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**The "ventral rib" of the shell in *Spirula*
(Cephalopoda, Coleoidea): a cryptic rostrum?**

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Abstract: After more than 100 years a membrane of the *Spirula* shell is rediscovered. This sagittal membrane lies between the initial chamber and the ventral surface of the subsequent chambers. The membrane may be a guiding structure and mechanical reinforcement during the formation of the early chambers. The evolutionary origin of the membrane is likely related to a rostral formation.

Zusammenfassung: Nach mehr als 100 Jahren wurde eine fragile Membran an der Schale von *Spirula* wiederentdeckt. Diese Membran befindet sich zwischen dem Protoconch und der ventralen Oberfläche der anschließenden Kammern und ist rein organisch. Bei lange in Bouin fixiertem Material sind Anwachsstreifen zu finden. Die Membran könnte eine formende und festigende Aufgabe beim Bau der ersten Kammern besitzen und evolutiv mit dem Rostrum zusammenhängen.

Keywords: Cephalopoda, *Spirula*, shell, ventral rib, rostrum

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Introduction

In the shell of *Spirula*, Branco (1880) described a peculiar sagittal membrane lying between the initial chamber and the ventral surface of the subsequent chambers. Appellöf (1893) confirmed these observations, whereas Naef (1922) figured a "ventral rib" that clearly represents only part of the membrane under discussion (Fig. 1). Freshly recovered material from animals caught in mid-water allows us to describe this structure, its variability, and also its frail nature. The instability of the membrane in exposed shells suggests that beach collected shells lacking the membrane are incomplete due to mechanical removal (abrasion). Finally, we address the question whether this structure represents a greatly reduced rostrum.

Material and Methods

A total of 16 shells dissected from animals caught by midwater trawl in the eastern North-Atlantic were used. Five specimens yielded most of the essential information. After dissection from fresh dead or preserved animals (fixed in formalin and preserved in 75% ethanol), shells were examined under a dissecting microscope, air-dried or critical point dried, and processed for SEM (Stereoscan 360, Cambridge Instruments or LEO 1450 VP, Zeiss), with gold sputtering for most specimens. For comparison a specimen preserved in Bouin's fluid for 36 years was dissected and its shell examined.

Results and Discussion

The "ventral rib" described by Naef (1922) turns out to be the solid base of the sagittal membrane, which is secreted by the shell sac epithelium (Fig. 1, Fig. 2). This membrane is purely organic and shows striations that reflect appositional growth. The free edge is a slightly curved, slanting line. Depending on the length of preservation (max. 36 years) the membrane is more or less condensed and hardened.

