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Cenozoic Dasycladales

**A photo-atlas of Thanetian,
Ypresian and Bartonian species
from the Paris basin**

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(2011: : Livre 1 - Book 1)

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Cenozoic Dasycladales.

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A photo-atlas of Thanetian, Ypresian and Bartonian species from the Paris basin.

Patrick GENOT & Bruno GRANIER

Following the publication of the photo-atlas of living Dasycladales (BERGER, 2006) and their fossil representatives from the Lutetian of the French Cenozoic basins (GENOT, 2009), we propose a photo-atlas of 17 species discovered in the Thanetian, Ypresian and Bartonian sediments of the Paris basin.

Cenozoic Dasycladales of the French sedimentary basins are noteworthy for the exceptional quality of their preservation. Although most fossil Dasycladales are known only in thin sections often difficult to interpret, the coatings of the Dasycladales in these basins, particularly in the Paris basin, are easy to extract from sandy sediments and then are examined under the electron microscope. This method of investigation facilitates greatly the identification of the external and internal features of each species.

The preservation of the species depends on the initial degree of calcification, which may vary greatly. Thus, using species in this atlas as models:

- most of the thallus is calcified in *Zittelina dactyloporoides*: main axis, laterals, gametophores and gametangia (cysts),
- laterals and gametophores without gametangia are entirely calcified in *Cymopolia zitteli*,
- laterals are calcified but fertile organs are unknown in *Belzungia*

borneti,

- elongated gametophores containing gametangia are the only calcified organs in *Acicularia eocaenica*,
- gametophores and secondary laterals are well calcified but primary laterals are rarely calcified in *Neomeris arenularia* and *N. scrobiculata*,
- groups of small gametophores are calcified but laterals are partially calcified in *Jodotella veslensis* or uncalcified in *Jodotella thilense* and *Carpenterella morelleti*,
- gametophores and secondary laterals are well calcified while the primary laterals are still unknown in *Neomeris craniphora* and *N. herouvalensis*,
- some parts of the laterals are preserved in *Uteria encrinella* but gametophores are unknown...

Main morphological features of the species figured in this photo-atlas are already well-known (Fig. 1). However, almost all the photos are new and some of them show for the first time features that have never been or were incompletely illustrated.

► **Figure 1** : Main morphological features of the genera represented by species in the Ypresian, Thanetian and Bartonian sediments of the Paris basin (drawings: Alain COSSARD).

GENERA	MAIN MORPHOLOGICAL FEATURES OBSERVED ON FOSSILS	SHAPE OF THE THALLUS	SCHEMATIC ASPECT OF THE ORGANS
Acicularia	<i>Isolated or associated elongated gametophores (spicules) arranged radially. Numerous gametangia (cysts) embedded into a lime matrix filling the gametophores.</i>		
Belzungia	<i>Up to six orders of slender lateral segments. Last orders irregularly arranged inside the wall. Reproductive organs unknown.</i>		
Carpenterella	<i>Gametophores clustered in tufts (probably located along the sides of the laterals).</i>		
Clypeina	<i>Superposed crowns of tubes interpreted as gametophores arranged radially..</i>		
Cymopolia	<i>Segmented thallus. Two orders of lateral segments in fertile whorls. The top of each primary lateral segment bears numerous secondary laterals surrounding a gametophore. No cyst.</i>		
Dactylopora	<i>Numerous gametangia scattered in the calcareous wall or set in groups along the sides of the laterals.</i>		
Jodotella	<i>Primary lateral segments each bearing two secondary laterals and clusters of two or three gametophores.</i>		
Neomeris	<i>Two orders of lateral segments. The top of each primary lateral segment bears two secondary lateral segments surrounding a gametophore. Uncalcified cyst in each gametophore in living Neomeris, never observed on fossils.</i>		
Parkerella	<i>Pairs of gametophores, well individualized inside the wall. Lateral segments unknown.</i>		
Uteria	<i>Segmented thallus. Alternation along the stalk of whorls of slender sterile lateral segments (SS) and of very enlarged fertile segments (FS) bearing short secondary segments.</i>		
Zittelina	<i>Rounded or irregular gametophores arranged along the sides of the lateral segments. Calcification surrounds several gametangia (cysts) inside each gametophore.</i>		

calcified organs

uncalcified organs

G

gametophore

g

gametangia (cyst)

R₁, R₂, ...

primary lateral segment, secondary lateral segment, etc...

A

stalk or main axis

SS

sterile lateral segment

FS

fertile lateral segment

New information concerns:

- the arrangement of the gametangia, observed in a tangential section of a gametophore in *Acicularia eocaenica*,
- the internal surface of the main axis showing the location of the proximal ends of the primary laterals in *Belzungia borneti*,
- the internal surface and the longitudinal section of the tubular calcification of the main axis in *Dactylopora cylindracea*; the previous photos concerned only the transverse sections (LUCAS & POBEGUIN, 1954, pl. 5, fig. 2; BYSTRICKÝ, 1976, "*Dactylopora* aff. *cylindracea*", fig. 3) and the top of the main axis (GENOT, 1980, pl. 23, fig. 8),
- the features of the sheath and the morphology of the gametophores in *Neomeris defrancei*, the arrangement of the units containing the gametophores in *Parkerella binodosa*; these features were difficult to see on the original illustrations (L. & J. MORELLET, 1922, pl. 1, figs. 12-18, 53-55) because the photos are too small,
- the longitudinal section of an exceptionally preserved sheath of *Neomeris scrobiculata* shows the internal surface of the calcification of the main axis and the calcification of several primary laterals; a transverse section of the sheath showing these calcifications had been previously illustrated (GENOT, 1987, pl. 8, fig. 6),
- the calcification of the top of the main axis in *Uteria encrinella*. A comparison with the previously illustrated specimen, regularly rounded at the top (GENOT, 1987, pl. 8, fig. 16), suggests that the calcification in this area of the thallus takes various shapes.

Systematic classification:

Section: Chlorophyta

Class: Ulvophyceae (Dasycladophyceae)

Order: Dasycladales PASCHER, 1931

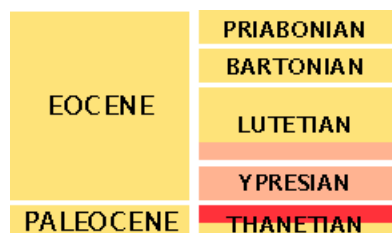
Illustrated species:

- *Acicularia eocaenica* L. & J. MORELLET, 1922
- *Belzungia borneti* L. MORELLET, 1908
- *Carpenterella morelleti* GENOT, 1980
- *Clypeina digitata* (PARKER & JONES, 1860) L. & J. MORELLET, 1913
- *Cymopolia zitteli* L. & J. MORELLET, 1913
- *Dactylopora cylindracea* LAMARCK, 1816
- *Jodotella thilense* GENOT, 1980
- *Jodotella veslensis* L. & J. MORELLET, 1913
- *Neomeris arenularia* MUNIER-CHALMAS ex L. & J. MORELLET, 1913
- *Neomeris craniphora* (L. MORELLET, 1908) PIA, 1927
- *Neomeris defrancei* (L. & J. MORELLET, 1922) PIA, 1927
- *Neomeris encrinula* (DEFRANCE, 1822) PIA, 1927 (= *Neomeris auversiensis* (L. & J. MORELLET, 1913) PIA, 1927)
- *Neomeris herouvalensis* MUNIER-CHALMAS ex STEINMANN, 1899
- *Neomeris scrobiculata* (GÜMBEL, 1872) L. & J. MORELLET, 1913
- *Parkerella binodosa* L. & J. MORELLET, 1922
- *Uteria encrinella* MICHELIN, 1845
- *Zittelina dactyloporoides* (L. & J. MORELLET, 1913) GENOT, 1987

More information and detailed descriptions of the Cenozoic Dasycladales of the French sedimentary basins are in the main papers of L. & J. MORELLET (1913, 1917, 1922) and GENOT (1978, 1980, 1987, 2009). Features of some Cenozoic species are close to those of Recent species: publications of VALET (1968, 1969), BERGER (2006), BERGER and KAEVER (1992) are useful to the interpretation of fossil specimens and to make comparative studies.

Remark: the stratigraphical range indicated on each slide is the complete stratigraphical range of the species (not just its range in the Paris basin).

► **Plate 1:** *Acicularia eocaenica* L. & J. MORELLET, 1922



Main references with description and illustrations: L. & J. MORELLET, 1922, p. 24, pl. 2, figs. 16-20; GENOT, 1987, p. 187-193, pl. 14, figs. 1-11.

1. Partial hypothetical reconstruction of a living representative. Drawing: Philippe CORBARD.

2. Hypothetical reconstruction of several living representatives. Drawing: Philippe CORBARD.

3. External view of a gametophore. Circular openings correspond to the location of the gametangia (cysts). Scale: 200 µm.

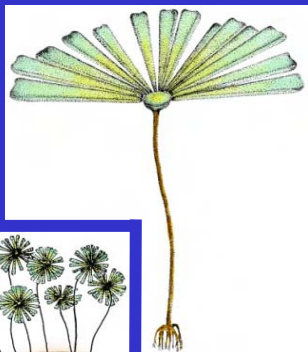
4. External view of the distal end of a gametophore. Scale: 100 µm.

5-7. Various shapes of transverse sections and internal aspect of the cavities marking the location of the gametangia. Scales: 100 µm.

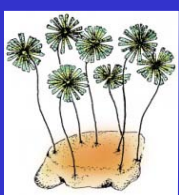
8. Longitudinal tangential section of a gametophore showing the arrangement of the gametangia. Scale: 100 µm.

Figs. 3-8: Thanetian, Abbecourt (Oise).

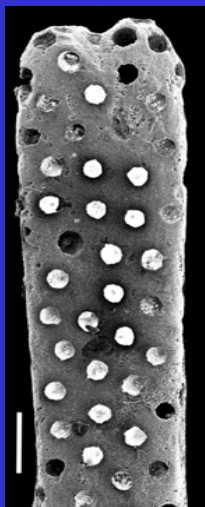
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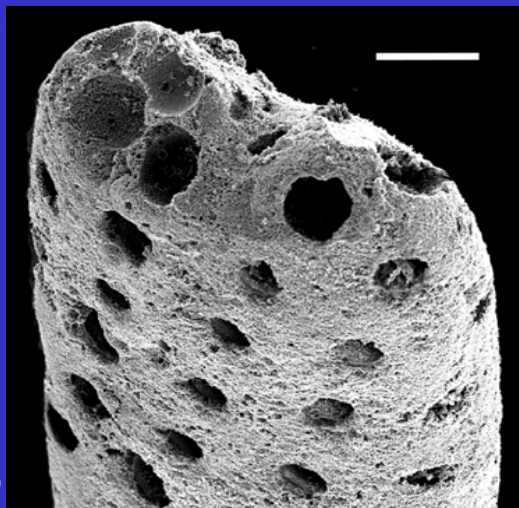
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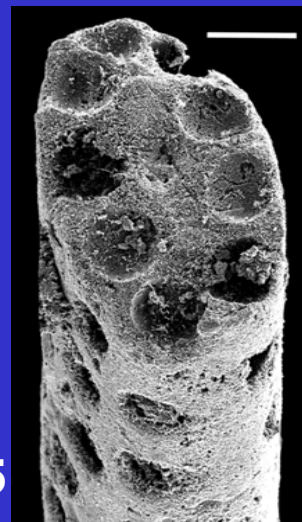
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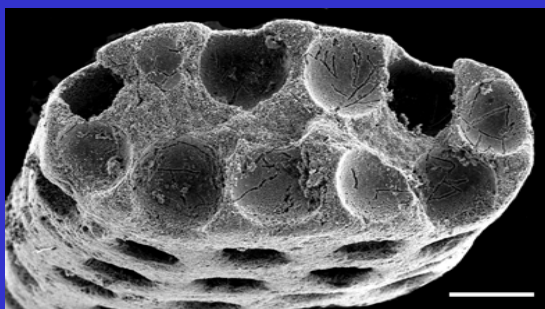
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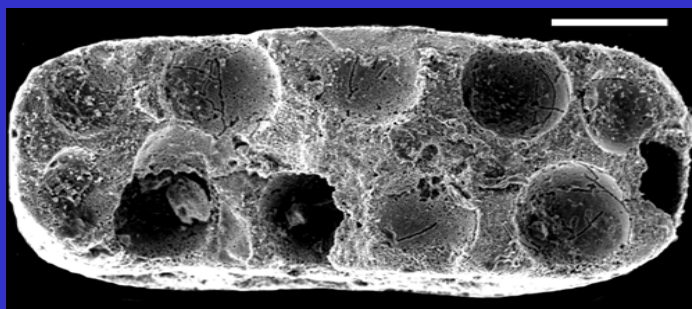
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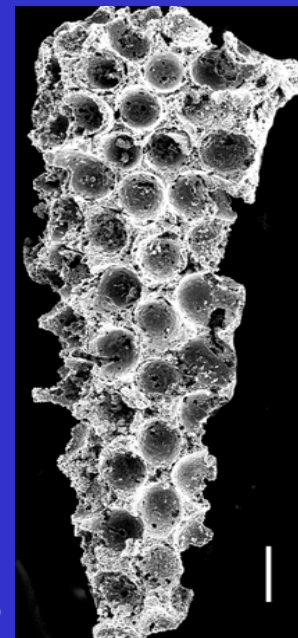
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7



