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Nilssonia yezoensis, sp. nov., from the Upper Cretaceous Hakobuchi Group, in Hokkaido, Japan.

By

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Abstract *Nilssonia yezoensis*, sp. nov. is proposed from the Campanian-Maestrichtian Hakobuchi Group in Hokkaido, Northern Japan. This species is characterized by its varied leaf-form and size and by having paracytic stomatal complex in leaf-cuticle. *Nilssonia* leaves hitherto described from the Hakobuchi Group, based only on their external leaf-form, such as *N.* cf. *johnstrupi* HEER, *N.* cf. *orientalis* (or *N. orientalis*) HEER, *N. serotina* HEER and *N.* sp., belong probably to a single and the present new species.

Foreword

The Hakobuchi Group is mostly of marine origin and yields abundant fossil plants. Its macro fossil-plants were described by ENDO (1925) and OISHI (1940), and palynomorphs by SATO (1961) and TAKAHASHI (1964). According to OISHI (1940), this macro plant-assemblage consists of four fern or fern-like plants, five cycadophytes including two species of *Nilssonia*, two conifers and four dicotyledons.

We examined microscopically many *Nilssonia* leaves collected by ASAMA from the Hakobuchi Group at Hatsune-sawa locality and concluded that they belonged to a single and new species.

According to MATSUMOTO (1959, 1978), the geological age of the Hakobuchi Group ranges from Campanian to Maestrichtian on the basis of its guide ammonites and other marine fossils.

We express our sincere gratitude to Dr. Kazuo ASAMA who offered his valuable specimens for our present study. These specimens examined by us are kept in the National Science Museum, Tokyo.

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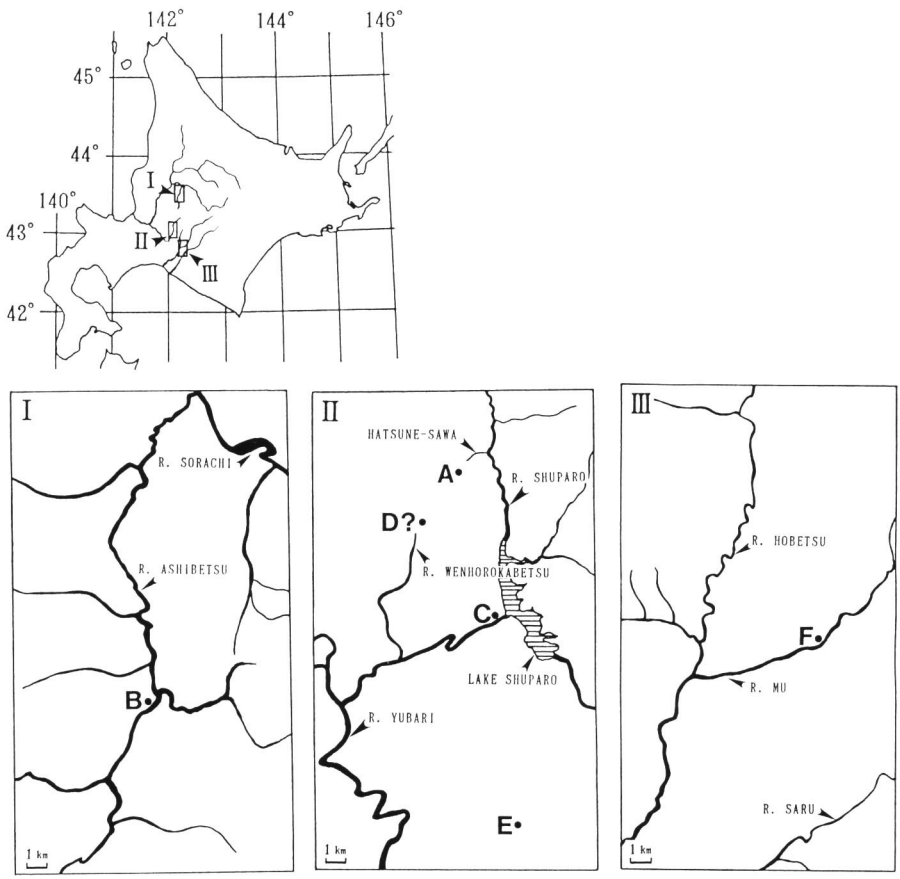

