Supplementary Information for

Three-dimensional reconstructions of the putative metazoan Namapoikia show that it was a microbial construction

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Supporting Information Text

A. Comparative Morphological Analysis.

The scale and variance of partitions and interpartition spacing aside, cross sections of Namapoikia are similar to those of certain specimens of hypercalcified sponges in the literature. To demonstrate how these apparent 2D similarities do not translate to 3D morphological characteristics, we compare Namapoikia to three groups of sponges, selected either because of a previously proposed affinity or because of a striking visual resemblance in two dimensions.

We begin by considering the polyphyletic group Sphinctozoa, which is characterized by the presence of articulated chambers [Fig. S1C; (1)]. These chambers are internally segmented and may contain skeletal elements that form while compartments are being actively utilized by the sponge. Chambers are evacuated as the organism grows. For example, in Vaceletia crypta, living tissue occupies the spaces of the chambers of the organism, while skeletal elements in older, evacuated regions progressively calcify and thicken over time (2). Our Namapoikia reconstructions lack laterally extensive, unbroken tabulae (Figs. 2 C and D, S1F), precluding a chambered construction and ruling out sphinctozoans as analogs. Additionally, since partitions are not appreciably thicker towards the bottom of specimens (and, in one of the specimens, actually become thinner; Fig. 3E), as would be expected if the organism grew like V. Crypta, it is likely that Namapoikia did not undergo progressive calcification of partitions post-construction (if it did, it exhibited a significant underfilling of evacuated regions (3)).

Next, we turn to the chaetetids, another polyphyletic group of sponges (4). Chaetetids such as Acanthochaetetes seunesi build closely packed, regularly spaced vertical tubules. Typically, tubes are circular to elliptical in cross-section and contain irregularly spaced tabulae (Fig. S1D). Although Namapoikia specimens do appear to be made up of tubules in longitudinal sections, 3D reconstructions demonstrate that interpartition voids are extensive, sinuous, and often sheet-like (S1F). Furthermore, the presence of large voids that are punctuated throughout both reconstructions is inconsistent with the regular, ordered growth of chaetetid tubules. Finally, interpartition spaces in Namapoikia lack even discontinuous connective tabulae. Taken together, these morphological findings exclude chaetetids as an analog for Namapoikia.

Lastly, we examine the tabulae-free polyphyletic group Inozoa (1). Some inozoans—namely the aspicular Inozoida Auriculapora perforata—appear to be visually similar in cross-section to Namapoikia, with sinuous structural elements splitting and merging in both transverse and longitudinal directions (1). For comparative analysis, we reconstruct a single specimen of A. perforata from upper Permian bioherms in the Djebel Tébaga region of Tunisia (USNM PAL 70646 (5)). The A. perforata reconstruction comprises a skeleton that radiates upwards from the bottom and outwards from the center and lacks large voids (Fig. S2B, Movie S3). The specimen exhibits a narrow range of skeletal and void thicknesses (280/330/396 and 268/312/351 microns for skeletal elements and void spaces, respectively; Fig. 3A), the scale of which is typical for inozoans (G. discoforma (6) being an exception). Skeletal elements regularly split and merge in transverse and longitudinal sections to form a lattice-like structure (Fig. S1E). This structure produces compartments, which have a height to width aspect ratio of 1.5 (Fig. S1E). In contrast, reconstructed Namapoikia specimens only exhibit regular spacing in longitudinal sections, suggesting that Namapoikia did not create compartments like A. perforata. Additionally, unlike the A. perforata sample, Namapoikia specimens do not exhibit a radiating skeletal pattern and have much a greater scale and variance of partition and interpartition sizes (Fig. 3 A, B, and C). On the basis of these morphological differences, it is unlikely that Namapoikia was an inozoan.

Movie Captions

Movie S1. A 3D reconstruction of Sample A, depicting a morphology of splitting and merging curtains with no clear evidence of tabulae.

Movie S2. A 3D reconstruction of Sample B.

Movie S3. A reconstruction of an A. perforata specimen. Note the regularity of both the skeletal and void dimensions.

Movie S4. A 3D reconstruction of a Favosamaceria cooperi specimen. Note the difference in scale—F. cooperi is not a true analog for Namapoikia, but serves as a demonstration of how microbially-mediated structures can build splitting and merging walls, much like Namapoikia.

References

4. West RR (2011) Treatise online, no. 20, part e, revised, volume 4, chapter 2a: Introduction to the fossil hypercalcified chaetetid-type porifera (demospongiae). Treatise Online.
Fig. S1. Connected components and skeletal area relationships of proposed models/analogues and Namapoikia. A and B. Transverse and latitudinal sections through the models shown in C–F. Letters in circles denote which model the section is from. Wireframe models in A and B depict representative transverse and latitudinal transects through specimens, respectively, corresponding to the plots in C–F. C. A simplified synthetic model of chambered construction, representative of spininctozoans. Partitions and tabulae are highlighted in white and blue, respectively. When taking sections through the specimen transversely or latitudinally, connected components decrease and the amount of occupied area increases as a tabula or partition is encountered. This negatively correlated relationship provides a search image for perpendicular tabulae. D. A simplified synthetic model of a chaetetid construction, modelled after transverse images of A. seunesi (4). Although tabulae (highlighted in blue) can be irregularly spaced in any one tubule, they still appear as small peaks of occupied area in transverse sections. Importantly, both transverse and latitudinal sections through the specimen reveal a strongly connected skeleton. E. Reconstruction of A. perforata. The sample exhibits regularity in both transverse and latitudinal transects. Strong negative correlations between occupied area and connected components suggest the presence of compartments. Note the peaks present in skeletal area and use of average spacing between peaks to calculate an aspect ratio for the compartments. F. Reconstruction of Namapoikia sample B. Transversely, there is a weak correlation between occupied area and connected components (influenced by the presence of a large void, marked), precluding tabulae. The movement of individual partitions, which propagated, shrank, joined, and split, appear as high frequency variations in occupied area. Latitudinally, the spacing between partitions are clearly expressed, and, as expected, there is a negative correlation between occupied area and connected components. Where applicable, correlation coefficients between occupied area and connected components are reported as \( r \); asterisks denote statistical significance (\( p < 0.001 \)). For E and F, correlation coefficients are calculated for smoothed data. Scalebars depict 0.5 centimeters.
Fig. S2. A. Two slices through *A. perforata*. Left, a latitudinal face of the sample. Right, a transverse face. B. Rendering of the *A. perforata* reconstruction. Scalebars at the bottom left of each panel depict 0.5 centimeters. As in the main text, the direction of stratigraphic up is denoted by the red arrow on the axis figure above the scalebar in each panel.
Fig. S3. A modified still from Movie S3 that illustrates the splitting/merging present in sinuous vertical elements (or maceriae) of a reconstructed *F. cooperi* specimen. Yellow outlines mark the contours of the specimen at the slice plane.