8



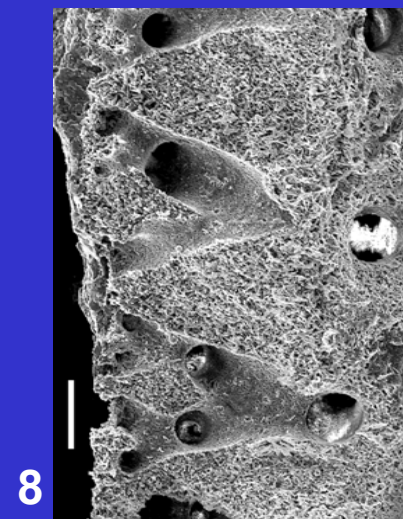
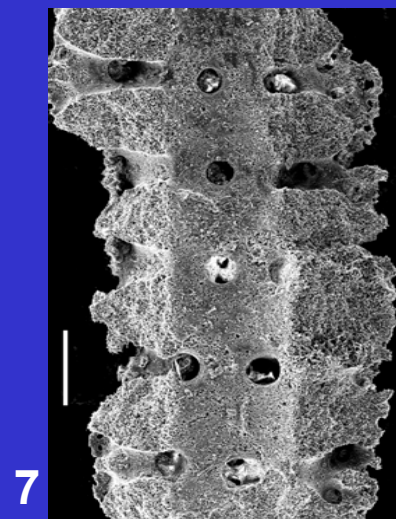
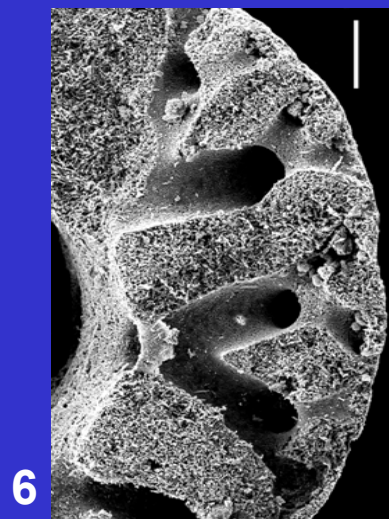
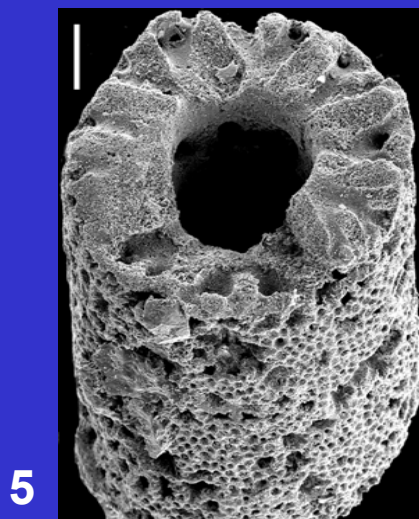
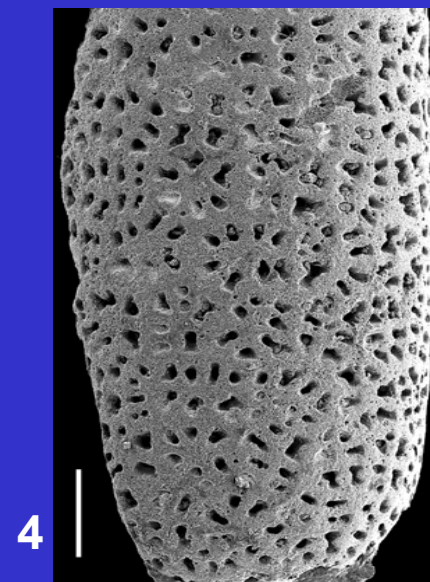
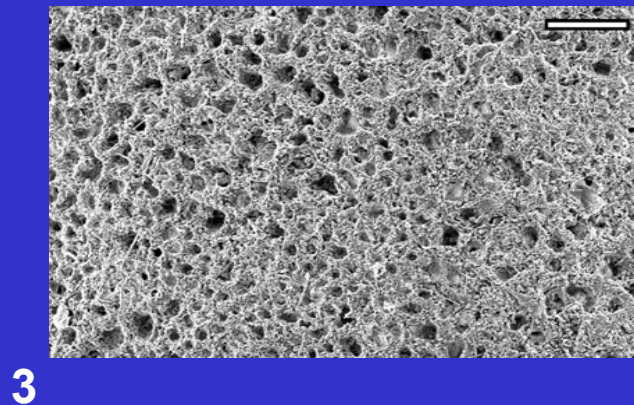
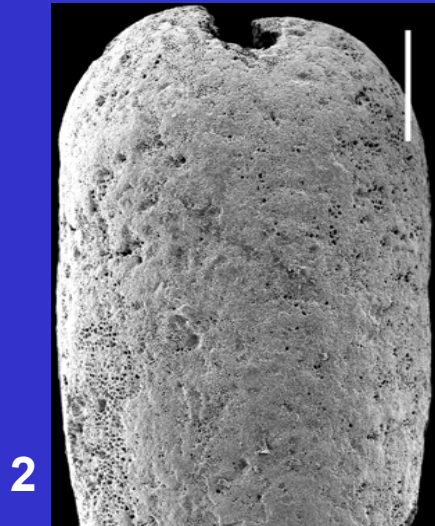
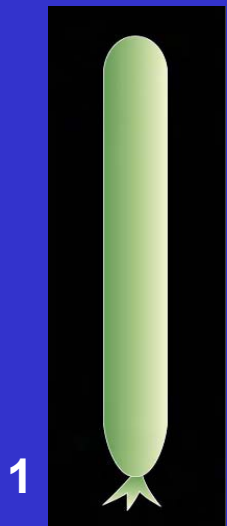
► **Plate 2:** *Belzungia borneti* L. MORELLET, 1908

EOCENE	PRIABONIAN
	BARTONIAN
	LUTETIAN
	YPRESIAN
PALEOCENE	THANETIAN

Main references with description and illustrations: L. MORELLET, 1908, p. 97-99; 1913, p. 38, pl. 3, figs. 38-39; GENOT, 1980, p. 22, pl. 25, figs. 1-3; 1987, p. 263, pl. 7, figs. 7-8, 10-11.

1. Schematic reconstruction of the general shape of the thallus.
2. External view of the sheath. Scale: 500 μm .
3. Detail of the external surface of an irregularly worn specimen. The circular openings with various diameters indicate the location of the fifth and sixth orders of laterals. Scale: 50 μm .
4. Worn specimen showing the arrangement of the third order of laterals. Scale: 200 μm .
- 5-6. Transverse sections of the sheath traversing several orders of laterals inside the wall. Scales: 100 μm (fig. 5), 50 μm (fig. 6).
- 7-8. Longitudinal sections of the wall that include several orders of laterals and features of the internal surface of the main axis (fig. 7) showing the regular arrangement of the primary laterals (circular openings). Scales: 100 μm (fig. 7), 50 μm (fig. 8).

Figs. 2-3: Thanetian, Boncourt (Oise); figs. 4-8: Thanetian, Abbecourt (Oise).



► **Plate 3:** *Carpenterella morelleti* GENOT, 1980

EOCENE	PRIABONIAN
	BARTONIAN
	LUTETIAN
	YPRESIAN
PALEOCENE	THANETIAN

Main references with description and illustrations: GENOT, 1980, p. 19, pl. 22, figs. 5-11; 1987, pl. 8, figs. 10-11, 14.

1. Hypothetical reconstruction of a living representative.

2-3. Rings composed of several associated units, each containing a cluster of gametophores. Scales: 100 μm .

4. Groups of small openings corresponding to the location of the peduncles of the gametophores and longitudinal section of a gametophore. Scale: 20 μm .

5. Transverse section of a ring showing the transverse and oblique sections of the numerous gametophores. Scale: 100 μm .

6-8. Longitudinal sections showing the pedunculate gametophores inside the wall. Scales: 100 μm (figs. 6-7) and 50 μm (fig. 8).

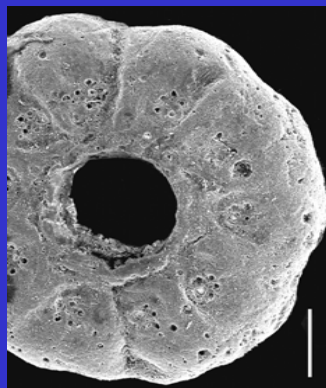
9. Reconstruction of two clusters of gametophores located along the laterals. Drawing: Robert DUFOUR.

Figs. 2-8: Upper Ypresian (Cuisian), Hérouval (Oise).

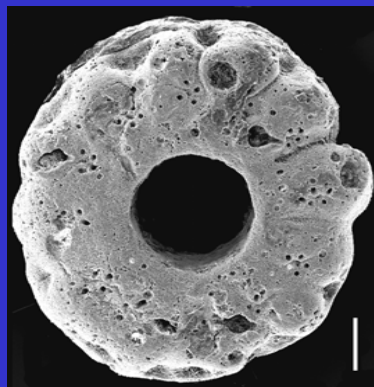
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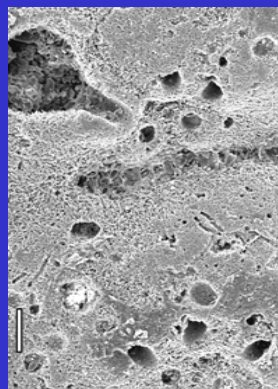
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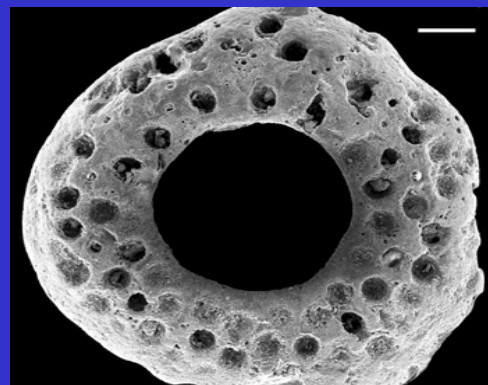
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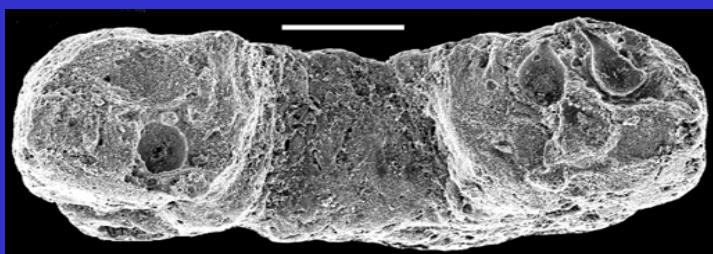
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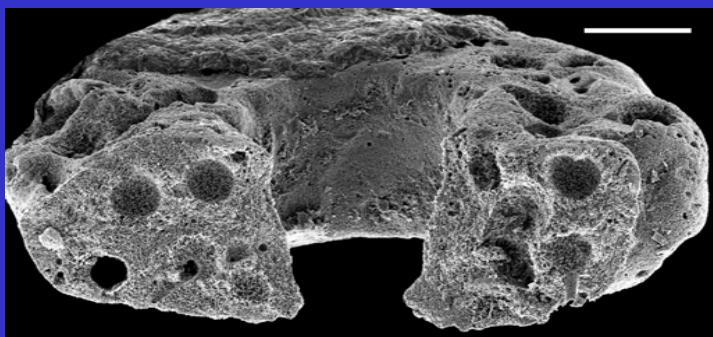
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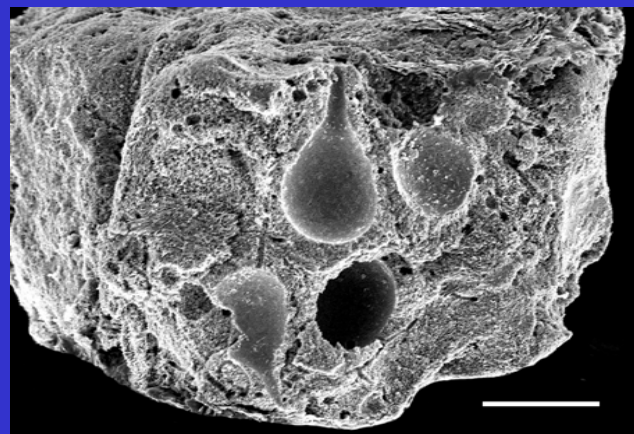
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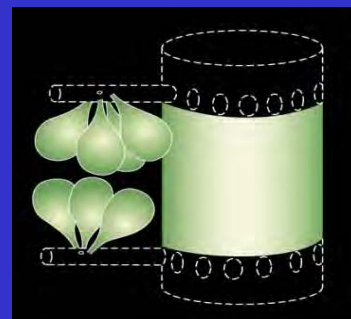
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► **Plate 4:** *Clypeina digitata* (PARKER & JONES, 1860) L. & J. MORELLET, 1913

EOCENE	PRIABONIAN
	BARTONIAN
	LUTETIAN
	YPRESIAN
PALEOCENE	THANETIAN

Main references with description and illustrations: L. & J. MORELLET, 1922, p. 27, pl. 2, figs. 37-44 (*Cl. pezanti*, synonymous); GENOT, 1987, p. 237-243, pl. 3, fig. 13, pl. 11, figs. 11-12, pl. 28, figs. 1-10.

1. Hypothetical reconstruction of a living representative. Drawing: Alain COS-SARD.

2. Lower side of a whorl of gametophores. Scale: 200 µm.

3. Lower side of a whorl with two complete gametophores. Scale: 200 µm.

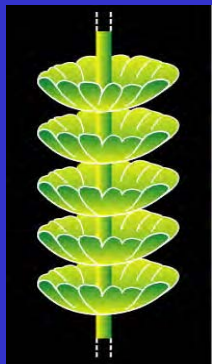
4. Lower side of a whorl of gametophores. A row of openings located on the internal surface of the axial cavity marks the locations of the proximal ends of the gametophores. Scale: 200 µm.

5. Upper side and transverse sections of several gametophores. Scale: 100 µm.

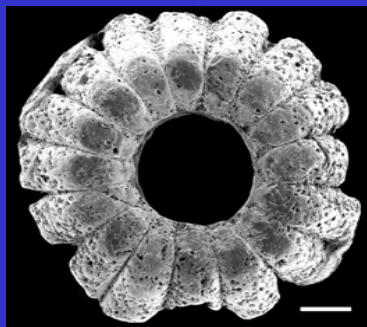
6-7. Proximal ends of several gametophores (circular openings) and a longitudinal section of the lower end of a gametophore (fig. 6). Scales: 100 µm.

