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The long and short of sperm tails

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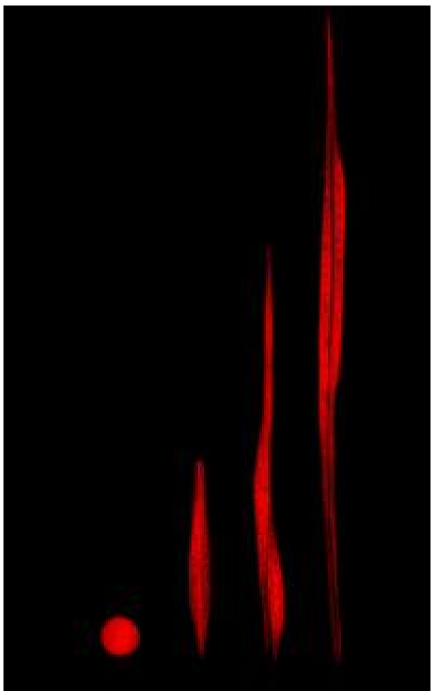

Giant mitochondria in the tail of fruit fly sperm elongate and show an increase in length, while the volume remains constant. Credit: 2011 Shigeo Hayashi

A team of biologists in Japan has uncovered an unexpected role for mitochondria1, the power houses of cells, in the development of sperm in the fruit fly Drosophila melanogaster.

Drosophila melanogaster belongs to a family of two-winged flies called the drosophilids. Some drosophilid species have sperm with short tails, but others have exceptionally long tails. Males of D. bifurca, for example, produce sperm with tails that are over twenty times as long as the insect itself. "The diversity of sperm morphology among drosophilid flies has long fascinated reproductive and evolutionary biologists alike," says Shigeo Hayashi of the RIKEN Center for Developmental Biology, Kobe, who led the team.

Biologists believe that the long sperm found in some drosophilid species evolved in response to strong post-mating selection driven by 'sperm competition', the race between sperm from different males to fertilize an egg. Longer sperm would have the advantage of positioning their head closer to the egg.

Sperm movement is driven by waves that propagate along a hair-like motile structure called the flagellum within the sperm tail. The flagellum core, called the axoneme, is composed of microtubules formed of tubulin molecules arranged in chains. "We were aware from previous studies using mutant flies that the axoneme is dispensable for sperm cell elongation, so we set out to understand the underlying mechanism," explains Hayashi.

In addition to the axoneme, the membrane-bound sperm tails of insects typically contain giant mitochondria that extend along their entire length, as well as free microtubules. Working with D. melanogaster, Hayashi and his colleagues showed that sperm tail growth is driven by the mutually dependent extension of the giant mitochondria and microtubules that form around them (Fig. 1).

Experiments with cultured spermatids, the precursors of sperm, revealed that sperm elongation crucially depends upon the integrity of mitochondria and the reorganization of microtubules at the growing tip. In addition, the researchers found that the essential sliding movement of microtubules at the tip requires accumulation of Milton, a mitochondria–microtubule linker protein.

Hayashi and colleagues showed that experimentally disrupting Milton and its associated protein dMiro, as well as the potential microtubule cross-linking proteins Nebbish and Fascetto, caused defective tail elongation, resulting in abnormal sperm. They also showed that spermatid tail elongation requires both the association between mitochondria and microtubules, and microtubule cross-linking. "We have demonstrated that mitochondria form a structural platform for microtubule reorganization, which supports robust elongation at the growing tip of the long sperm tail," Hayashi concludes.

More information: Noguchi, T., et al. Sustained elongation of sperm tail promoted by local remodeling of giant mitochondria in Drosophila. *Current Biology* 21, 805–814 (2011). www.riken.jp/engn/r-world/rese … b/cdb/mor/index.html

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