Fig. 1. Localities of *Nilssonia* leaves from the Hakobuchi Group. A. Hatsune-sawa (the present work), Yubari City. B. Upper course of the Ashibetsu-gawa, Ashibetsu City. C. Hakobuchi gorge, Yubari City. D. Wenhorokabetsu (exact point uncertain), Yubari City. E. Noborikawa, Yubari City. F. Hetonai (or Tomiuchi), Hobetsu-cho, Yufutsu-gun.

Description

Order Cycadales (or Nilssoniales)

Genus ***Nilssonia*** BRONGNIART, 1825

Nilssonia yezoensis OKUBO et KIMURA, sp. nov.

(Pls. 1–2; Figs. 2–4)

Material: Holotype; NSM PP-6596a. Paratypes; NSM PP-6596b, 6598, 6601a, 8978. Examined specimens; NSM PP-6590a and 31 other specimens.

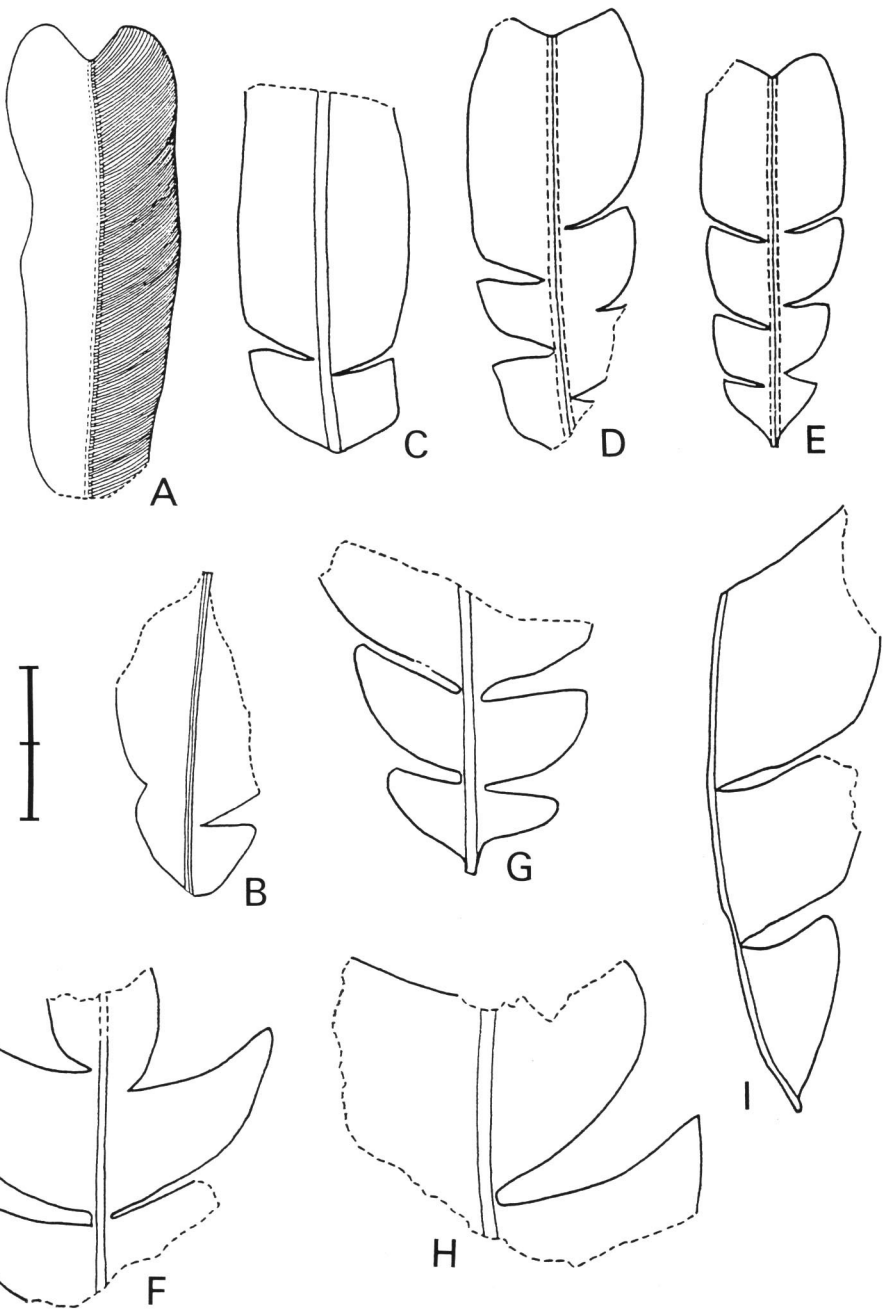

Fig. 2. *Nilssonia yezoensis* sp. nov., showing the variations of leaf-form and size. The scale is totally 2 cm long and applies to each figure. A. Paratype, NSM PP-8978. B. NSM- PP 8979. C. NSM PP-6603a. D. NSM PP-6590a. E. Holotype, NSM PP-6596a. F. Paratype, NSM PP-6596b. G. Paratype, NSM PP-6598. H. Paratype, NSM PP-6601a. I. NSM PP-6601c.

Stratum typicum: Upper part of the Lower Subgroup of the Hakobuchi Group [corresponding to the Takinosawa Member of the Tomiuchi Formation (MATSUMOTO, 1954) or roughly to the so-called *Nilssonia*-bed (ENDO, 1925)].

Locus typicus: A small gorge of the Hatsune-sawa, Yubari City (Fig. 1; A-point: roughly 142°05′20″E, 43°05′23″N).

Occurrence: Locally abundant, but all are represented by detached leaves.

Derivatio nomainis: After the old name of Hokkaido.

Diagnosis: Leaf varied in size and form, more than 7 cm long and 2–4 cm wide (noted range between 1.6 and 6.4 cm). Lamina narrowly oblong or oblanceolate in outline, with emarginate or obcordate apex, rarely mucronate at apex and with rotund or attenuate base, flat and completely covering the upper surface of rachis; margins entire or irregularly segmented; deeper incision reaching to the rachis. Rachis slender, about 1 mm wide. Veins arising from the median part of rachis at an angle of 60–70 degrees, simple, and slightly curved upwards; density 20–35 in number per cm.

