RESEARCH NEWS STORY

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Self-Organization of Cell-Sized Chiral Rotating Actin Rings Driven by a Chiral Myosin

Researchers explore how actin filaments and a motor protein can spontaneously give rise to cell-sized structures

Understanding how microscopic interactions between proteins in cells produce large-scale organization and asymmetry is a fundamental question in cell biology. In a recent study, researchers from Japan investigated how actin and myosin create cell-scale structures using experimental setup. They found that *Chara corallina* myosin XI—a fast motor protein—drives actin filaments into large unidirectionally rotating rings. Their findings reveal physical principles of self-organization, inspiring new ways to design self-organizing biomimetic materials for biotechnological applications.

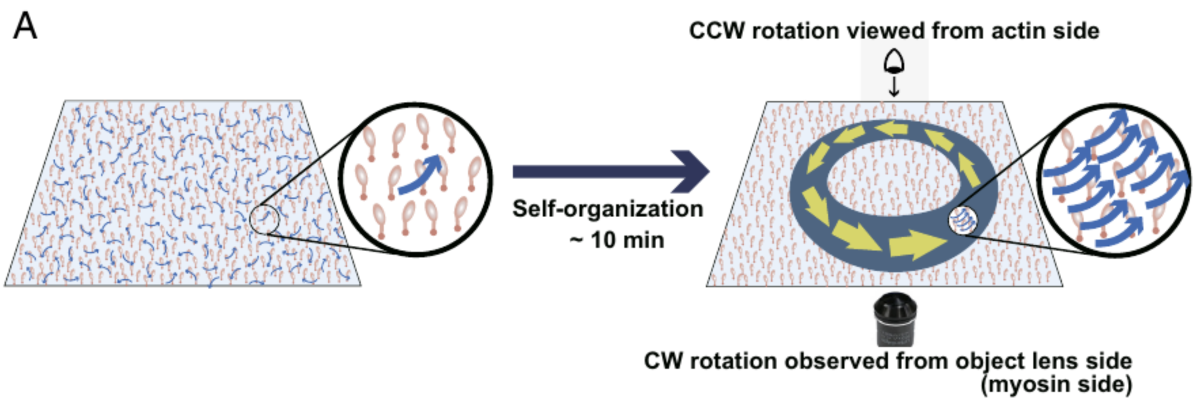

Image title: Autonomous formation of actin chiral rings through the collective motion by myosin *Cc*XI
Image caption: *Chara corallina* myosin XI (*Cc*XI) drives the movement of actin filaments, which spontaneously form ring-like structures due to a slight curvature that leads to polar alignment.
Image credit: Professor Kohji Ito and Dr. Takeshi Haraguchi from Chiba University, Japan
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Living cells are highly organized, yet they are not assembled using rigid blueprints or by following a predetermined plan. Instead, order emerges on its own from countless interactions between molecules that are constantly moving and rearranging. One of the most striking examples of this emerging order is the left–right asymmetry. This type of chirality—the property of an object that makes it different from its mirror image—is essential for many biological processes and can be observed throughout nature. Interestingly, how both small- and large-scale order arise from interactions between microscopic components remains a fundamental question in biology.

To tackle this knowledge gap, scientists have carefully studied the biomolecules that drive movement inside cells. Actin and myosin are perfect examples; actin forms a network of filaments that gives cells their shape and helps with material transport, while myosin is a family of tiny 'molecular motors' that convert chemical energy into mechanical force. Together, actin and myosin power processes such as muscle contraction in animals and cytoplasmic streaming in plant cells. Despite their importance, it remains unclear how simple interactions between these two proteins can generate asymmetric structures at the scale of an entire cell, especially in the absence of any guiding template or external influence.

Motivated by this question, a research team led by Professor Kohji Ito and Dr. Takeshi Haraguchi solely from the Graduate School of Science, Chiba University, Japan, investigated how order can emerge from actin–myosin interactions alone. Their study was made available online on January 28, 2026, and published in Volume 123, Issue 5 of the journal *Proceedings of the National Academy of Sciences (PNAS)* on February 3, 2026, focused on a fast plant motor protein known as *Chara corallina* myosin XI (*Cc*XI). Using a simplified laboratory system, the researchers directly observed and simulated how actin filaments organize when driven by this motor. This work was done in collaboration with Dr. Yasuhiro Inoue from Kyoto University, Japan; Dr. Toshifumi Mori from Kyushu University, Japan; and Dr. Kenji Matsuno from The University of Osaka, Japan.

In the experiments, purified actin filaments and myosin XI were combined with ATP—the molecule that supplies the chemical energy needed for motor activity. Under these simple conditions, the researchers observed an unexpected behavior. Instead of forming random patterns or flowing collectively in one direction, the actin filaments spontaneously assembled into stable, ring-shaped structures roughly comparable in size to a cell. These rings rotated continuously in a single direction and remained fixed in place, even as individual filaments continued to move within them.

Further investigation revealed that this collective behavior originates from individual actin filaments driven by *Cc*XI. Unlike many other myosins, *Cc*XI drives filaments along curved paths rather than straight lines. This curvature arises at the leading tip of each filament, where repeated motor-driven steps gradually bias its direction of movement. When many such curved filaments interact at a sufficiently high density, they naturally align and close into rotating rings, creating a stable chiral structure without any external guidance.

The researchers ran computer simulations to further validate this interpretation, demonstrating that filament curvature is a key requirement for ring formation. Notably, the size of the reproduced rings was determined by the degree of curvature. "*The ring-shaped* *structures formed in our experiments closely resemble the uniformly polarized alignment of actin filaments observed in plant cells. This suggests that the self-organization process identified here represents a fundamental principle that holds even in simplified reconstituted systems and captures the essential mechanism underlying actin alignment in living cells*," highlights Prof. Ito.

Taken together, these findings help clarify how plant cells may organize their internal architecture to promote efficient molecular transport through self-organizing actin networks. "*By deepening our understanding of the principles governing cell growth and intracellular transport in plant cells, our results may contribute foundational knowledge toward controlling plant growth and improving agricultural productivity*," says Prof. Ito. Beyond plant biology, the results have broader implications for materials science and bioengineering. Systems that can autonomously generate order and motion from simple components could inspire new approaches to designing active biomaterials or nanomachinery.

Overall, this work highlights the emergence of self-organization not as a mysterious or complex outcome, but as a predictable process governed by simple physical principles that we can understand.

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About Professor Kohji Ito from Chiba University, Japan

Professor Kohji Ito received a PhD degree in Science from Nagoya University in 1995. He joined Chiba University in 2007, where he currently serves as a Professor in the Department of Biology, Graduate School of Science. His research focuses on myosin and molecular motor proteins, with particular emphasis on plant-specific myosin-11, cytoplasmic streaming, actin dynamics, and cellular chirality. He has authored over 45 peer-reviewed publications on these topics. He is a member of several academic societies, including the Botanical Society of Japan, the Biophysical Society of Japan, and the Japanese Society of Cell Biology.

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