Figs. 2, 4-7: Bartonian (Auversian), Ronquerolles (Val-d'Oise); fig. 3: Lutetian, Montjavoult (Oise).

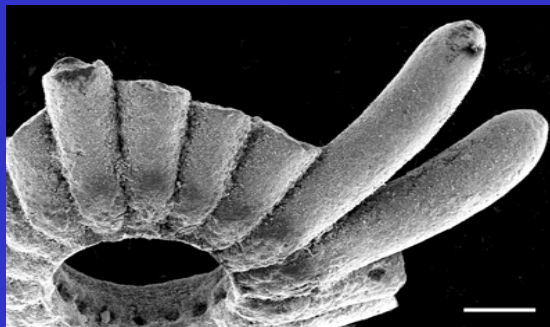
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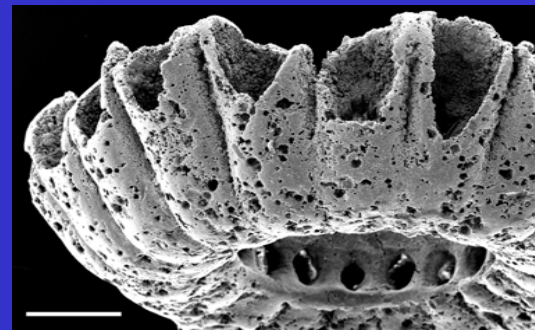
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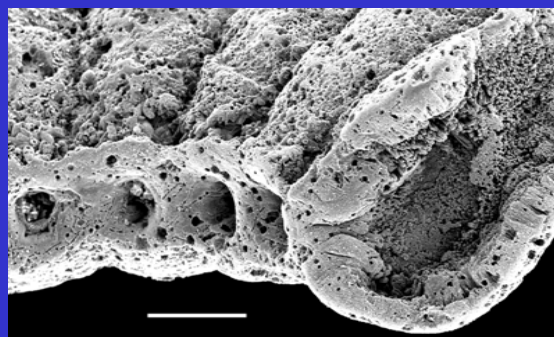
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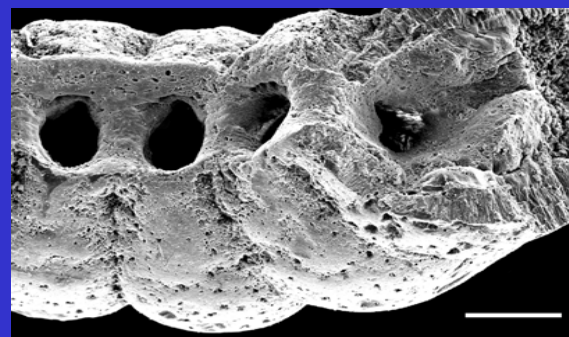
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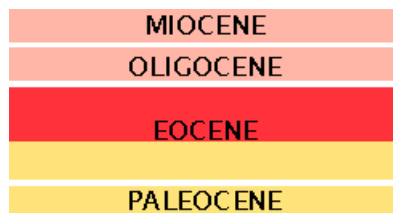
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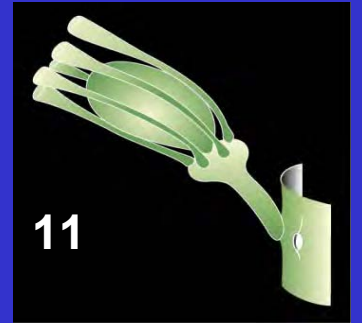
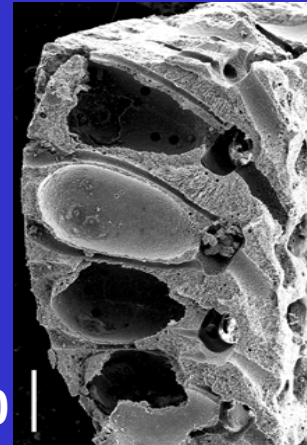
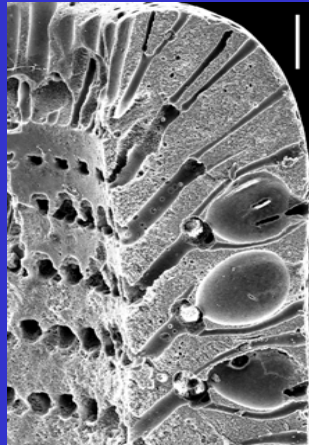
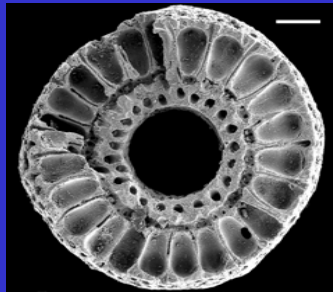
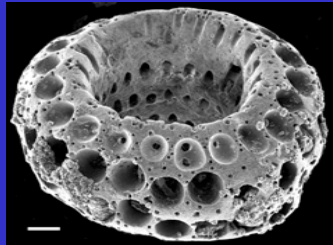
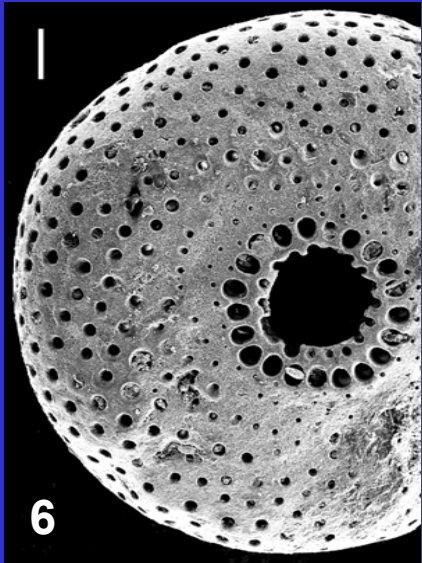
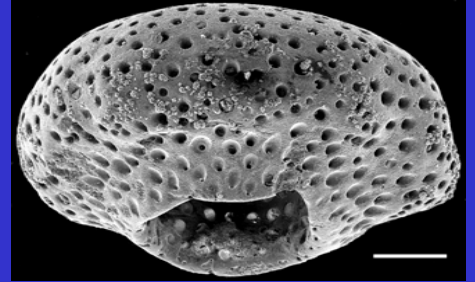
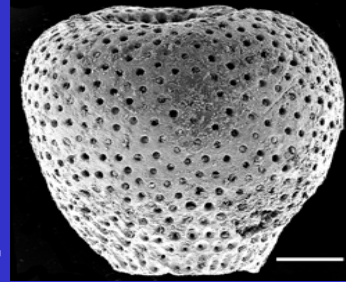
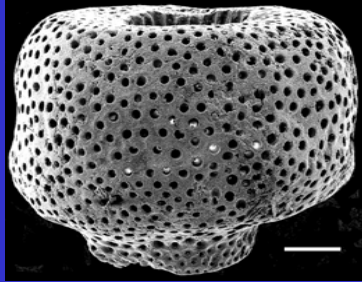
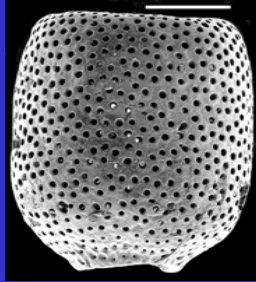
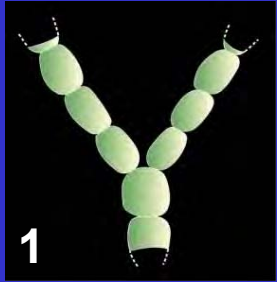


► **Plate 5:** *Cymopolia zitteli* L. & J. MORELLET, 1913

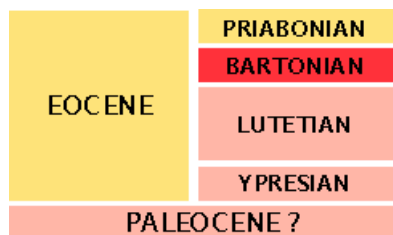


Main references with description and illustrations: L. & J. MORELLET, 1913, p. 11-12, pl. 1, figs. 13-24; GENOT, 1980, p. 18, pl. 2, figs. 1-11, pl. 3, figs. 1-5; 1987, p. 289-290, pl. 2, fig. 3, pl. 11, figs. 7-10.

1. Schematic reconstruction of the general shape of the thallus.
 - 2-5. External views showing the great morphological variability of the articles. The small circular openings mark the location of the secondary laterals. Scales: 500 μm (fig. 2), 200 μm (figs. 3-5).
 6. Upper end of an article. Scale: 100 μm .
 7. Worn specimen showing the transverse sections of the gametophores (larger openings) surrounded by the secondary laterals (small openings). Scale: 100 μm .
 8. Transverse section crossing a circular row of gametophores and several secondary laterals. Scale: 200 μm .
 - 9-10. Longitudinal sections of the upper ends of two articles showing the two orders of laterals and the gametophores. Scales: 100 μm .
 11. Reconstruction of a primary lateral segment bearing several secondary laterals and a gametophore. Drawing: Robert DUFOUR.
- Figs. 2-3, 5, 7: Bartonian (Auversian), Valmondois (Val-d'Oise); figs. 4, 6, 8-10: Bartonian (Auversian), Le Fayel (Oise).



► **Plate 6:** *Dactylopora cylindracea* LAMARCK, 1816



Main references with description and illustrations: L. & J. MORELLET, 1913, p. 26-27, pl. 3, figs. 1-4; LUCAS & POBEGUIN, 1954, p. 325-336, pl. 5, figs. 1-4, pl. 6, figs. 5-8, pl. 7, fig. 9; BARATTOLO & DE CASTRO, 1976, p. 15, pl. 3, figs. 1-2, pl. 4, figs. 1-4; GENOT, 1980, p. 21, pl. 23, figs. 1-8.

1-2. External views of the sheath. Scales: 1 mm.

3. Longitudinal section and internal surface of the sheath showing the arrangement of the primary laterals (circular openings). Scale: 1 mm.

4. Internal features of the axial cavity with the exceptional preservation of the calcification of the main axis. Scale: 500 μ m.

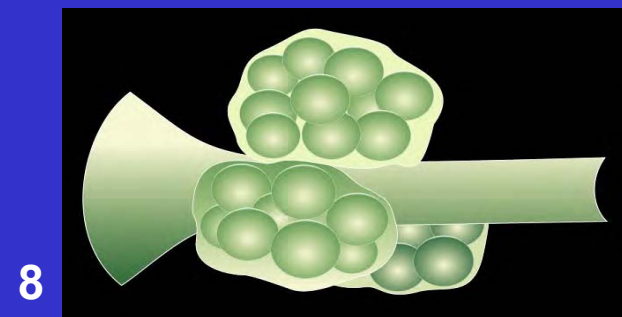
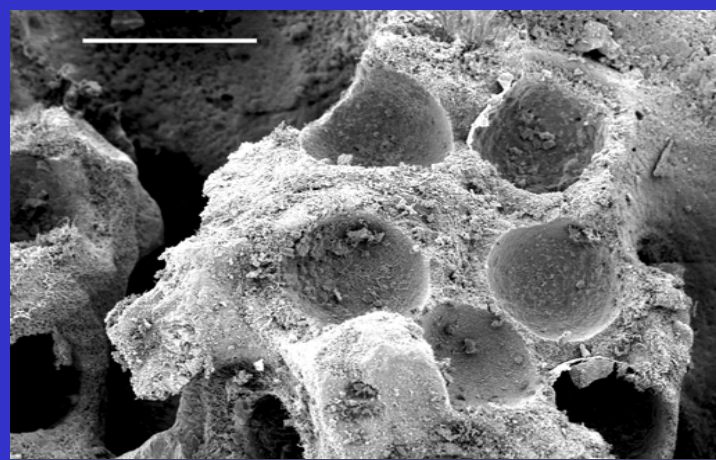
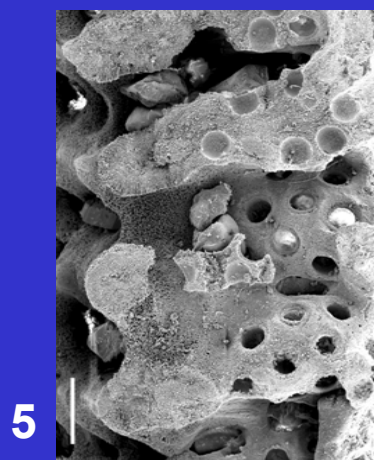
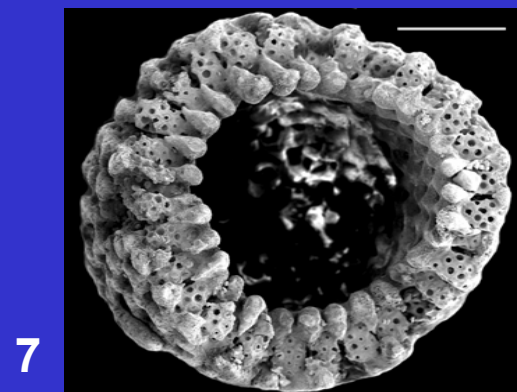
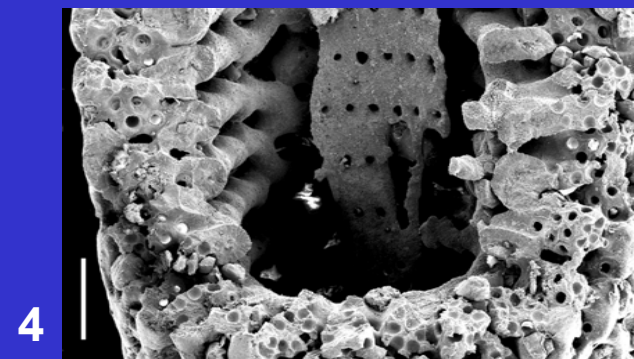
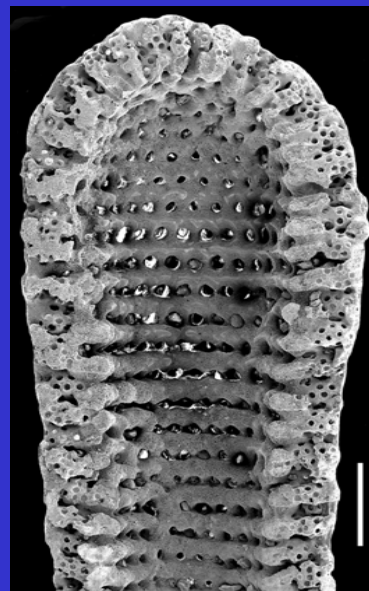
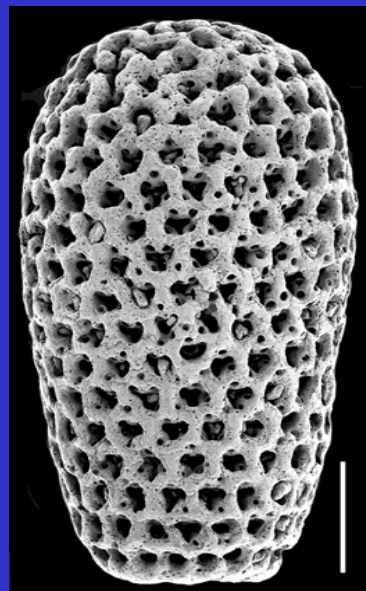
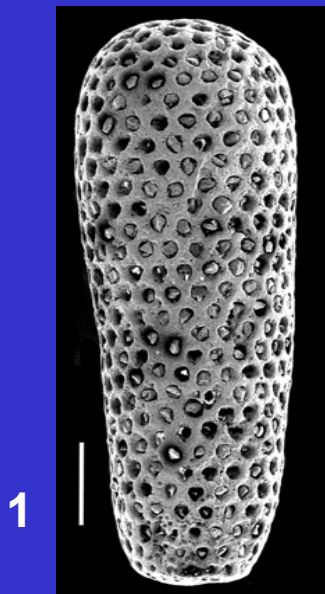
5. Detail of the wall containing groups of gametangia (cysts) inside the partially differentiated gametophores. Scale: 200 μ m.