Cuticle hypostomatic. Upper cuticle 1 μm thick, consisting only of ordinary cells. Ordinary cells varied in size and form, square to rectangular in general, but sometimes polygonal, 70–160 μm long and 20–50 μm wide; anticlinal walls straight or slightly waved and end walls sometimes oblique. Inner periclinal walls flat and finely sculptured, but sometimes granulated; granule 5–13 μm in diameter.

Lower cuticle 1 μm thick, consisting of ordinary cell zone on the vein-course and stomatal zone between vein-courses. Ordinary cells in the ordinary cell zone rectangular in form, 75–200 μm long and 13–35 μm wide; other features like those of upper cuticle except for smooth surface of the inner periclinal wall. Stomatal zone 130–200 μm wide, consisting of stomatal complexes and ordinary cells. Ordinary cells rectangular, but sometimes square, polygonal or elongate-polygonal, 33–105 μm long and 18–38 μm wide. Stomata coarsely scattered, about 50 in number per square mm. Stomatal complex paracytic, but subsidiary cells not clearly differentiated from ordinary cells; two neighbouring cells surrounding the guard cells laterally. Guard cells sunken, elliptic in form, 22–25 μm long (excluding polar appendages) and 13–15 μm wide with a pair of long-elongated polar appendages at both poles. Inner surface of dorsal thickening of guard cells smooth. Stomatal aperture oriented transversely or obliquely. Trichome bases restricted in distribution on the stomatal and non-stomatal zones of the lower cuticle, 15–25 μm in diameter and 15–20 per square mm in density. Resin body absent.

