'Penis worm' pokes holes in evolutionary dogma

Priapulid highlights the need to rename the largest animal group.

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26 October 2012

A study on the development of priapulids or 'penis' worms throws doubt on a feature that has been thought for more than 100 years to define the largest branch of the animal tree of life. Members of this branch — the protostomes — have historically been defined by the order in which they develop a mouth and an anus as embryos. But gene-expression data suggest that this definition is incorrect, researchers report this week in *Current Biology*[1].

Evolutionary biologists will need to rename the protostomes. To do that, "we need to rethink how our earliest ancestors developed," says Andreas Hejnol, an evolutionary developmental biologist at the University of Bergen in Norway and lead author on the report.

Deep roots

Tiny differences in how embryos develop have defined branches of the animal tree of life because they can lead to monumental changes in adults. For example, a major step in evolution occurred when an embryonic ball of cells formed two indentations as opposed to one, giving way to a separate mouth and an anus rather than the single opening that creatures such as jellyfish and sea anemones have. In 1908, animals with a mouth and anus were divided into two groups. In the protostomes (from the Greek for 'mouth first'), the mouth formed first, and the anus second. In the other, the deuterostomes ('mouth second'), the mouth formed after the anus.

Today, the protostomes include priapulids and most other invertebrates. The deuterostomes include vertebrates such as humans and a few spineless animal lineages. Embryologists have examined only a fraction of animals in each group, because tracing how each cell divides and what it gives rise to remains technically challenging. Nonetheless, other characteristics, such as DNA sequence data, have supported the general shape of this evolutionary tree, and the division between protostomes and deuterostomes has persisted.

Shaking the tree

Now, using molecular techniques to analyse gene expression, Hejnol and his team have revealed that a primitive protostome, the

priapulid *Priapus caudatus*, develops like a deuterostome. These ‘living fossils’ look nearly identical to their priapulid ancestors, which littered the ocean floor during the Cambrian period, when protostomes originated (see ‘Protostome outlier’). That their development does not follow the protostome pattern suggests that early protostomes might also have developed differently. The order of the origin of the mouth and anus is now uncertain.

"Here is an animal that is the poster child for early protostomes, and it develops just like a deuterostome," says Mark Martindale, a developmental biologist at the University of Hawaii in Honolulu. “We’ve been using the name protostome for 100 years, and now it’s clear that it doesn’t mean anything.”

Priapulids are not simply placed on the wrong side of the tree. Other similarities, such as DNA sequences, indicate that they are closely related to their protostome kin. Further, this is not the first report of a maverick protostome. Embryologists who have watched invertebrates develop under a microscope have previously noted variations in how protostome mouths develop. Hejnol’s study corroborates the underlying diversity and takes the evidence further by backing it up with molecular techniques and assessing a primitive protostome, says Martindale.

The researchers observed where genes associated with mouth and anus formation turn on in three-day-old embryos. As the first cells caved in, genes typically expressed in animals’ rears activated, indicating that the cells in this region form the anus. “This is a big achievement because for years, people have wanted to do work like this in priapulids, but it’s technically very difficult,” says Detlev Arendt, an evolutionary developmental biologist at the European Molecular Biology Laboratory in Heidelberg, Germany.

Arendt agrees that a new name is in order, but says that biologists do not have one prepared because they disagree about whether mouth and anus formation or another key innovation should be used to name the group.

Just as molecular techniques have revealed data that triggered revisions in cell biology, techniques to sequence genes and observe their activity are now challenging long-standing evolutionary scenarios. "At the turn of the twentieth century, embryologists drew what they saw. But their microscopes stunk and they didn't know about genes," Martindale says. "Now we're finally able to look closer, and we're finding that they're often wrong. But if you think about the tools they had, maybe it's more surprising that anything is right at all."

Nature | doi:10.1038/nature.2012.11667

References

1. Martín-Durán, J. M., Janssen, R., Wennberg, S., Budd, G. E. & Hejnol, A. *Curr. Biol.* http://dx.doi.org/10.1016/j.cub.2012.09.037 (2012).