PRESS RELEASE

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Title: Scientists discover potential key missing link protein bridging eukaryotes and prokaryotes

Release subtitle: Modern eukaryotic cells have proteins that enable chromosome segregation during cell division, new discoveries shed light on their origin in simpler prokaryotic organisms.

Release Summary:

Modern nucleated (eukaryotic) cells use specialized protein scaffolds to ensure chromosomes segregate properly into daughter cells, with each daughter receiving one copy of each chromosome. Similar proteins have been found previously in simpler unicellular organisms, which typically only have one chromosome. A new study finds a protein in an intermediary class of organisms has properties that may help explain the transition between these two types of cells.

Full text release:

All modern organisms fall into two classes, eukaryotes and prokaryotes. Eukaryotes (from the Greek meaning "true kernel") have a cell nucleus that harbours most of the cell's genetic information and includes organisms such as humans, plants and fungi. In prokaryotes, the cell's contents, including its genetic material, are diffusely distributed. Eukaryotes typically have much larger genomes, which is generally thought to relate to their greater complexity: indeed, all multicellular organisms are eukaryotes. Prokaryotes, however, not to be outclassed, comprise the bulk of Earth's biomass. Generally speaking, prokaryotes seem to approach the process of living by making copies of themselves as quickly as they can, while eukaryotes survive by being highly specialized at making copies of themselves in particular ways.

A new study by a team of scientists including researchers at the Earth-Life Science Institute (ELSI) at Tokyo Institute of Technology, Research Institute for Interdisciplinary Science (RIIS) at Okayama University and Nagoya University may have identified a key intermediate in the transition from prokaryotes to eukaryotes.

Most prokaryotes have single circular genomes and reproduce asexually, which means when the time comes for their cells to divide, they simply have to copy their circular genomes and make sure one circular copy ends up in each daughter cell. In contrast, eukaryotes typically have multiple linear chromosomal genomes and often reproduce sexually, meaning they have to make sure an appropriate set of multiple copied chromosomes ends up in each daughter cell. This is a much more complicated process, and it remains unclear how the precise sorting required for this process arose from the simpler system used by prokaryotes.

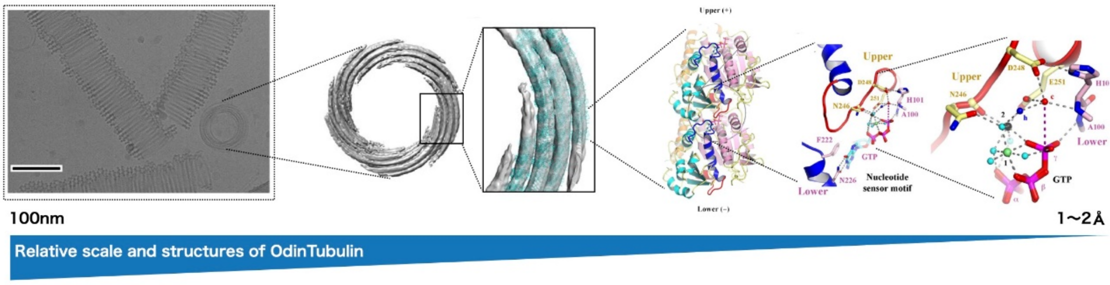
In prokaryotes, typically, the circular chromosome becomes attached to the cell membrane, and then as the cell grows and begins to separate into two cells, this attachment assures that one copy will end up in each daughter cell. This process is much more complex in eukaryotes. In eukaryotes, a complex protein scaffolding forms, mainly based on the protein tubulin. Tubulin forms long fibres, which help draw the copied chromosomes towards the poles of the dividing cell. Failures of this process, called nondisjunction, result in unequal numbers of chromosomes being present in daughter cells, which gives rise to disorders collectively known as aneuploidy. In humans, this leads to numerous recognizable birth defects, perhaps most notably Down's Syndrome.

How the processes arose that allowed eukaryotic cells to precisely segregate chromosomes have been a mystery for some time. Prokaryotes produce a protein similar to tubulin, but rather than helping move chromosomes about, it helps pinch off the daughter cell from the parent. This protein is known as FtsZ.

When prokaryotes and eukaryotes split is yet another evolutionary mystery, this split is generally believed to have occurred ~ 1-2 billion years ago, but recently a group of organisms that appear to be evolutionarily intermediate has been identified. These organisms are known as the Asgard archaea, whose name references Norse creation myths. A team of scientists, including Caner Akil and Kosuke Fujishima of ELSI, has now identified a protein similar to eukaryotic tubulin in the genome of an Asgard species isolated from the hot spring waters of Yellowstone National Park.

"These new asgard archaeal proteins, which the scientists have named OdinTubulin, in another shout-out to the Norse pantheon, are similar to both eukaryotic tubulins and prokaryotic FtsZ proteins," says Samson Ali, Nagoya University and Okayama University. Linh T. Tran, Okayama University, adds that "OdinTubulin may therefore represent an evolutionary intermediate between prokaryotic FtsZ and eukaryotic microtubule-forming tubulins."

