Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)
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IPK scientists uncover paths in centromere type evolution

Press Release

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Gatersleben, 22.12.2025 **The formation of different types of centromere over the course of evolution remained unclear for a long time. An international research team led by the IPK Leibniz Institute examined this phenomenon by studying two lily-like plants. Their findings have now been published in the journal 'Nature Communications'.**

The centromere is necessary for the transport of chromosomes during cell division and, therefore, for the correct transmission of genetic information. Most plants and animals have chromosomes with a single centromere, known as a monocentromere. However, around 350,000 organisms, including nematodes, butterflies, and plants such as nutmeg and papyrus, have a different type of centromere. In this case, there is not only one localised centromere per chromosome, but rather several small centromeres distributed along its entire chromosome length. This is called a holocentromere.

This type of centromere has the advantage that chromosomes with multiple centromeres can respond more effectively to chromosome breaks and rearrangements, since chromosome fragments are not lost during cell division. However, the mechanism underlying the transition between centromere types remains unclear.

In their study, an IPK research team analysed the genomes and centromere organisation of two closely related lily-like plant species: a species with an unusually large monocentromere, and a holocentric species. This comparison provided new insights into the evolution of different chromosome types. "We expected a large centromere to form first and then evolve into a long, elongated centromere in a linear process," says Prof. Dr. Andreas Houben. "However, we found that the second type, the holocentric chromosomes, developed independently of chromosomes with a macromonocentric centromere," explains the head of IPK's research group 'Chromosome Structure and Function'.

"In our study, we demonstrated that the evolution of centromere types is driven by a complex interplay of gene mutations, epigenetic changes, and centromeric DNA expansion," explains Dr. Yi-Tzu Kuo, the study's first author. Over time, a single large centromere formed in the species *Chamaelirium luteum*, whereas a long, elongated centromere developed in *Chionographis japonica*. "For the first time, we have succeeded in accurately describing the giant monocentromere of *Chamaelirium luteum* through sequencing." The IPK team found that, although the centromeric proportion of the total genome is similar in both species at around 15%, it is distributed differently.

"This study expands our knowledge of centromere diversity and demonstrates the value of researching non-model species for evolutionary comparisons," says Dr. Pavel Neumann, a co-author from the Academy of Sciences of the Czech Republic in České Budějovice. "This makes it possible to discover new features, even in structures that have been well studied, such as the centromere."

Original publication:

Kuo *et al.* (2025): Kinetochore mutations and histone phosphorylation pattern changes accompany holo- and macro-monocentromere evolution. Nature Communications.
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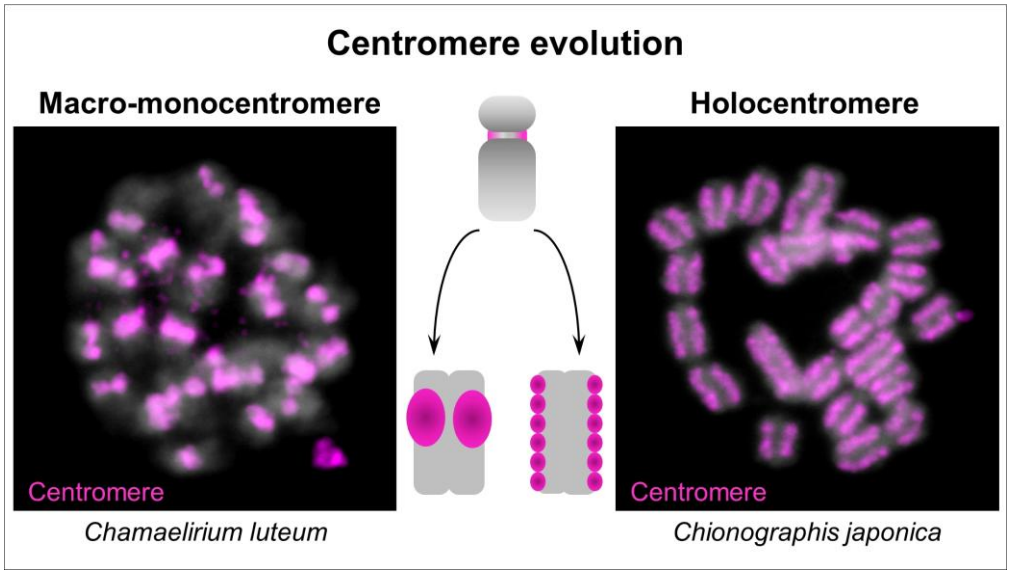
Graphic:



Two different types of centromeres evolved from a monocentromere, a macro-monocentromere in *Cha. luteum* and a holocentromere in *Chi. japonica.* Micrographs show mitotic chromosomes.