Supplementary description: We examined 37 leaves from the Hatsune-sawa locality (Fig. 1; A-point) and their morphological variation was shown in Fig. 2. Among these 37 leaves, three have entire margins (Fig. 2A) and the rest have incised margins; the degree of leaf-incision is mutually continuous (Fig. 2A–I). The leaf width of 78% of leaves ranges from 2 cm to 4 cm; the widest one is 6.4 cm (Fig. 2H). The relationship between leaf-width and vein-density correlates negatively (Fig. 4). The segments of lamina vary in shape; triangular, long-rectangular, rhomboidal and

trapezoid (Fig. 2B–I).

At the marginal region of a leaf, the anticlinal walls of lower ordinary cells are heavily cutinized (Pl. 1, left side of fig. 3), but such cutinization can not be observed at the same region on the upper cuticle. The stomatal complex is paracytic and its subsidiary cells do not differentiate clearly from their neighbours (Pl. 2, fig. 3 and Fig. 3B). Each stoma forms a stomate row in general (Pl. 1, fig. 3 and Fig. 3A–B). Occasionally, two stomata which are adjacent to each other share the same neighbouring cell (Pl. 2, fig. 3 and Fig. 3B). The surface features of inner periclinal walls of ordinary cells are quite different between upper and lower cuticles; the former is sculptured and/or granulated (Pl. 2, figs. 2 and 4) and the latter is smooth.

On the lower cuticle, according to the SEM observation, there is a common feature of inner periclinal surface between ordinary and neighbouring cells.

Discussion and *comparison*: The macroscopic features of our leaves correspond to the diagnostic features of the genus *Nilssonia*; for instance, the lamina of each leaf completely covers the upper surface of rachis. But in the microscopic features, the stomatal complex of our leaves is paracytic-type which is observed commonly in those of bennettitaleans.

According to HARRIS (1964), a pair of guard cells is surrounded by haplocheilic subsidiary cells in cycadaleans and pteridosperms. This idea is based on FLORIN's division of stomatal complexes (FLORIN, 1933; ESAU, 1977) as follows:

1) Haplocheilic: Subsidiary cells are not related to the guard cells ontogenetically; observed in cycadaleans, pteridosperms, czekanowskialeans and ginkgoaleans.

2) Syndetocheilic: Subsidiary cells are derived from the same protodermal cell as the mother cell of the guard cell; observed in bennettitaleans.

After FLORIN's study, many botanists have tried to classify the stomata ontogenetically (RASMUSSEN, 1981), for example, the former was called mesoperigenous and the latter mesogenous (PAYNE, 1979). However, recently some workers began to use such term for the latter fossil stomatal complexes as paracytic (SINCOCK and WATSON, 1988), because it was hard to classify the stomata ontogenetically on fossil plants. We use terms 'paracytic' according to SINCOCK and WATSON (1988).

HARRIS (1964) mentioned that the guard cells of *Nilssonia* leaves were surrounded and more or less protected by a more or less regular ring of subsidiary cells. While, our leaves have paracytic stomata. But we at present suppose that our stomata might not be typically syndetocheilic, because in our stomata, one subsidiary cell is often shared between two neighbouring stomata as shown in Fig. 3B.

Nilssonia leaves with paracytic or paracytic-like stomata were described as shown below:

Nilssonia tenuicaulis (PHILLIPS) FOX-STRANGWAYS: Jruassic of Yorkshire (HARRIS, 1964): Each stoma has two large lateral subsidiary cells.

N. arrab-mabi BARNARD et MILLER: Jurassic of Iran (BARNARD and MILLER, 1976): Each stoma has two lateral subsidiary cells and its polar cells are not clear.

