Journal club

CHROMOSOMES WORK BETTER WHEN THEY ARE TENSE

Although science often proceeds by systematic advances that are driven by our intellectual abilities, certain advances have only been made thanks to awe-inspiring sleight-of-hand. Take the experiment that Bruce Nicklas designed to test Dietz's theory that chromosomes adopt bipolar orientations during metaphase of mitosis and meiosis because this orientation enables them to be under tension.

Nicklas predicted that: "If natural spindle tension toward opposite poles makes bipolar orientation stable, then artificial tension should stabilize unipolar orientations." To test this, he used a microneedle to shape a chromosome, such that both

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kinetochores bound the same pole. When the microneedle was retracted, the chromosomes dropped the microtubules within 16 minutes, reorientated and then bound microtubules from opposite poles.

Crucially, Nicklas then repeated the chromosome manipulation, but with a twist. When both kinetochores were attached to the same pole, he then used the microneedle to carefully stretch the chromosome away from the pole, replicating precisely the force that biorientated chromosomes would be under. In over 5 hours of holding 8 chromosomes, none of them let go of the microtubules.

So, a kinetochore is like a puppy. Throw it a stick and ignore it, and it soon drops the stick to explore other possibilities. If you pull on the stick, however, the puppy holds on with all its might until you let go. With this simple, classic, virtuosic experiment,

Nicklas firmly established that tension regulates chromosome behaviour. Moreover, he posed questions that remain at the cutting edge of kinetochore research. How do kinetochores sense tension? How can tension cause the molecular interactions between kinetochores and microtubules to become less reversible? And, importantly, how did Nicklas manage to hold the microneedle so steady throughout his experiments?

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ORIGINAL RESEARCH PAPERS Nicklas, R. B. & Koch, C. A. Chromosome micromanipulation. 3. Spindle fiber tension and the reorientation of mal-oriented chromosomes. *J. Cell Biol.* **43**, 40–50 (1969) | Dietz, R. Multiple geschlechtschromosomen bei den cypriden ostracoden, ihre evolution und ihr teilungsverhalten. *Chromosoma* **9**, 359 (1958) (in German)