6. Internal features of a gametophore containing several gametangia. Scale: 100 μ m.

7. Transverse section of the sheath (the calcification of the main axis is not preserved in this specimen). Scale: 1 mm.

8. Reconstruction of a primary lateral segment bearing three gametophores with several gametangia inside. Drawing: Robert DUFOUR.

Fig. 1: Bartonian (Auversian), Auvers-sur-Oise (Val-d'Oise); figs. 2-7: Bartonian (Auversian), Le Fayel (Oise).



► **Plate 7:** *Jodotella thilense* GENOT, 1980

EOCENE	PRIABONIAN
	BARTONIAN
	LUTETIAN
	YPRESIAN
PALEOCENE	THANETIAN

Main references with description and illustrations: GENOT, 1980, p. 19, pl. 22, figs. 1-4; 1987, p. 293, pl. 7, figs. 14, 17-18.

1. Schematic reconstruction of the general shape of the thallus.

2-3. Rings corresponding to the calcification of the gametophores. The circular openings at the surface of the rings show the location of the peduncles of the gametophores. Laterals are not calcified. Scales: 100 μ m.

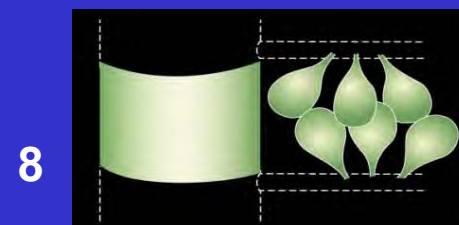
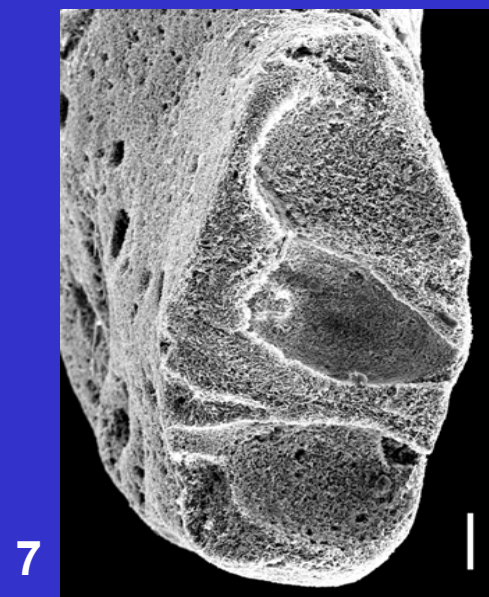
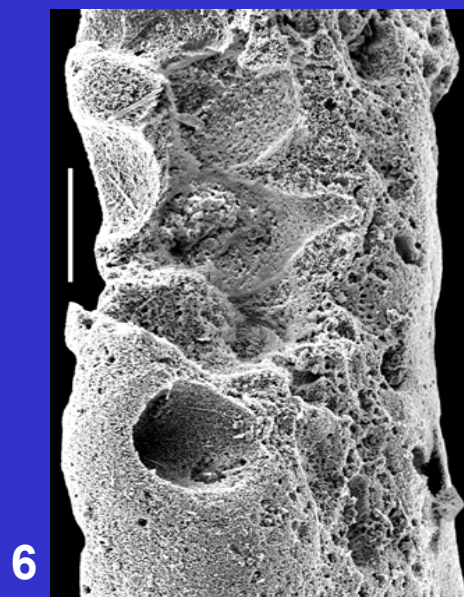
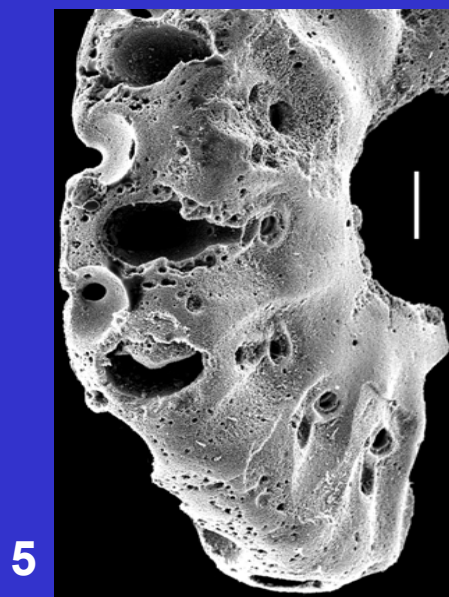
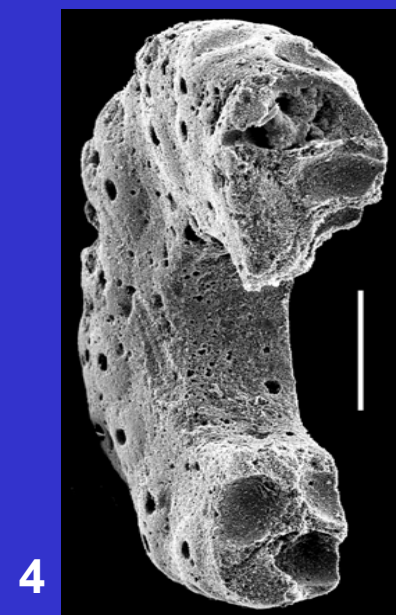
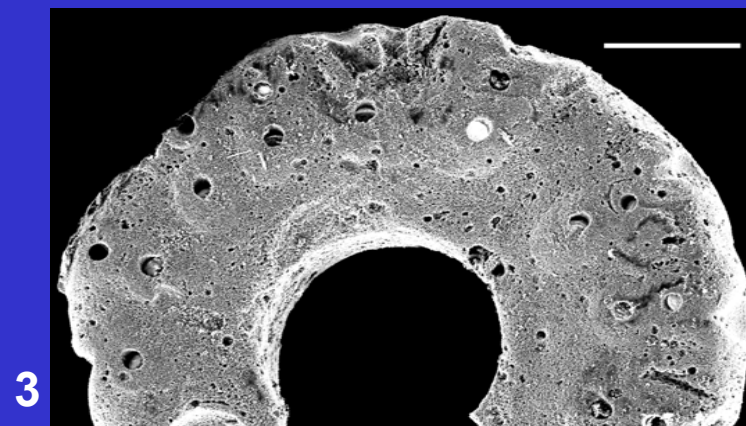
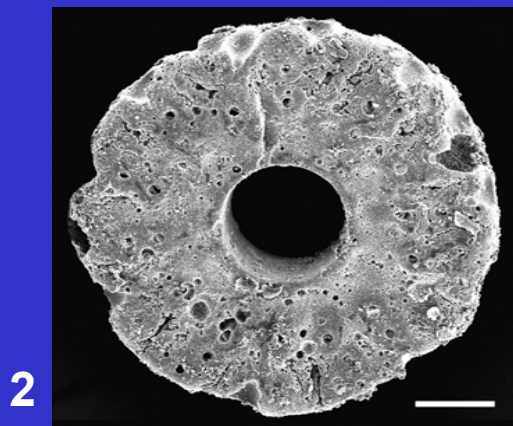
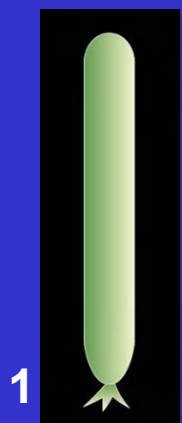
4. Longitudinal section of a ring showing the location of some gametophores (ovoid cavities). Scale: 100 μ m.

5. Worn specimen showing the arrangement, more or less in lineations, of the proximal ends of the peduncles (circular openings) and the longitudinal section of a pedunculate gametophore. Scale: 50 μ m.

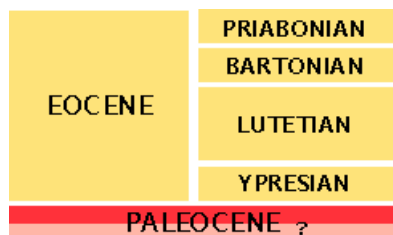
6-7. Longitudinal sections showing several pedunculate gametophores inside the wall. Scales: 50 μ m (fig. 6), 20 μ m (fig. 7).

8. Reconstruction of two rows of gametophores along the laterals. Drawing: Robert DUFOUR.

Figs. 2-7: Thanetian, Thil (Marne).



► **Plate 8:** *Jodotella veslensis* L. & J. MORELLET, 1913



Main references with description and illustrations: L. & J. MORELLET, 1913, p. 29-30, pl. 3, fig. 12; 1922, p. 16, pl. 1, figs. 49-52; GENOT, 1980, p. 18-19, pl. 21, figs. 1-2; DIENI *et alii*, 1985, p. 11-14, pl. 7, figs. 1-10, pl. 8, figs. 1-8.

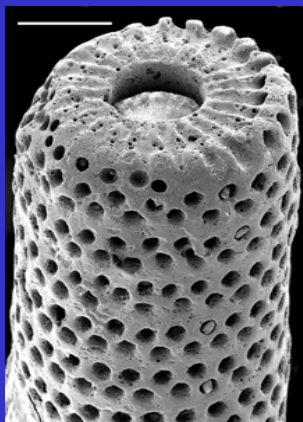
1. Schematic reconstruction of the general shape of the thallus.
2. External view of the sheath. The numerous circular openings show the location of the upper ends of the secondary laterals. Scale: 400 µm.
3. Longitudinal section and features of the internal surface of the sheath. Scale: 400 µm.
4. Detail of a longitudinal section showing the pedunculate gametophores at the upper part of a partially preserved primary lateral. Scale: 50 µm.
5. Tangential section of the wall showing transverse, oblique and longitudinal sections of the gametophores. The deep furrows correspond to the location of the partially calcified primary laterals. Scale: 100 µm.
6. Transverse section of the sheath across the location of the laterals (lower part of the photo) and the gametophores (upper part). Scale: 200 µm.
7. Detail of a transverse section across the partially calcified laterals. The groups of two or three circular openings indicate the location of the proximal ends of the pedunculate gametophores. Scale: 100 µm.
8. The large circular openings correspond to the calcification surrounding the secondary laterals. Scale: 100 µm.
9. Reconstruction of two primary laterals, each bearing groups of two or three gametophores and two secondary laterals. Drawing: Robert DUFOUR.

Figs. 2, 6: Thanetian, Jonchery-sur-Vesle (Marne); figs. 3, 7: Thanetian, Abbecourt (Oise); figs. 4-5, 8: Thanetian, Thil (Marne).