N. aff. *obtusa* (NATHORST) HARRIS: Jurassic of Karatau (DOLUDENKO and

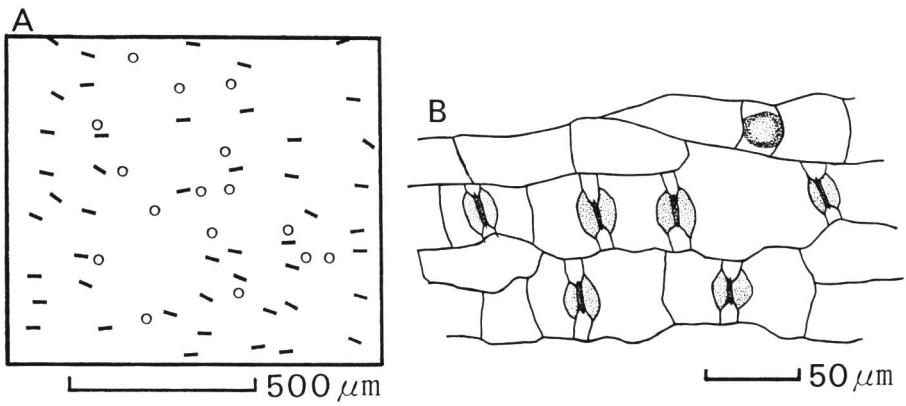

Fig. 3. *Nilssonia yezoensis* sp. nov.: A. Distribution of the trichome base-scars (open circles) and orientation of the stomatal apertures (dashed lines) on the lower cuticle. Compare with Pl. 1, fig. 3 (slide no. 6596a–1). B. Sketch of a stomatal zone on the lower cuticle, showing two stomatal rows and a trichome base (slide no. 6598–1).

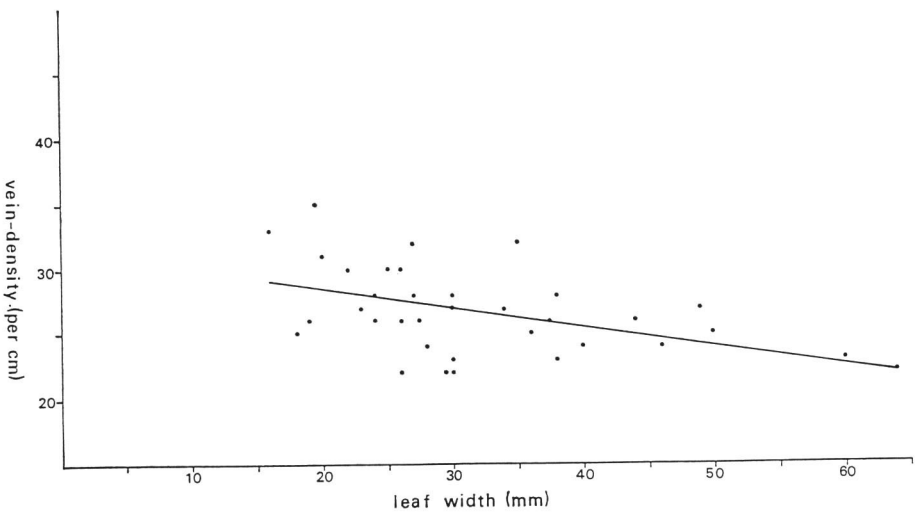

Fig. 4. Relationship between leaf-width and vein-density of *Nilssonia yezoensis* sp. nov.

ORLOVSKAJA, 1976): Subsidiary cells are thickly cutinized and stomatal apertures are oriented transversely. They look like those of bennettitaleans.

In our guard cells, well developed polar appendages are seen. Similar appendages are recognized in *Nilssonia arrab-mabi* and *N. callistoma* (BARNARD and MILLER, 1976).

