

# Title

Life-long indeterminate growth in brittle stars is driven by a subterminal growth zone at arm tips.

## Authors

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## Abstract

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### Background

Echinoderms are a phylum of marine invertebrates with shared ancestry with chordates. Unlike chordates, many members of the phylum Echinodermata are capable of extensive post-traumatic regeneration and life-long indeterminate growth. Different from regeneration, the life-long elongation of the main body axis in adult echinoderms has received little attention. The anatomical location and the nature of the dividing progenitor cells contributing to adults' growth is unknown.

### Results

We show that the proliferating cells that drive the life-long growth of adult brittle star arms are mostly localized to the subterminal (second from the tip) arm segment. Each of the major anatomical structures—including the radial nerve, water-vascular canal, and arm coelom—contains its own dividing progenitors. At least some of those proliferating progenitor cells are capable of multiple rounds of cell division. Within the nervous system, the progenitor cells were identified as a subset of radial glial cells that do not express *Brn1/2/4*, a transcription factor with

a conserved role in the neuronal fate specification. In addition to characterizing the growth zone and the nature of the precursor cells, we provide a detailed description of the microanatomy of the four distal-most arm segments and, for the first time in the literature, outline their distinct structural differences from the well-studied more proximal, "mature," segments.

## Conclusions

The growth of the adult brittle star arms occurs via proliferation of progenitor cells in the distal segments, which are most abundant in the second segment from the tip. At least some of the progenitors are capable of multiple rounds of cell division. Within the nervous system the dividing cells were identified as Brn1/2/4-negative radial glial cells.

## Supplementary materials

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Files in here ([Zenodo](#), DOI: [10.5281/zenodo.5762494](https://doi.org/10.5281/zenodo.5762494)) are the supplementary digital materials corresponding to the article "Life-long indeterminate growth in brittle stars is driven by a subterminal growth zone at arm tips," written by Mashanov et al. Files include:

- **Video file** ( [Morphology.avi](#) ): Video illustration of the three-dimensional reconstruction of the arm tip of *Amphipholis kochii*.
- **Blender file** ( [Model.blend](#) ): Blender file containing the 3D model of the *A. kochii* arm tip morphology.
- **File S1** ( [FileS1\\_Statistics.Rmd](#) ): R Markdown file (R version 4.0.4). This file contains the data and statistical analysis about proliferating cells counted in the four terminal arm segments of five different individuals, using only one arm per individual.