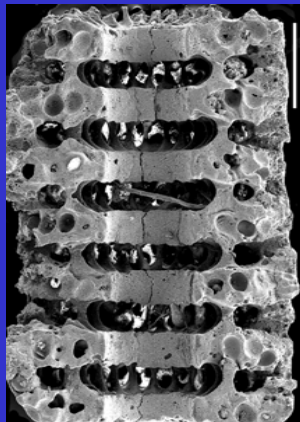
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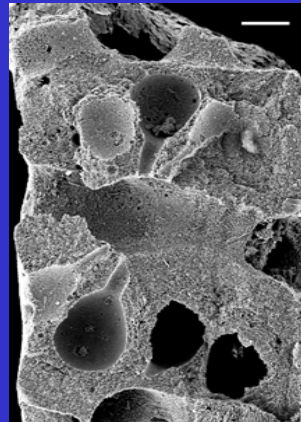
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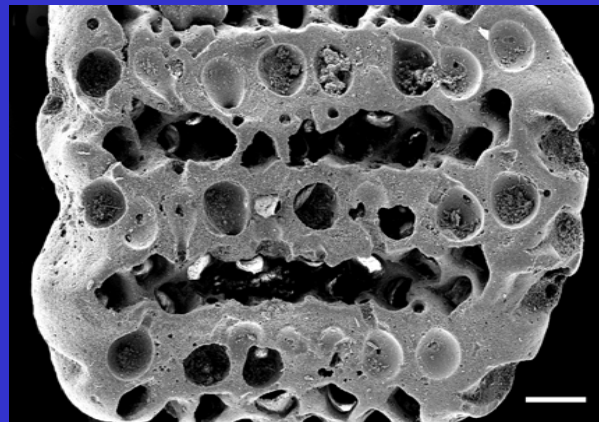
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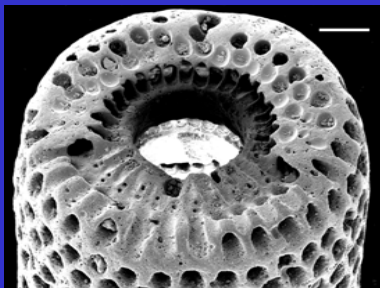
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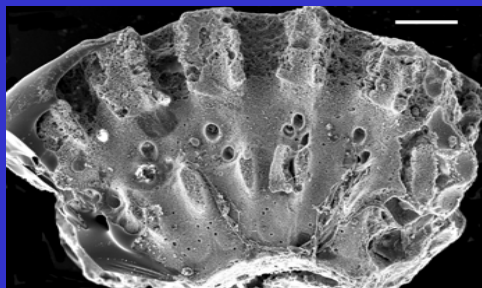
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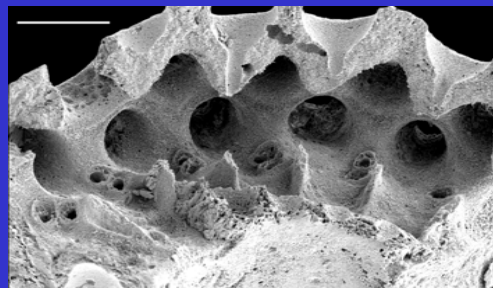
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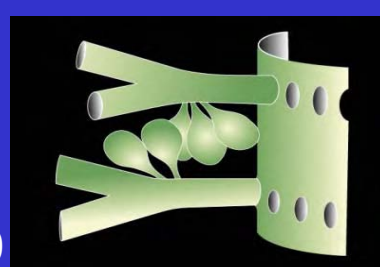
7



8



9



► **Plate 9:** *Neomeris arenularia* MUNIER-CHALMAS ex L. & J. MORELLET, 1913

EOCENE	PRIABONIAN
	BARTONIAN
	LUTETIAN
	YPRESIAN
PALEOCENE	THANETIAN

Main references with description and illustrations: L. & J. MORELLET, 1913, p. 22-23, pl. 2, figs. 10-14; GENOT, 1980, p. 15, pl. 9, figs. 1-11, pl. 10, figs. 11-12, pl. 11, figs. 13-14, pl. 12, fig. 7; 1987, p. 315-316, pl. 5, figs. 14-15, pl. 11, figs. 1-3.

1. Schematic reconstruction of the general shape of the thallus.

2-3. External views of the cylindrical sheath. Single or pairs of openings correspond to the location of the secondary laterals. Scales: 500 μm (fig. 2), 400 μm (fig. 3).

4-5. Internal surfaces of the sheath showing the various shapes of the units that indicate calcification of the gametophores. Primary laterals are not calcified on these specimens. Scales: 200 μm (fig. 4), 100 μm (fig. 5).

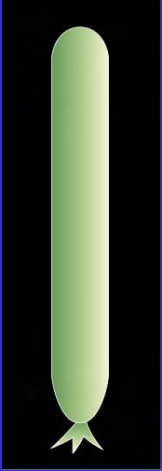
6. Internal surface and longitudinal section of the sheath showing numerous gametophores. The calcification of the distal ends of the primary laterals is preserved on the internal surface of the axial cavity. Scale: 200 μm .

7. Transverse section of the sheath across several gametophores. Scale: 200 μm .

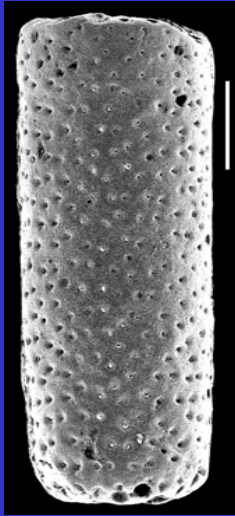
8. Reconstruction of the calcified organs: distal end of a primary lateral bearing two secondary laterals and a gametophore. Drawing: Alain COSSARD.

Figs. 2-5, 7: Bartonian (Auversian), Le Fayel (Oise); fig. 6: "Bartonien", Montagny (Oise), coll. MUNIER-CHALMAS.

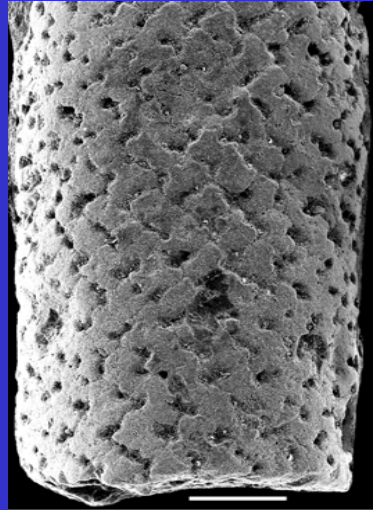
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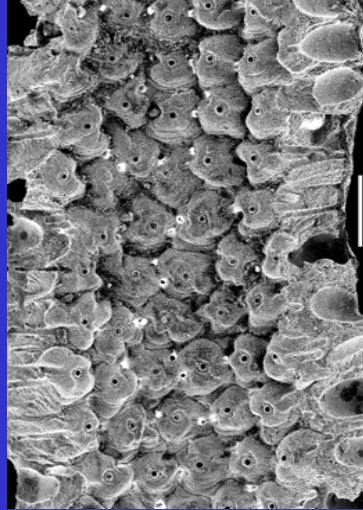
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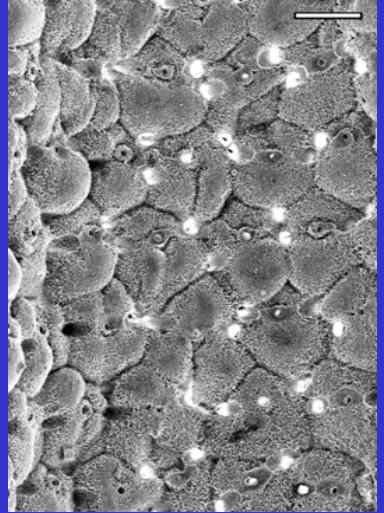
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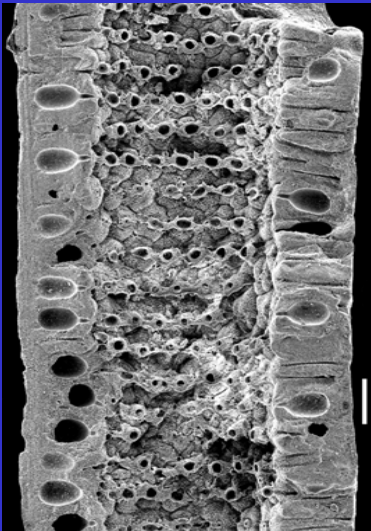
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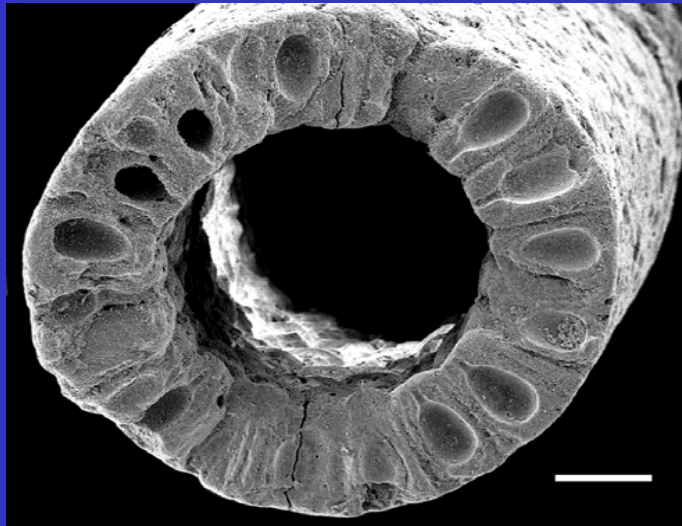
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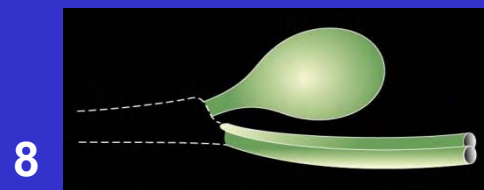
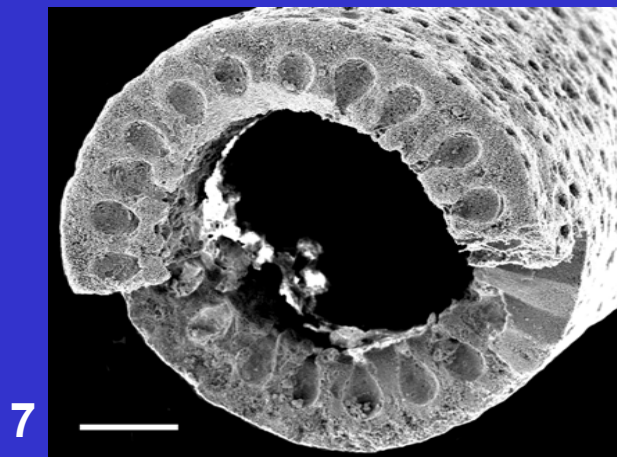
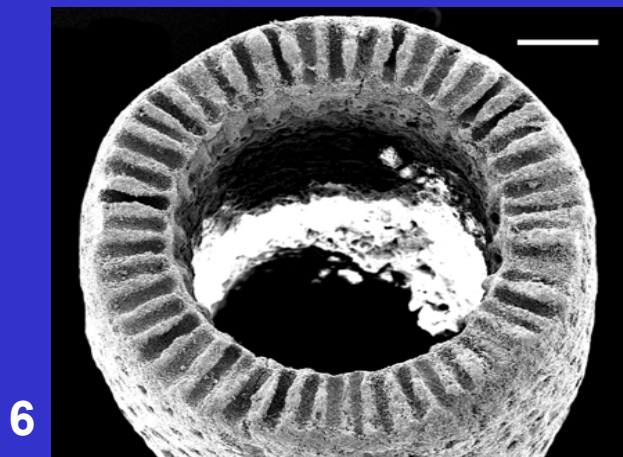
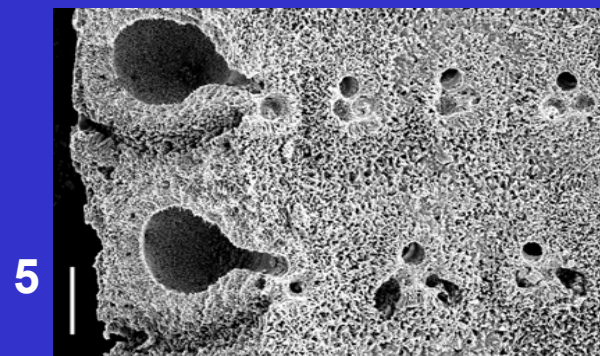
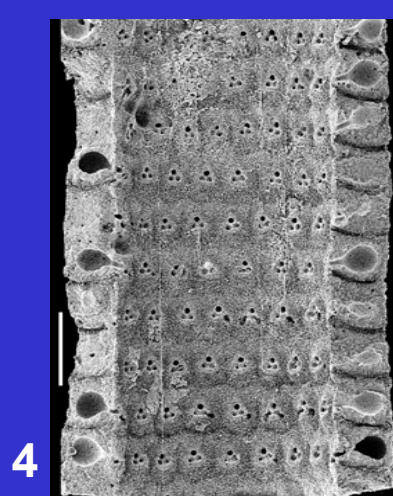
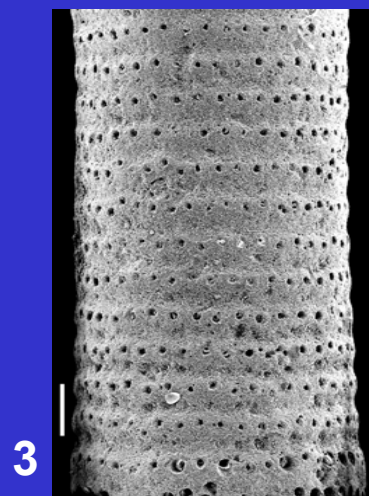
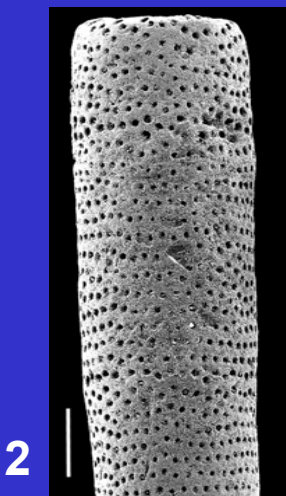
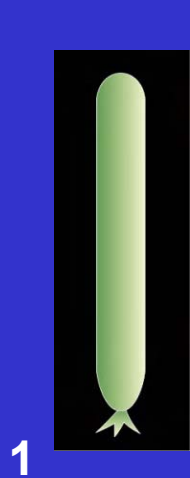
► **Plate 10:** *Neomeris craniphora* (L. MORELLET, 1908) PIA, 1927

EOCENE	PRIABONIAN
	BARTONIAN
	LUTETIAN
	YPRESIAN
PALEOCENE	THANETIAN

Main references with description and illustrations: L. MORELLET, 1908, p. 96-97, figs. 1a-1d; L. & J. MORELLET, 1913, p. 15-16, pl. 1, figs. 43-47; DELOFFRE, 1970, p. 361-368, pl. 4, figs. 1-14, pl. 5, figs. 1-7; GENOT, 1980, p. 15-16, pl. 13, figs. 1-9, pl. 18, figs. 1-2, pl. 19, figs. 1-2, pl. 20, figs. 1-2; 1987, p. 327-328, pl. 5, figs. 1, 5, 6, pl. 7, figs. 1-6.

