Multiple lines of evidence are used to identify the growth zones that produce asteroid arms. Evidence includes skeletal morphology, growth series specimens, regenerating specimens, branch-arm and arm stump specimens, positional information theory, regeneration models (distal-signaling), and identifying rudiment-derived and non-rudiment-derived body wall in the post-larvae.

Archaster angulatus (USNM 1139740) with arm stump that healed and did not regenerate the arm. The plates are smooth and join on the midline. This distinctive non-regenerating stump condition indicates that positional information in the asteroid arm is left-right symmetrical, and that outgrowth of the asteroid arm is by intercalation between a full-surface distal-signaling center and the last-formed section of arm (Hotchkiss 2005, Hotchkiss & Keesing 2012, Hotchkiss 2012). Photographed alive by J. Keesing (top images); bottom images dry.


The revision is that the asteroid arm lacks extraxial skeleton. In A, axial skeleton is produced only at the edge of the terminal/ocular plates that is directed toward the mouth (adoral edge). In B, the asteroid growth zone produces axial skeleton in the full surround of the terminal plates. In B, asteroid arms are composed of axial skeleton of the tenton of and of gusset plates that are developmentally secondary to the axial skeleton (actinal, intermarginal, and dorso-lateral gusset plates not separately diagrammed).

Regenerating arm tips help to determine growth zones because the blastema of regeneration is also the blastema of normal growth. Growth zones encompass all the plates ontogenetically related to a given terminal plate, plus the terminal plate itself. The youngest plates are next to the terminal plate.

A. B. Abactinal and undersurface views of Linokia laevigata (USNM 111695) with a regenerating arm; the smallest regenerating ambulacral, adambulacral, inferomarginal (IM), superomarginal (SM), and dorso-lateral gusset plates are in contact with the terminal; the regenerating arm is already integrated into the body contours.

The boundary between extraxial abactinal plate (green) and arm skeleton is neatly demonstrated in (A) Crenaster wallyi, and plausibly inferred in (B) Postopodaster polypoides and (C) Porcellanaster caeruleus. (A. C. after Sladen 1889; B. after Clark & Wright 1962).

As analyzed here, the growth zones develop arm plates in the full surround of the arm tip. This is congruent with regeneration models. The OPR applies individually to asteroid ambulacral, adambulacral, IM, and SM. Middribal abactinal plates form either consistent with the OPR, or as gusset plates that are developmentally secondary to superomarginals. Plate series that obey the OPR are defined to be axial skeleton. Secondary development of gusset plates does not change the status of OPR-formed axial plates. Gusset plate systems are often well supplied with papular pores.

An application is to understand the evo-devo origin of arms as outgrowths: the event that led to outgrowth of asteroid arms was acquisition of distal-signaling around the full periphery of each arm tip (full-surface distal-signaling).

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