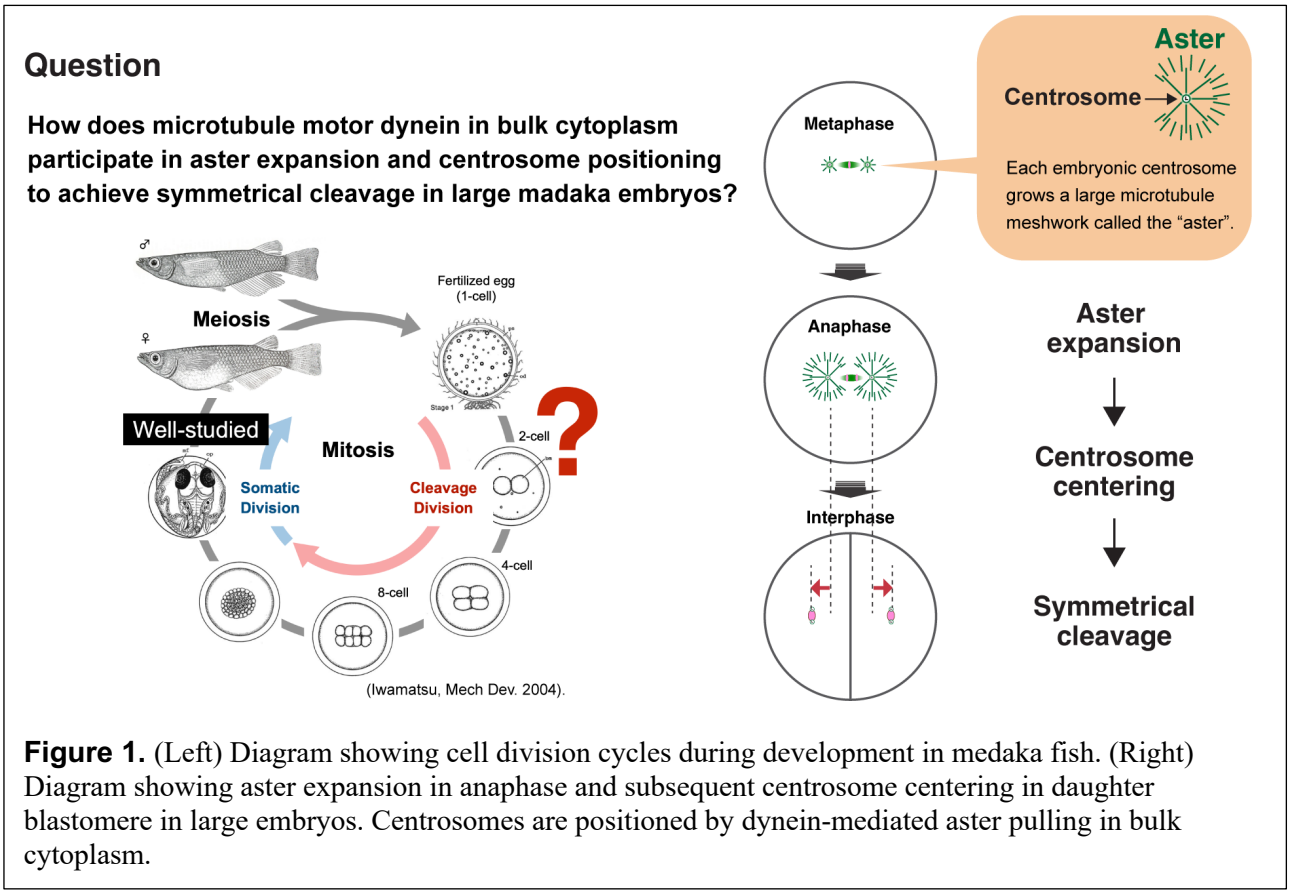

Figure 1. (Left) Diagram showing cell division cycles during development in medaka fish. (Right) Diagram showing aster expansion in anaphase and subsequent centrosome centering in daughter blastomere in large embryos. Centrosomes are positioned by dynein-mediated aster pulling in bulk cytoplasm.

2 Activities and Findings

In FY2025, I visualized endogenous dynein and its activator, dynactin, using CRISPR in live medaka fish embryos. Unexpectedly, I found that dynein and dynactin do not distribute uniformly in cytoplasm, but instead show a halo-like, cytoplasmic enrichment around the periphery of small metaphase asters in early embryos, which we call the dynein “halo” based on its appearance. Our live imaging further revealed that dynein relocates from the halo to growing asters and neighboring membranous organelles in anaphase, coincident with aster expansion and centrosome movement. To understand functions of the dynein halo, I next analyzed its functions using chemical (dominant negative construct), genetic (auxin-inducible degron), and mechanical (laser ablation) perturbations. As expected,

dynein inhibition prevented centrosome movement. However, surprisingly, dynein inhibition also prevented aster expansion and caused ectopic microtubule nucleation in anaphase cytoplasm, which created ectopic furrows. Based on these results, we propose a new model that inactive cytoplasmic dynein that accumulated at the metaphase aster periphery is activated in anaphase and incorporates both microtubule nucleators and organelles into anaphase asters, to coordinately promote aster growth and pulling for rapid centrosome centering in large embryos.

These results were presented in Dynein 2025 international conference and OIST Cell Division workshop. The manuscript has been submitted.

3 Collaborations

Kiyomitsu Unit (OIST)
Prof. Timothy J. Mitchison (Harvard Medical School)
Dr. Luolan Bai (Harvard Medical School)
Prof. Satoshi Ansai (Okayama University)

4 Publications and other output

<Poster presentation>

Kiyomitsu A, Kiyomitsu T.
Dynein's cytoplasmic halo promotes anaphase aster expansion and pulling while suppressing ectopic furrow formation in large medaka embryos
Dynein 2025 Conference, Ann Arbor, MI, USA, July 22-24, 2025

Kiyomitsu A, Bai L, Mitchison TJ, Kiyomitsu T.
Dynein in bulk cytoplasm promotes aster expansion and centrosome positioning in large embryos
OIST Cell Division Workshop 2026, Okinawa, Japan, March 2-5, 2026