# Research shines spotlight on a key player in the dance of chromosomes

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Cell division is essential to life, but the mechanism by which emerging daughter cells organize and divvy up their genetic endowments is little understood. In a new study, researchers at the University of Illinois and Columbia University report on how a key motor protein orchestrates chromosome movements at a critical stage of cell division. The study appeared in the *Proceedings of the National Academy of Sciences.*

Within the complex world of the cell, motor proteins function as a kind of postal service. These proteins carry cargo from one location to another in the cell, a job that requires precision, in both the location and the timing of delivery. They are fueled by a small molecule, adenosine tri-phosphate (ATP).

Some motor proteins are essential to mitosis – the process by which cell division occurs in higher organisms. During cell division it is important for chromosomes to line up at the middle of the parent cell allowing for their separation between the two daughter cells.

Motor proteins play a key role in the movement of chromosomes to and from the poles of the cell. Should any of these processes lose coordination, it could result in disease or cell death.

How chromosomes move during cell division is a question that is fundamental to biology and is of importance in understanding many diseases. University of Illinois physics professor Paul Selvin and his colleagues focused on a motor protein, centromeric protein E (CENP-E)

that is known to be associated with chromosomes.

“The question is whether CENP-E acts like a transporter or like an anchor,” Selvin said.

“A transporter moves things around the cell, whereas an anchor sits someplace in the cell, holds onto something, and causes the thing to be held down,” Selvin said. “It turns out CENP-E is known to be an anchor, but is it also a transporter?”

Earlier studies had established a role for CENP-E in aligning paired chromosomes. This alignment is important for ensuring that one of each pair makes its way into a different daughter cell.

CENP-E is part of a large class of proteins called kinesins. These motor proteins walk across the cell on special tightropes, called microtubules, using ATP as an energy source.

“The motion of ’normal‘ kinesin, kinesin-1, is now well known,” Selvin said. “It turns out it’s like a little person – it walks with its two feet, one in front of the other. I was interested to know whether the normal rules of how kinesin walks apply to these different kinds of kinesins.”

“In vivo studies are hampered by the presence of lots of other proteins, making it hard to study how much a single protein moves, how fast it moves and how much force it produces,” said Hasan Yardimci, a post doctoral researcher in Selvin's lab and lead author on the study.

Instead, Yardimci used a technique that allowed him to look at one molecule at a time.

The most direct way to measure how a protein moves is to watch it in real time. Using special molecular bulbs called quantum dots, which light

up the protein, Yardimci was able to watch CENP-E move along its microtubule tightrope. By resolving these motions on the nanometer scale, he was able to make two key observations.

“The protein takes eight nanometer steps in a hand-over-hand fashion,” Yardimci said. The protein moved in a direction consistent with the way chromosomes move within cells, over lengths that are normally observed during cell division.

To test the kind of loads that CENP-E could withstand, Yardimci set up a tug of war between a micron-sized bead and the protein. As the protein moved, it pulled on the bead.

By measuring the force on the bead, the researchers were able to calculate how much force CENP-E could exert.

The observation that CENP-E shares several common features with kinesin-1 provides insights into its molecular workings.

“We showed that it is likely that CENP-E moves chromosomes around,” Selvin said. “That is, we showed that it is a transporter in vitro, hauling around a little bead. Now we need to do it in vivo, on chromosomes.”

Source: University of Illinois at Urbana-Champaign