Proper developmental patterning in worms determined in part by effective range at which signaling molecule can act

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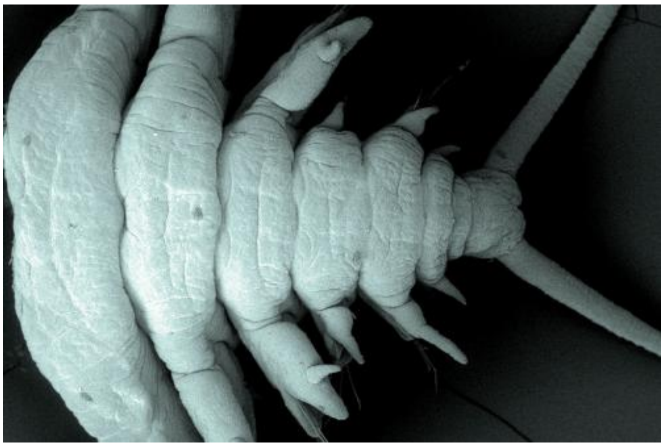

Figure 1: Electron microscopy image of the posterior end of Perinereis nuntia, where new segment addition takes place as the worm grows. Credit: 2013 Shigeo Hayashi, RIKEN Center for Developmental Biology

During development, vertebrate embryos rely on a process called segmentation to establish fundamental body patterning. This entails the formation of orderly bands of cells, which can subsequently contribute to the formation of skeletal elements and associated tissues in response to developmental instructions. Insects and worm embryos undergo similar segmentation processes during development but with notable mechanistic differences that remain to be fully clarified. Now, a research team led by Shigeo Hayashi from the Laboratory for Morphogenetic Signaling at the RIKEN Center for Developmental Biology in Kobe has gained new insight into the process of annelid segmentation through a series of experiments using the marine worm Perinereis nuntia.

The P. nuntia worm (Fig. 1) is known to show vigorous regenerative activity. The researchers exploited this capacity for regeneration to monitor the timing of segment formation under controlled experimental conditions.

Segment formation typically occurs in an anterior to posterior (front to back) sequence and is governed in part by signaling proteins called Wingless and Hedgehog. Hayashi and his colleagues determined that regeneration of an amputated posterior segment begins with the production of Wingless in the cells immediately anterior to the site of regeneration. This leads to the production of Hedgehog in the next row of cells, which form the front of the new segment, followed by multiple rounds of cell division that lead to complete segment formation within approximately 24 hours. "We were surprised by the highly regular and periodic pattern of new segment addition that we observed at cellular resolution," says Hayashi.

Each of the segments that formed during the process of regeneration consists of five rows of cells. "This implies that segment addition is precisely controlled by a system that counts the number of cellular rows added per segmentation cycle," says Hayashi. He and his colleagues hypothesize that this count is established by the range of Wingless signaling, as their results showed that cells in the final row of the segment underwent cell division at a considerably lower rate than observed in the first row of cells. Conversely, worms treated with a chemical that stimulates excessive Wingless signaling formed more rows of cells per segment, suggesting that segment-forming activity was increased.

These results indicate a potentially critical role for Wingless in establishing both the timing and scale of segment formation, which may generally explain the essentially unlimited activity of segmentation in worms. "Exploring how this signaling system controls segment length measurement will be an interesting future challenge," says Hayashi.

More information: Niwa, N., Akimoto-Kato, A., Sakuma, M., Kuraku, S. & Hayashi, S. Homeogenetic inductive mechanism of segmentation in polychaete tail regeneration. *Developmental Biology* advance online publication, 20 April 2013 (DOI: 10.1016/j.ydbio.2013.04.010).

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