Varied *Nilssonia* leaves in size and form were described without mentioning their cuticular features by ENDO (1925) and OISHI (1940) from the Hakobuchi Group at

various localities as follows:

Nilssonia serotina HEER: ENDO (1925). Loc. Hakobuchi gorge (Fig. 1; C-point), Wenhorokabetsu (Fig. 1; D?-point) and Ashibetsu-gawa (Fig. 1; B-point): OISHI (1940). Loc. Hetonai (Fig. 1; F-point).

N. orientalis Heer: OISHI (1940). Loc. Ashibetsu-gawa and Wenhorokabetsu.

N. cf. *orientalis* HEER: ENDO (1925). Loc. Hakobuchi gorge, Wenhorokabetsu and Ashibetsu-gawa.

N. cf. *johnstrupi* HEER: ENDO (1925). Loc. The same as the above.

N. sp.: ENDO (1925). Loc. Noborikawa (Fig. 1: E-point).

We are of the opinion that the future study on their cuticle would show they belong to the present new species.

The following *Nilssonia* leaves are similar in external leaf-form and size to the present species: *N. bargi-bidi* BARNARD et MILLER, 1976 (Middle Jurassic of Iran), *N. sarakha* BARNARD et MILLER, 1976 (ditto), *N. revoluta* HARRIS, 1964 (Middle Jurassic of Yorkshire), *N. tenuinervis* SEWARD (HARRIS, 1964; ditto), *N. thomasi* HARRIS, 1964 (ditto), *N.* sp. (HARRIS, 1964; ditto) and *N. dictyophylla* KIMURA et OKUBO, 1985 (Lower Cretaceous of Japan). But they are distinguished fundamentally from the present leaves by their cyclocytic (or haplocheilic) stomatal complexes.

The following Japanese *Nilssonia* leaves are also similar in leaf-form and size to the present ones: *N. variabilis* PRYNADA (TANAI, 1979; Upper Cretaceous Kuji Group), *N. glossoformis* MATSUO, 1962 (Upper Cretaceous Asuwa Group), *N. orientalis* HEER (MATSUO, 1962; ditto), *N. serotina* HEER (MATSUO, 1962; ditto), *N.* cf. *serotina* HEER (MATSUO, 1968; Upper Cretaceous Omichidani Formation) and *N. densinerve* (FONTAINE) BERRY (MATSUO, 1968; ditto). It is, however, difficult to make a precise comparison of these leaves with the present ones, because their cuticular features have not been known.

Externally similar *Nilssonia* leaves have been described by various authors from the Mesozoic plant-beds in Eurasia under a familiar name of *N. orientalis* HEER. But at present it is also difficult to make a precise comparison of these *Nilssonia* leaves with the present ones on the basis of their external form only, because *N. orientalis* was defined somewhat vaguely (KIMURA and TSUJII, 1983).

STOPES (1910) described '*Nilssonia orientalis*' anatomically from the Upper Cretaceous of Hokkaido, but its precise locality and stratigraphical horizon were still uncertain, and its leaf-cuticle was not shown by her.

Under the circumstances, we here propose *Nilssonia yezoensis*, sp. nov. to accommodate the present *Nilssonia* leaves derived from the Hatsune-sawa locality.

Nilssonia serotina HEER described by KRASSILOV (1979) from the Upper Cretaceous of Sakhalin is distinguishable from the present species, because, so far as his figure is concerned, the former stomatal complex appears to be cyclocytic (or haplocheilic).

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Explanation of Plates

Plate 1: *Nilssonia yezoensis* sp. nov.

Fig. 1. Holotype, NSM PP-6596a. Scale bar 1 cm.

Fig. 2. One of the paratypes, NSM PP-8978. Scale bar 1 cm.

Figs. 3–7. Light micrographs. Scale bar 10 μm except for Fig. 3 where it is 100 μm.

Fig. 3. Lower cuticle: Trichome base-scar is indicated by an arrow (slide no. 6596a–1 from the holotype).

Fig. 4. A stoma on the lower cuticle (slide no. 6596a–1).

Fig. 5. A stoma on the lower cuticle from NSM PP-8978 (slide no 8978–1).