Images:

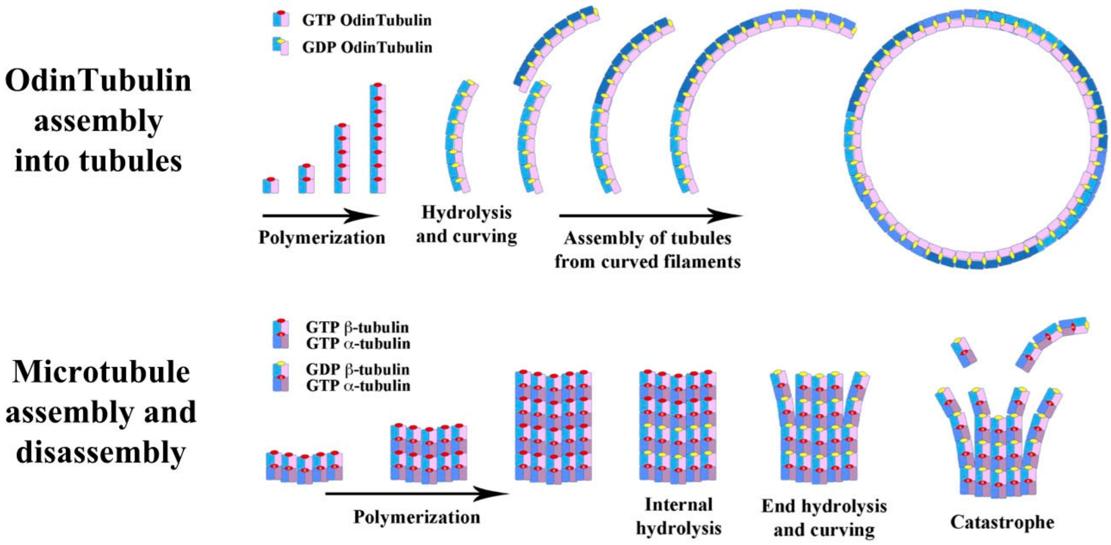


[IMAGE1]

Title: Macro-to-microscopic structures of OdinTubulin.

Caption: Macro-to-microscopic structures of OdinTubulin

Credit: Caner Akıl, Kosuke Fujishima and Robert Robinson / adapted from C. Akıl et al. *Sci. Adv.* 2022



[IMAGE2]

Title: Comparison of OdinTubulin assembly and microtubule assembly/disassembly

Caption: Comparison of OdinTubulin assembly and microtubule assembly/disassembly that is used in chromosome segregation in eukaryotic cells

Credit: Robert Robinson / adapted from C. Akıl et al. *Sci. Adv.* 2022

Reference

Caner Akıl[1,2 †], Samson Ali[1,3 †], Linh T. Tran[1 †], Jérémie Gaillard[4], Wenfei Li[5], Kenichi Hayashida[6], Mika Hirose[7], Takayuki Kato[7], Atsunori Oshima[6,8,9], Kosuke Fujishima[2,10], Laurent Blanchoin[4,11], Akihiro Narita[3*], Robert C. Robinson[1,12*], Structure and dynamics of Odinarchaeota tubulin and the implications for eukaryotic microtubule evolution, *Science Advances*, DOI: 10.1126/sciadv.abm2225

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More information

Tokyo Institute of Technology (Tokyo Tech) stands at the forefront of research and higher education as the leading university for science and technology in Japan. Tokyo Tech researchers excel in fields ranging from materials science to biology, computer science, and physics. Founded in 1881, Tokyo Tech hosts over 10,000 undergraduate and graduate students per year, who develop into scientific leaders and some of the most sought-after engineers in industry. Embodying the Japanese philosophy of "monotsukuri," meaning "technical ingenuity and innovation," the Tokyo Tech community strives to contribute to society through high-impact research.

The Earth-Life Science Institute (ELSI) is one of Japan's ambitious World Premiere International research centers, whose aim is to achieve progress in broadly inter-disciplinary scientific areas by inspiring the world's greatest minds to come to Japan and collaborate on the most challenging scientific problems. ELSI's primary aim is to address the origin and co-evolution of the Earth and life.

The World Premier International Research Center Initiative (WPI) was launched in 2007 by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) to help build globally visible research centers in Japan. These institutes promote high research standards and outstanding research environments that attract frontline researchers from around the world. These centers are highly autonomous, allowing them to revolutionize conventional modes of research operation and administration in Japan.

Okayama University is a national comprehensive university in Okayama prefecture, Japan. It originates from the Medical Training Place sponsored by the Ikeda Domain in 1870. Selected as one of the 30 "Top Global Universities" in Japan with an enrollment of approximately 10,000 undergraduates and 3,000 graduate students. **Research Institute for Interdisciplinary Science (RIIS)** is a new institute established in April, 2016 at Okayama University. RIIS produces world-class research achievements in mathematics, physics, chemistry, and structural biology as an interdisciplinary science institute.

Nagoya University, located in the Tokai Region of Japan, has a total of 16,000 students, of which 2,700 are international students. With a free and open-minded academic culture, it has achieved a variety of cutting-edge research and outstanding results, and the University is home to six researchers who have won Nobel Prizes in the 21st century.