1. Schematic reconstruction of the general shape of the thallus.
- 2-3. External views of the sheath. The openings indicate the location of the secondary laterals. Scales: 500 μ m (fig. 2) and 200 μ m (fig. 3).
4. Longitudinal section and features of the internal surface of the axial cavity. Scale: 200 μ m.
5. Detail of the longitudinal section of the sheath showing two gametophores and the secondary laterals below the gametophores. Primary laterals are not calcified. Scale: 50 μ m.
6. Transverse section across a row of secondary laterals. Scale: 200 μ m.
7. Transverse section across two superposed circular rows of gametophores. Scale: 200 μ m.
8. Reconstruction of the calcified organs: a gametophore and two secondary laterals. Drawing: Robert DUFOUR.

Figs. 2-3, 6-7: Thanetian, Boncourt (Oise); figs. 4-5: Thanetian, Abbecourt (Oise).



► **Plate 11:** *Neomeris defrancei* (L. & J. MORELLET, 1922) PIA, 1927

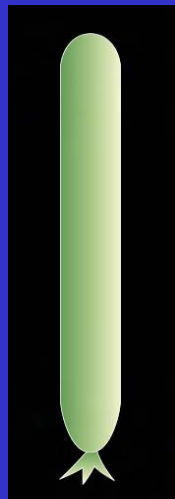
EOCENE	PRIABONIAN
	BARTONIAN
	LUTETIAN
	YPRESIAN
PALEOCENE	THANETIAN

Main references with description and illustrations: L. & J. MORELLET, 1922, p. 11, pl. 1, figs. 12-18.

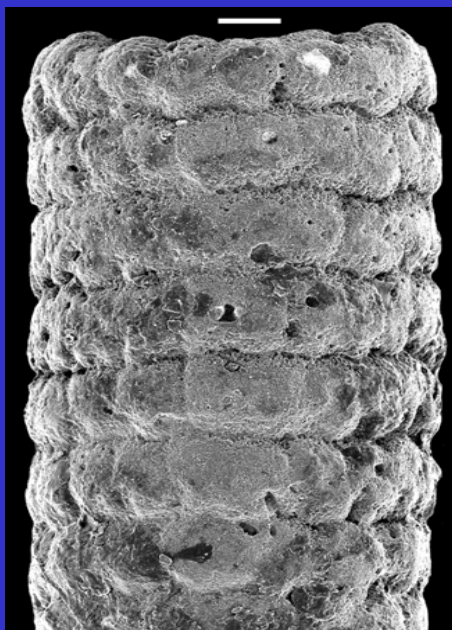
1. Schematic reconstruction of the general shape of the thallus.
2. External view of the sheath. Each ring corresponds to the calcification of a circular row of gametophores. Scale: 100 µm.
3. External view and transverse section of the sheath. Scale: 100 µm.
4. Internal surface of the axial cavity and longitudinal section of the sheath. Each unit is the calcification of a gametophore. The primary laterals are not calcified. The canals inside the wall (left side of the photo) show the location of the partially preserved secondary laterals. Scale: 100 µm.
5. Detail of a longitudinal section showing a gametophore inside the wall. Scale: 50 µm.
- 6-7. Isolated rings. The small circular openings located on the internal side of the ring correspond to the proximal ends of the gametophores. Scales: 100 µm.
8. Transverse section of the sheath crossing a circular row of gametophores. Scale: 100 µm.

Figs. 2-8: Thanetian, Abbecourt (Oise).

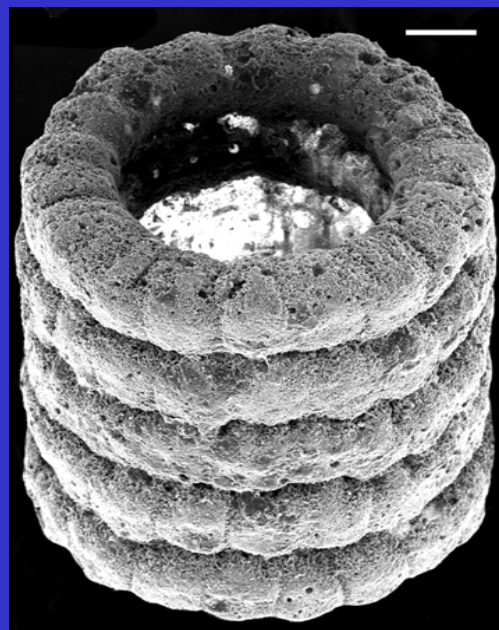
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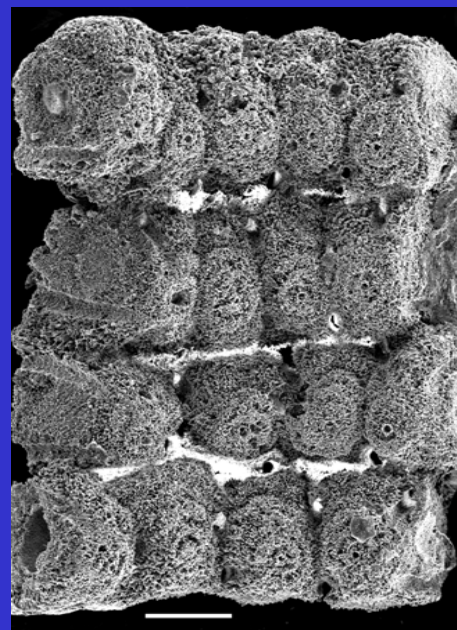
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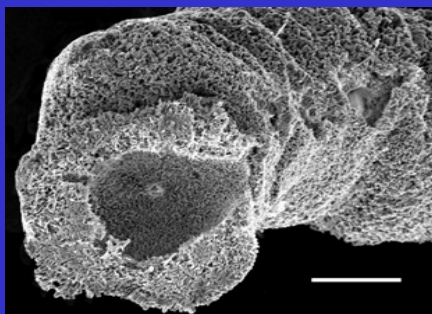
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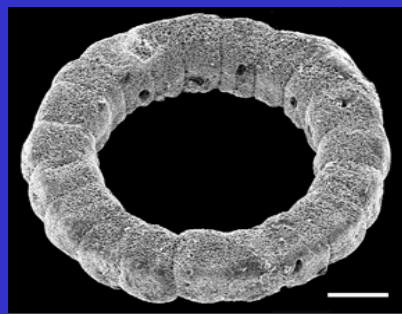
4



5



6



7



8



► **Plate 12:** *Neomeris encrinula* (DEFRANCE, 1822) PIA, 1927

EOCENE	PRIABONIAN
	BARTONIAN
	LUTETIAN
	YPRESIAN
PALEOCENE	THANETIAN

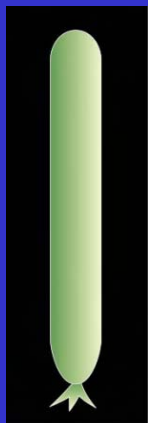
Remark: *Neomeris auversiensis* (L. & J. MORELLET, 1913) PIA, 1927 is considered junior synonym of *N. encrinula* (GENOT & LE RENARD, 2011).

Main references with description and illustrations: L. & J. MORELLET, 1913, p. 16-17, pl. 1, figs. 48-50; 1939, p. 30-33, pl. 4, figs. 7-20; GENOT, 1980, p. 17, pl. 16, figs. 10-12, pl. 17, figs. 1-11, pl. 18, figs. 7-8, 12-14, pl. 19, figs. 11-13, pl. 20, fig. 6-7; 1987, p. 317, 328-329, pl. 11, figs. 4-6, pl. 35, figs. 1-5; GENOT & LE RENARD, 2011, pl. 3, figs. 1-8.

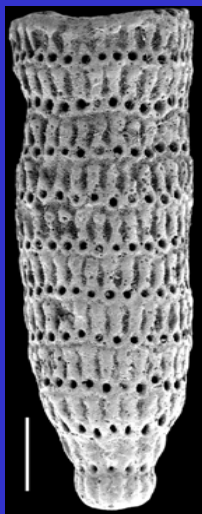
1. Schematic reconstruction of the general shape of the thallus.
2. External view of the sheath. The surface is characterized primarily by its longitudinal ridges. The circular rows of small openings correspond to the whorls of secondary laterals. Scale: 300 µm.
3. Transverse section of the sheath and detail of the external surface showing the regular rows of secondary laterals. Scale: 200 µm.
4. Detail of the axial cavity showing the well individualized calcification of the main axis. Scale: 100 µm.
5. Tangential section of the wall showing the transverse sections of several gametophores (large circular openings). Scale: 100 µm.
6. Transverse section across a circular row of secondary laterals. Scale: 100 µm.
7. Features of the axial cavity and longitudinal section of the wall across several gametophores. The calcification of the main axis is not preserved in this specimen. Scale: 100 µm.
8. Longitudinal section of the wall showing a gametophore and two secondary laterals. Scale: 50 µm.
9. Reconstruction of a gametophore and two secondary laterals. Primary laterals are unknown. Drawing: Alain COSSARD.

Figs. 2, 5, 7: Bartonian (Auversian), Val-d'Oise; figs. 3-4, 6, 8: Bartonian (Auversian), Mériel (Val-d'Oise).

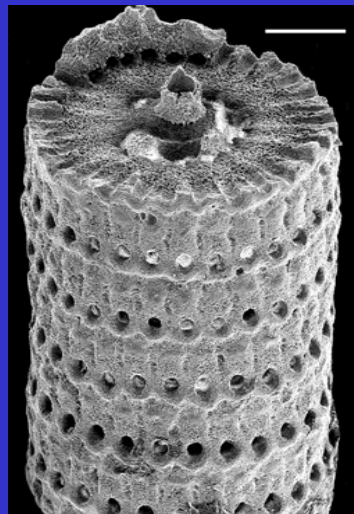
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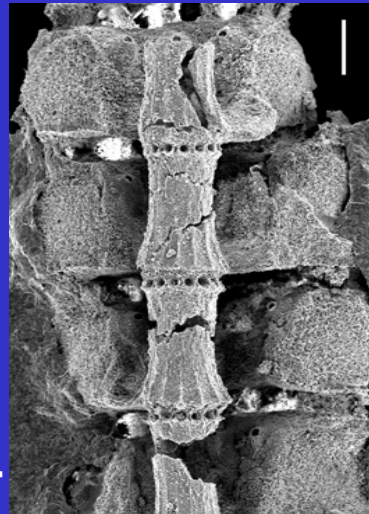
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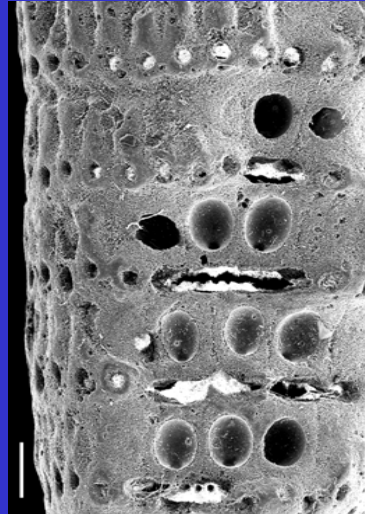
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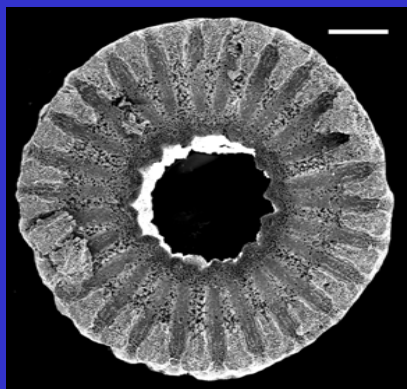
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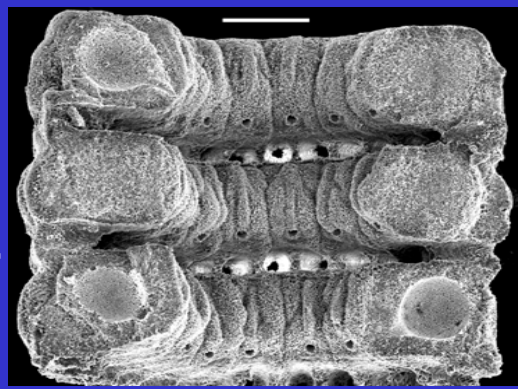
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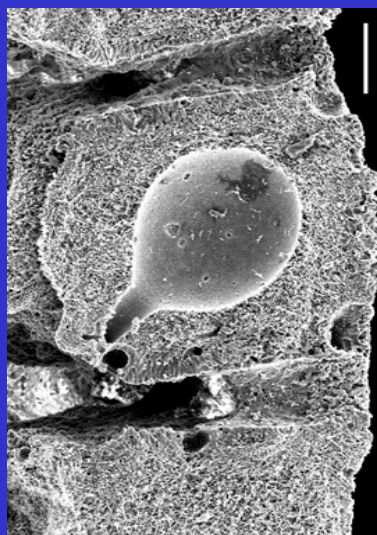
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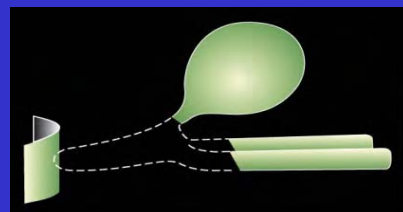
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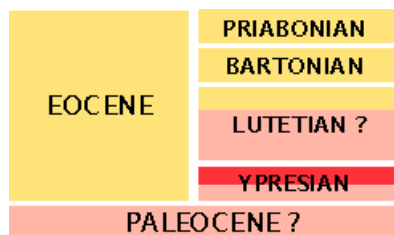
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9



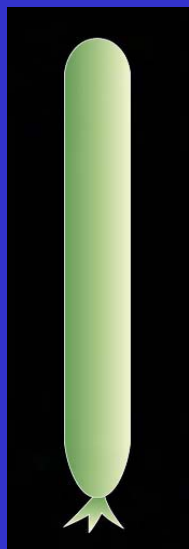
► **Plate 13:** *Neomeris herouvalensis* MUNIER-CHALMAS ex STEINMANN, 1899



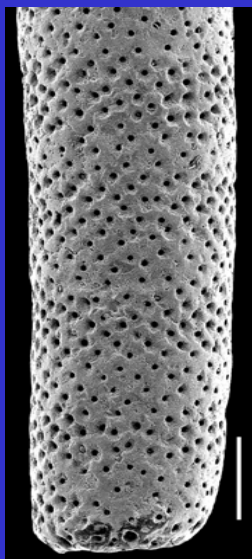
Main references with description and illustrations: L. & J. MORELLET, 1913, p. 23, pl. 2, figs. 21-23; GENOT, 1980, p. 13, pl. 5, figs. 1-8, pl. 10, figs. 1-2, pl. 11, figs. 1-2, pl. 12, fig. 1; 1987, p. 334-335, pl. 2, fig. 5, pl. 5, fig. 7, pl. 8, figs. 7-9.