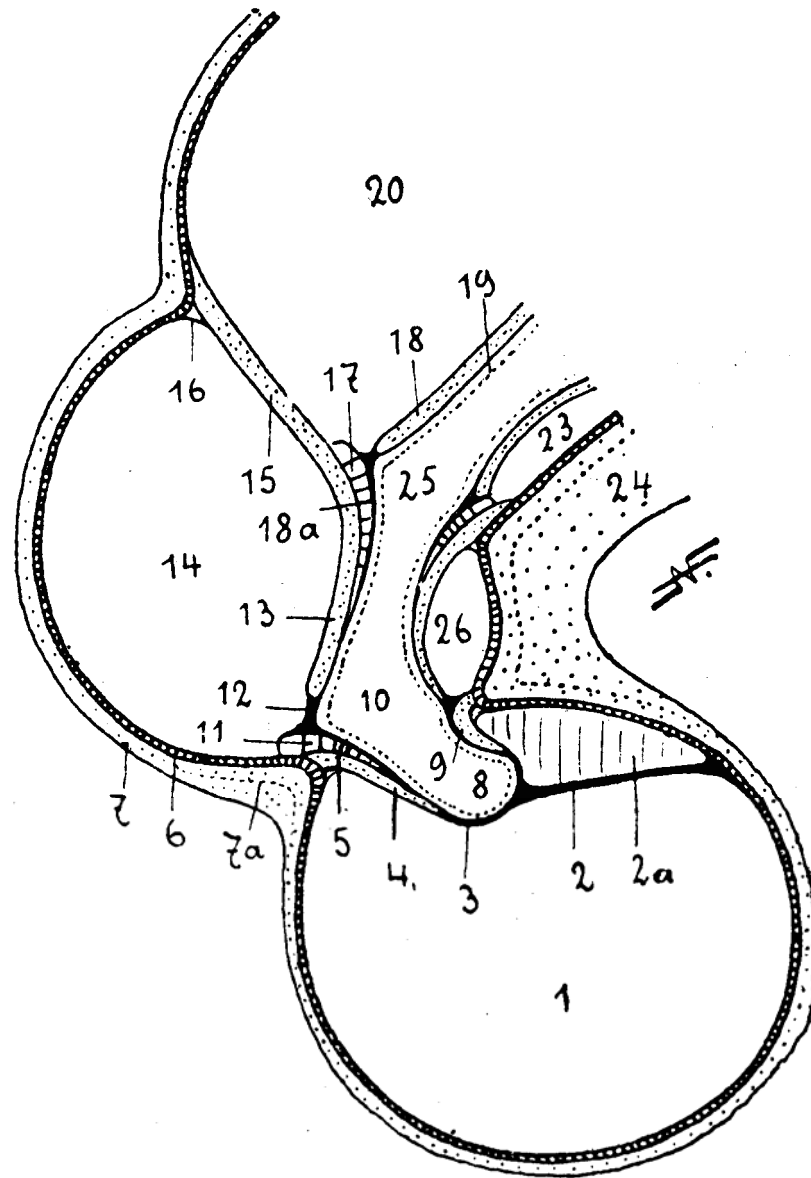


Fig. 1: Median section through the initial part of a *Spirula* shell (from Naef, 1922, p. 45, Fig. 27). $\frac{32}{1}$ nat. size. This figure integrates the data and figures of Appellöf (1893), especially his Pl. 9, Fig. 1.

The primary shell wall (ostracum and hypostracum) is marked by cross hatching (6), the periostracum is dotted (7); as are the septa and calcified cones (18, 15, 13, 5, 4). In the siphuncle the epithelium of the soft body is marked by dots. 1. initial chamber; 2. prosiphuncle (cross stay); 2a. sagittal lamella of prosiphuncle; 3. beginning of the conchiolin cap forming the initial part of the shell siphuncle; 4. adjoining calcified cone of first septum (rudimentary); 5. conchiolin cone of the second septum (extending through 12 to 13); 6. shell wall, ostracum and hypostracum; 7. periostracum; 8. beginning of fleshy siphuncle; 9. first cone and septum, ventral part; 10. septal knot of fleshy siphuncle; 11. pillar material; 12. conchiolin cone (beginning); 13. calcified cone of second septum; 14. second chamber; 15. second septum; 16. corner substance; 17. pillar belonging to the third cone; 18. third calcified cone; 19. siphuncular epithelium; 20. third air chamber; 23. ventral part of third air chamber; 24. ventral rib of periostracum; 25. second septal knot of siphuncle; 26. ventral part of second air chamber.

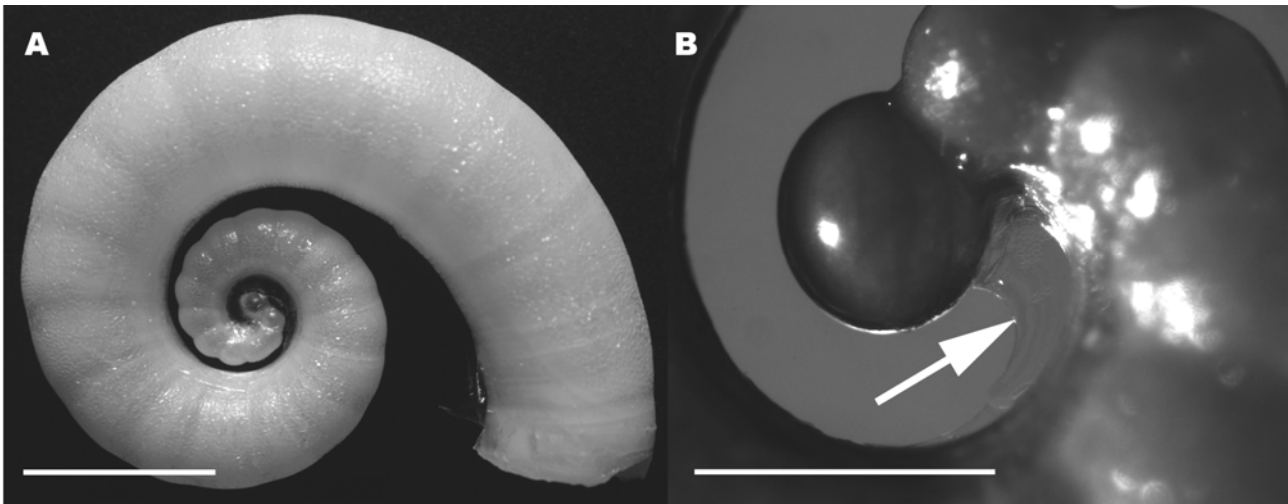


Fig. 2: Shell of freshly caught a) adult (scale bar = 5 mm) and b) juvenile (scale bar = 1 mm) *Spirula spirula* (arrow indicating sagittal membrane/ventral rib).

Fresh and recently preserved shells do not show the “growth lines” as distinctly as old specimens. The ventral rib may be a guiding structure and mechanical reinforcement during the formation of the early chambers, before the phragmocone as a whole provide the lead structure for the spiral complex of the subsequent chambers.

The evolutionary origin of the rib/membrane is likely related to a rostral formation, i.e. a putative rostral crest.

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