Fig. 6. Trichome base-scar enlarged from Fig. 3 (slide no. 6596a–1).

Fig. 7. Ordinary cells on the upper cuticle (slide no. 6596a–1).

Plate 2: Scanning electron micrographs of *Nilssonia yezoensis* sp. nov. (prepared from NSM PP-8978, paratype). Scale bar 10 μm.

Fig. 1. Internal view of upper cuticle of the ordinary cells.

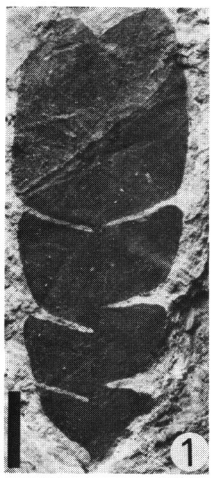
Fig. 2. Inner periclinal surface of upper cuticle enlarged from Fig. 1.

Fig. 3. Internal view of the lower cuticle.

Fig. 4. Inner periclinal surface of the upper cuticle with granules indicated by an arrow.

Fig. 5. Internal view of a stoma.

Fig. 6. Internal view of a polar appendage of guard cells.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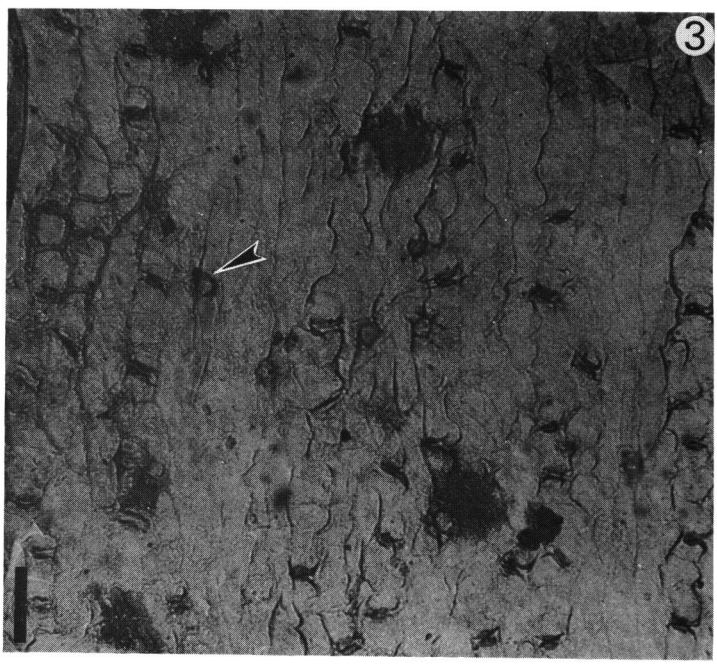
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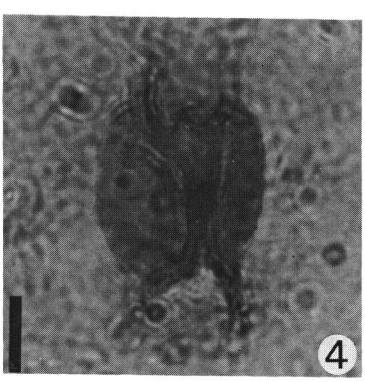
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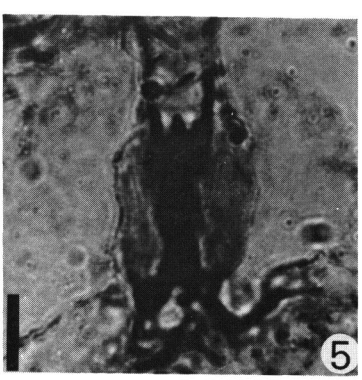
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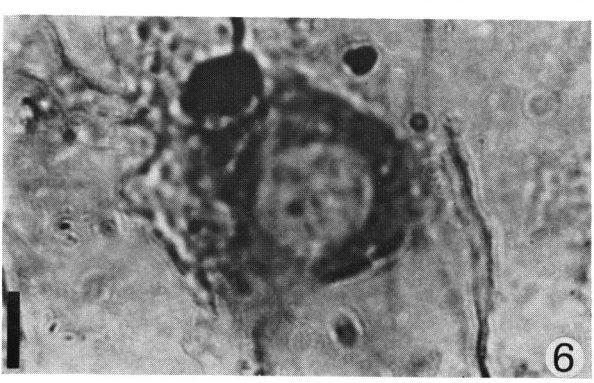
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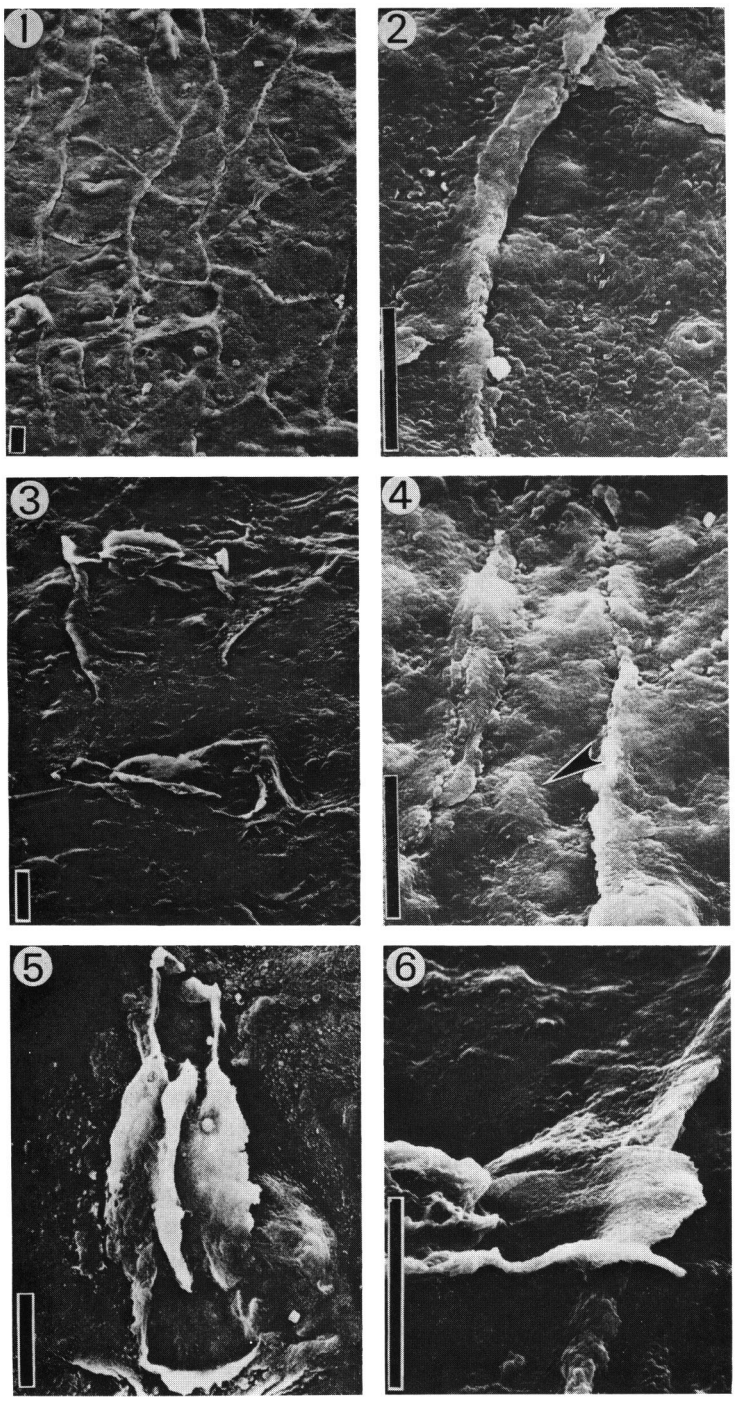
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