1. Schematic reconstruction of the general shape of the thallus.
 2. External view of the sheath. The circular openings show the location of the secondary laterals. Scale: 500 μm .
 3. Worn specimen showing the transverse sections of the gametophores (large circular openings at the top of the sheath) and the transverse sections of the secondary laterals (small circular openings). Scale: 300 μm .
 - 4-5. Different features of the internal surface of the sheath. Each unit indicates the calcification of a gametophore bounded by two secondary laterals. The main axis, the primary laterals and the lower part of the secondary laterals are never calcified. Scales: 100 μm .
 6. Transverse section of the sheath across several gametophores and secondary laterals. Scale: 200 μm .
 7. Detail of the wall showing a gametophore and several secondary laterals. Scale: 30 μm .
 8. Reconstruction of a gametophore together with two partially preserved secondary laterals. Drawing: Alain COSSARD.
- Figs. 2-7: Upper Ypresian (Cuisian), Hérouval (Oise).

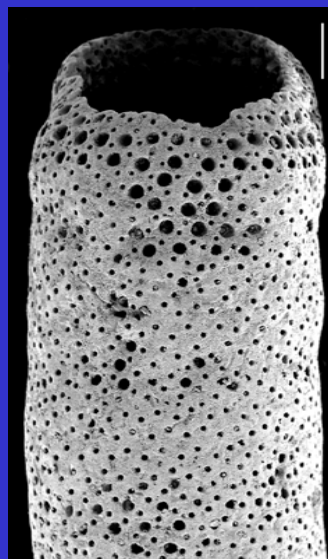
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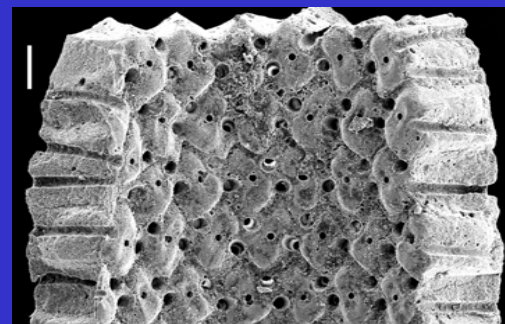
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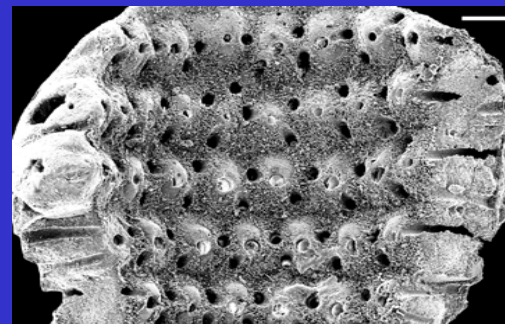
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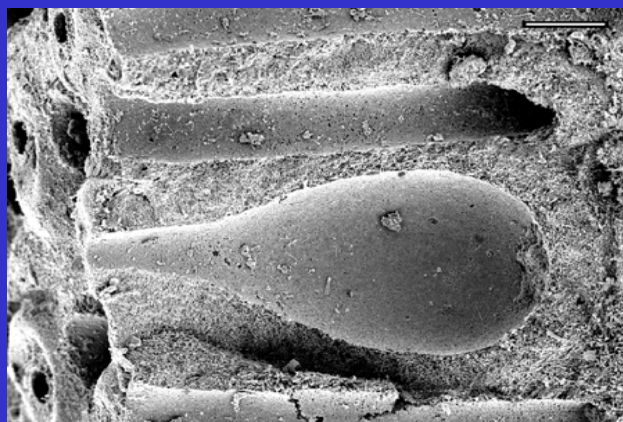
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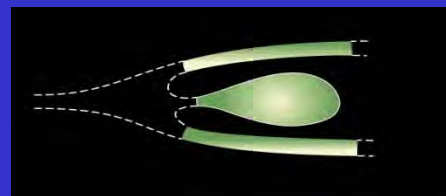
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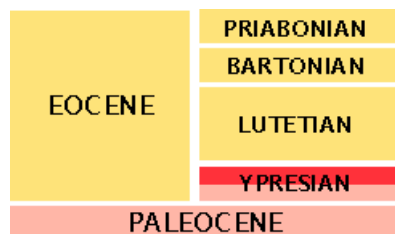
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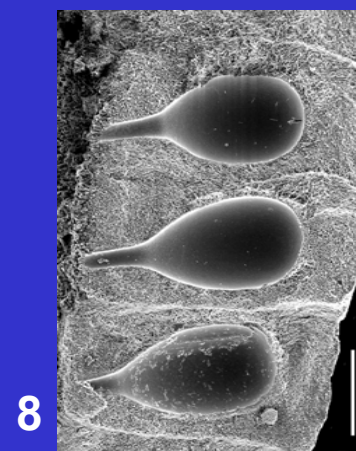
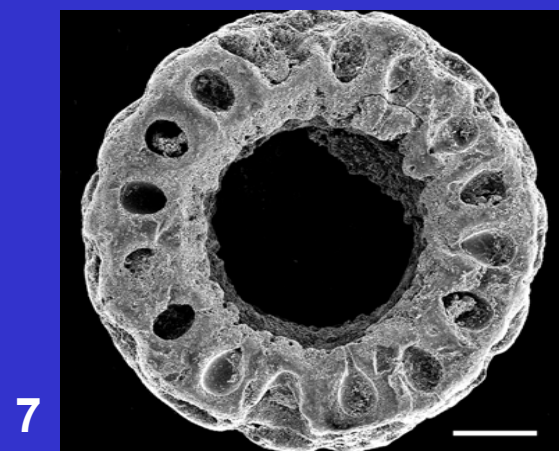
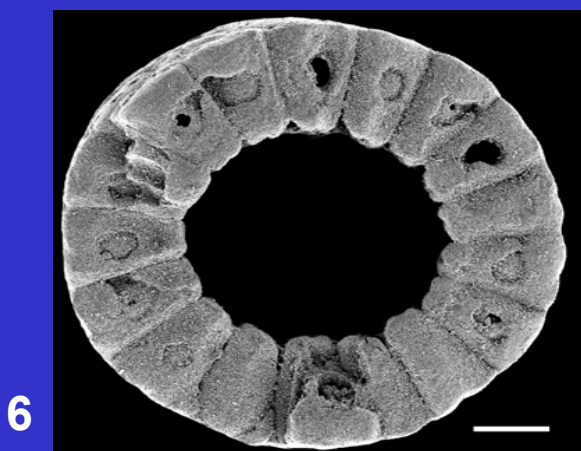
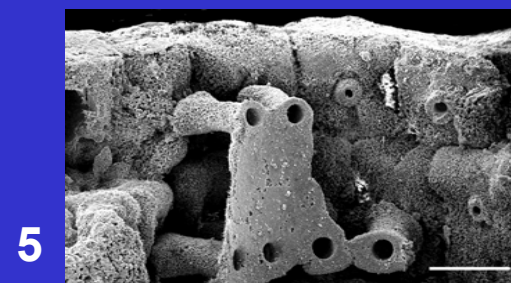
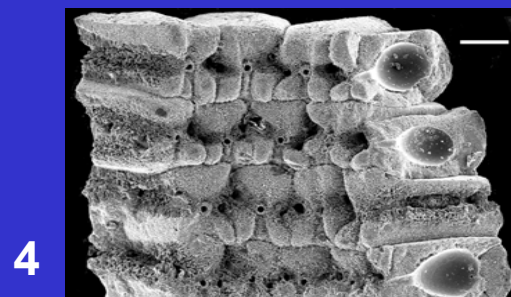
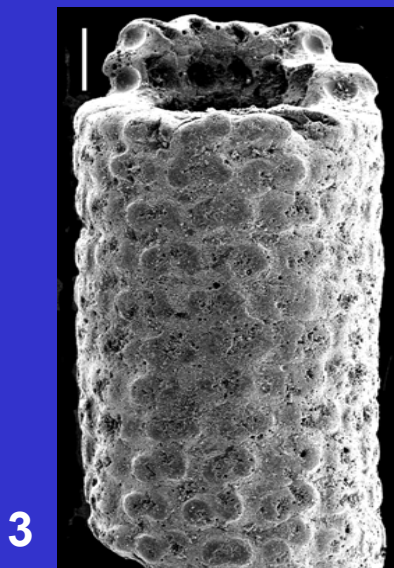
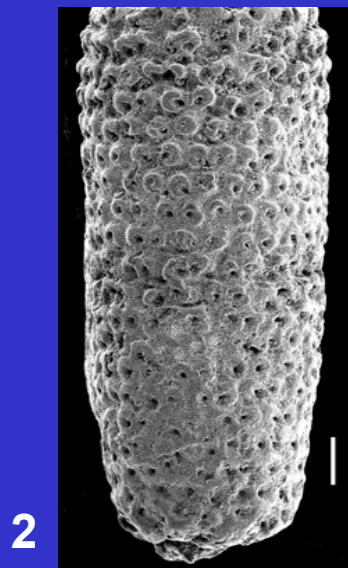
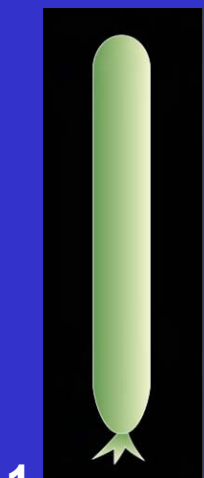


► **Plate 14:** *Neomeris scrobiculata* (GÜMBEL, 1872) L. & J. MORELLET, 1913



Main references with description and illustrations: L. & J. MORELLET, 1913, p. 21-22, pl. 2, fig. 20; 1922, p. 14, pl. 1, fig. 38; GENOT, 1980, p. 14, pl. 4, figs. 1-11, pl. 10, figs. 3-4, pl. 11, figs. 3-4, pl. 12, fig. 2; 1987, p. 353-354, pl. 5, figs. 8-9, pl. 8, figs. 1-6.

1. Schematic reconstruction of the general shape of the thallus.
 - 2-3. External views showing the typical feature of the wall: single or pairs of rounded swellings surrounding the location of the secondary laterals (small circular openings). Scales: 200 µm.
 4. Internal surface of the cylindrical sheath showing the calcification of four superposed rows of gametophores and longitudinal section of the wall crossing several gametophores. Scale: 100 µm.
 5. Calcification of the main axis preserved exceptionally inside the axial cavity of the sheath. Several primary laterals are also calcified. Scale: 100 µm.
 6. Transverse section. Each unit corresponds to the calcification of a gametophore. Scale: 200 µm.
 7. Transverse section across a circular row of gametophores. Scale: 200 µm.
 8. Longitudinal section of three pedunculate gametophores. Scale: 100 µm.
 9. Reconstruction of a primary lateral bearing two secondary laterals and a gametophore. Drawing: Alain COSSARD.
- Figs. 2, 4, 6-8: Upper Ypresian (Cuisian), Pierrefonds (Oise); figs. 3, 5: Upper Ypresian (Cuisian), Cuise-la-Motte (Oise).



► **Plate 15:** *Parkerella binodosa* L. & J. MORELLET, 1922

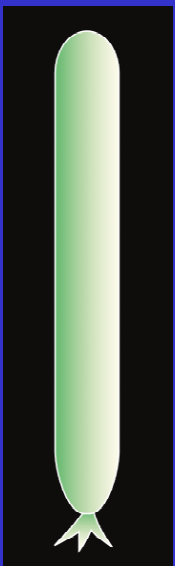
EOCENE	PRIABONIAN
	BARTONIAN
	LUTETIAN
	YPRESIAN
PALEOCENE	THANETIAN

Main references with description and illustrations: L. & J. MORELLET, 1922, p. 16, pl. 1, figs. 53-55; GENOT, 1978, p. 219-224, text.-fig. 22; 1987, p. 359-363, tabl. 33.

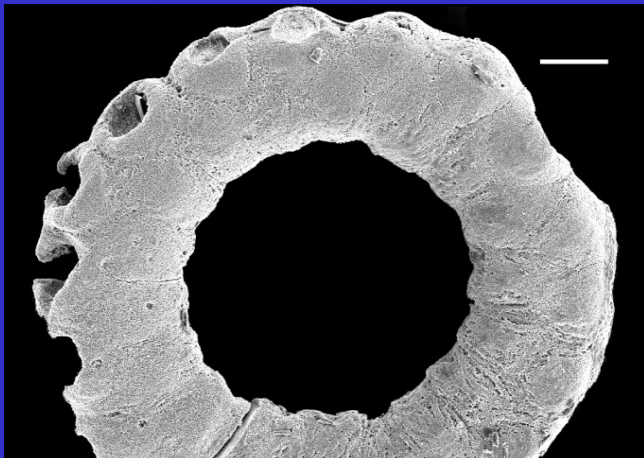
1. Schematic hypothetical reconstruction of the general shape of the thallus.
2. External view of a ring corresponding to the calcification of the gametophores. Laterals are not calcified (lectotype, specified by GENOT, 1987, p. 360; specimen previously figured in L. & J. MORELLET, 1922, pl. 1, fig. 53). Scale: 100 μ m.
3. Fragment of a ring (specimen figured in L. & J. MORELLET, 1922, pl. 1, fig. 54). Each unit corresponds to the calcification of a gametophore. The arrows indicate the location of the lower ends of the peduncles (pairs of small circular openings) bearing the gametophores. Scale: 100 μ m.
4. Transverse section of a ring showing two concentric and alternating rows of gametophores (specimen figured in L. & J. MORELLET, 1922, pl. 1, fig. 55). Scale: 200 μ m.
5. Detail of fig. 4. Sections of several gametophores. The small openings correspond to the transverse sections of the peduncles. Scale: 50 μ m.
6. Reconstruction of a pair of gametophores along a lateral (the shape of the lateral is hypothetical). Drawing: Robert DUFOUR.

Figs. 2-5: Thanetian, Abbecourt (Oise), coll. MUNIER-CHALMAS.

1



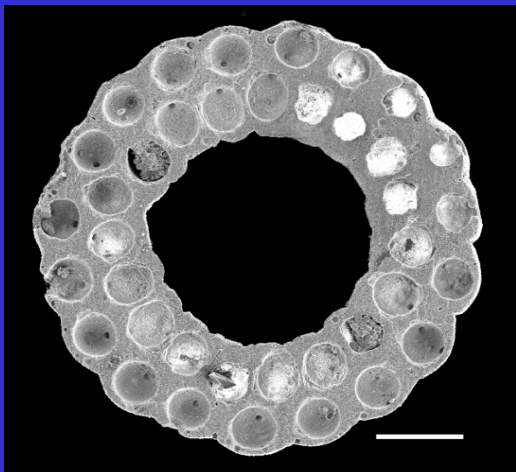
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► **Plate 16:** *Uteria encrinella* MICHELIN, 1845

EOCENE	PRIABONIAN
	BARTONIAN
	LUTETIAN
	YPRESIAN
PALEOCENE	THANETIAN

Main references with description and illustrations: L. & J. MORELLET, 1913, p. 39-41, pl. 3, figs. 40-46; 1938, p. 179-181, text.-figs. 1-4; GENOT, 1980, p. 22, pl. 25, figs. 8-13; 1987, p. 375, pl. 8, figs. 12-13, 15-16.

1. Schematic reconstruction of the general shape of the thallus (left) and schematic axial section (right) (L. & J. MORELLET, 1938, text.-fig. 4, modified).

2, 5. Two specimens showing the morphological variability of the articles. Scales: 200 μ m (fig. 2), 500 μ m (fig. 5).

3. Side view of an upper article. Scale: 200 μ m.

4. Three superposed articles at the upper end of the sheath. Scale: 500 μ m.

6. Upper side of the penultimate article. Scale: 500 μ m.

7. Internal view of the lower end of an article. The lower part of the photo shows the location of a whorl of laterals. Scale: 200 μ m.

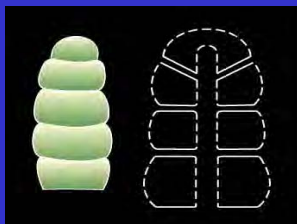
8. Longitudinal section of an article showing the calcification of the main axis. Scale: 200 μ m.

9. Detail of the internal surface of an article. Scale: 100 μ m.

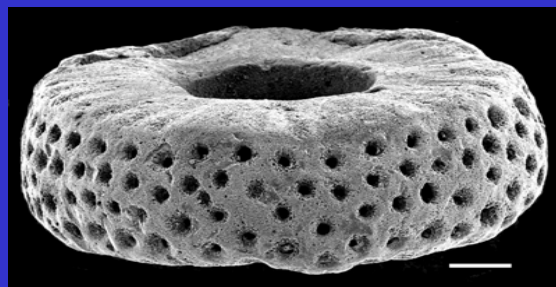
10. Upper end of the calcification of the main axis. Scale: 100 μ m.

Figs. 2-3, 6, 10: Upper Ypresian (Cuisian), Hérouval (Oise); figs. 4-5, 7-9: Upper Ypresian (Cuisian), Liancourt-Saint-Pierre (Oise).

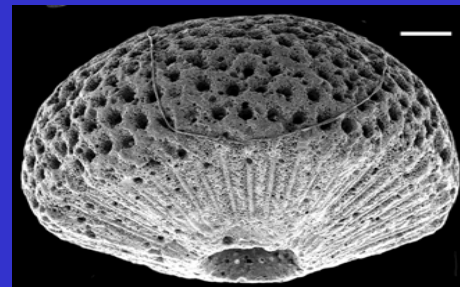
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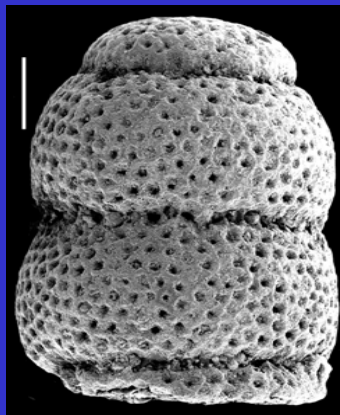
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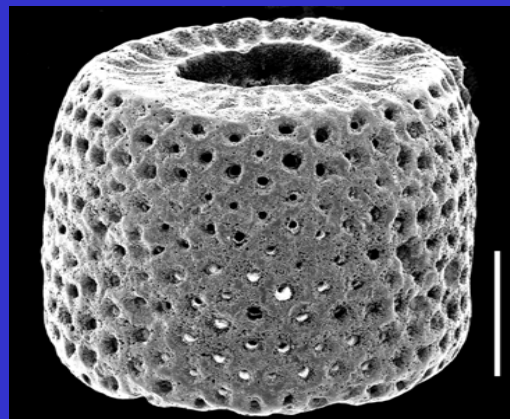
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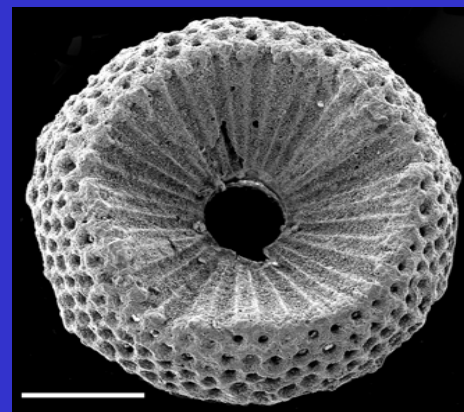
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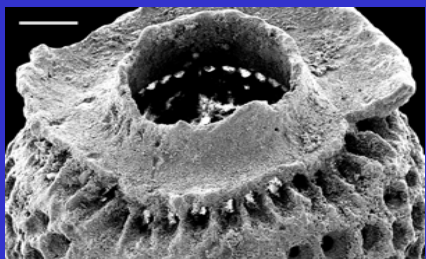
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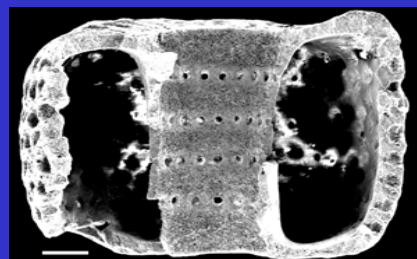
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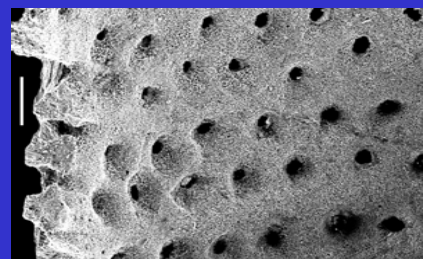
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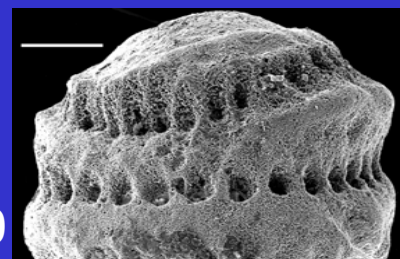
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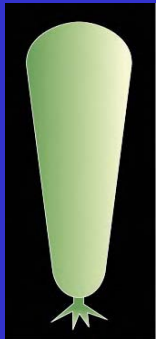
► **Plate 17:** *Zittelina dactyloporoides* (L. & J. MORELLET, 1913) GENOT, 1987

EOCENE	PRIABONIAN
	BARTONIAN
	LUTETIAN
	YPRESIAN
PALEOCENE	THANETIAN

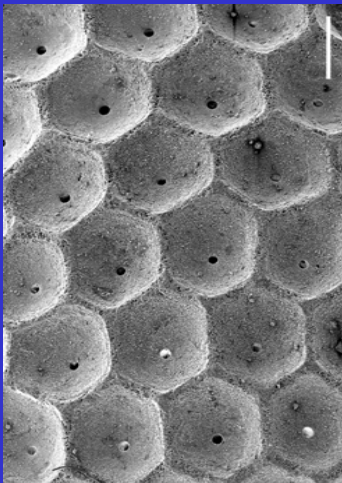
Main references with description and illustrations: L. & J. MORELLET, 1913, p. 28-29, text.-figs. 14-16; GENOT, 1987, p. 376, pl. 1, fig. 13, pl. 2, fig. 9, pl. 38, figs. 1-12.

1. Schematic reconstruction of the general shape of the thallus.
 2. Detail of the external surface of the sheath. The cortical layer is composed of alveoli that indicate the enlarged distal ends of the laterals. Scale: 200 μm .
 3. Transverse section across the calcification of the main axis and several laterals. The gametophores are sited along the laterals and contain numerous gametangia (small rounded cavities). Scale: 200 μm .
 4. Transverse section of a specimen containing gametophores very irregular in shape. Scale: 100 μm .
 5. Detail of the wall showing several gametophores enclosing the laterals (circular openings). Scale: 100 μm .
 6. Detail of the wall showing a gametophore near the alveolate cortical layer. Scale: 100 μm .
 7. Internal feature of a gametophore showing the location of several gametangia. Scale: 20 μm .
 8. Reconstruction of a primary lateral bearing several gametophores. Drawing: Robert DUFOUR, modified.
- Figs. 2-3, 5-6: Bartonian (Auversian), Baron (Oise); figs. 4, 7: Bartonian (Auversian), Echampeu (Aisne).

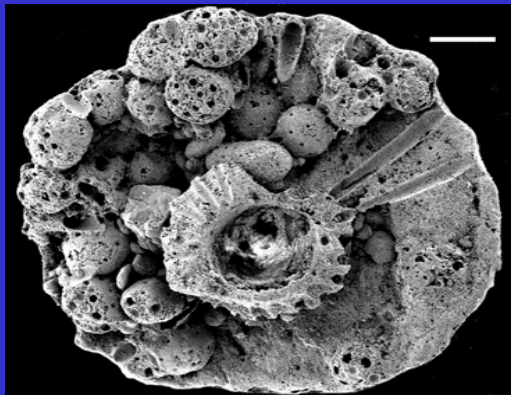
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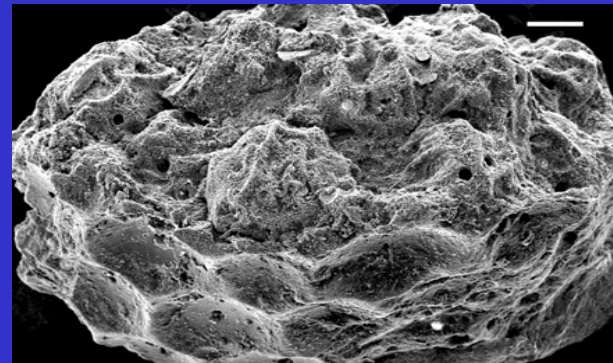
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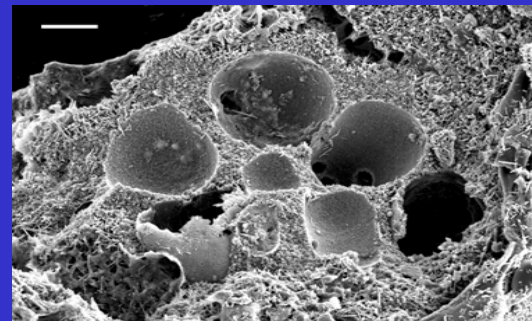
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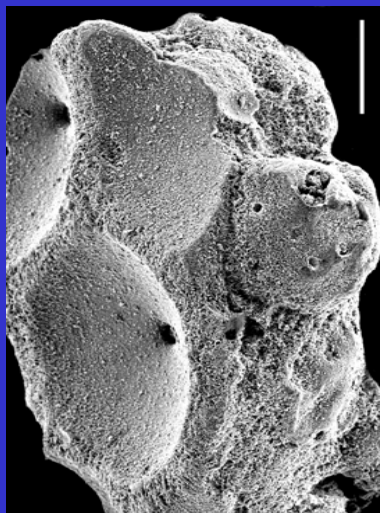
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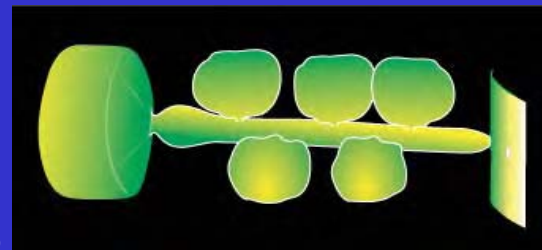
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8



Acknowledgments

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