論　　説

ミズワラビの胞子の形態*

佐　橋　紀　男**

Spore morphology of *Ceratopteris thalictroides* *

Norio SAHASHI**

It is well known that *Ceratopteris thalictroides* (L.) Brongn. is an aquatic or subaquatic fern and has large homospores with beatufiful striate patterns reminiscent of the ornamentation of *Anemia* spores.

Past studies of *Ceratopteris* spores have been limited in scope, dealing with the spore wall structure. Concerning the perine of *Ceratopteris* spores, Erdtman (1957), Lugardon (1974) and other several authors recognized thin perine on the surface of the mature spores. However, tetrahedral, trilete spores usually have thin perine which can not observe easily under the light microscope. Recently, Mitui (1978) found the usuful and the simple techniques for the identification of the perine.

The present study deals with the spore morphology of *Ceratopteris thalictroides* and its ontogenetical observations under the light and the scanning electron microscopes (SEM).

Materials and Methods

The spores of twelve materials were observed in this study. Most materials were collected in the herbaria of the institution of Department of Botany, the National Science Museum, Tokyo (TNS). They are as follows: 1). Niigata Pref. : T. Suzuki, Oct. 1958 (TNS). 2). Tochigi Pref. : S. Ogawa, Sept. 1964 (TNS). 3). Ibaragi Pref. : T. Kuramoto, Nov; 1970 (TNS). 4). Chiba Pref. : N. Sahashi, Nov. 1975 (TOHO)*. 5). Kanagawa Pref. : H. Kazami, Oct. 1970 (TNS). 6). Shizuoka Pref. : M. Watanabe, Oct. 1966 (TNS). 7). Mie Pref. : A. Nakajima, Dec. 1975 (TNS). 8). Kyoto Pref. : M. Tagawa, Nov. 1955 (TNS). 9). Tottori

* Dedicated to the memory of Dr. M. Ikuse whose retirement from the office.
幾瀬マサ教授定年記念号にこの小論文を捧げる。

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* The herbarium of Toho University, Funabashi, Chiba Pref.
This fresh plants were used for the ontogenetical study.

Pref. : A. Tanaka, Oct. 1945 (TNS). 10). Fukuoka Pref. : T. Osada, Oct. 1947 (TNS). 11). Saga Pref. : A. Baba, Nov. 1974 (TNS) and 12). Okinawa Pref. : N. Sahashi, Mar. 1973 (TOHO).

For the scanning electron microscopy, both unacetolyzed spores and acetolyzed ones were spattered with gold. For the light microscopy, spores were mounted with glycerin-jelly after Ikuse's method (1956). The preparation for the section was made by Dr. K. Mitui, Nippon Dental University, Niigata, for the present study. The section method follows Mitui (1978).

Observations and Discussion

Spores of *Ceratopteris thalictroides* are tetrahedral, trilete, only rarely transitional forms to monolete ones. The outline in polar view is nearly round or rounded triangular (Figs. 1, 3, 5). In equatorial view, they show two different patterns projecting from the surface (Fig. 2, 4, 6). The proximal side is nearly flat to convex, and the distal side is hemispherical to subconical. Fifty randomly selected spores were measured in each material, and polar diameter×equatorial diameter was found to average 86×97 μm, with a range of 65-125×75-140 μm. After the acetolysis, the average size was 118×130 μm, showing that a large swelling had resulted from the treatment.

They say that the mature spores of *Ceratopteris* has by far some of the largest spores among homosporous ferns. However, *Ceratopteris* spores are variable in size (Nayar et al., 1964 ; Hires, 1965 ; Erdtman & Sorsa, 1971 ; Sohma, 1973). Perhaps this may be derived from the successively maturation of sporangia in the same fronds.

The laesura usually known as the triradiate streak is conspicuously projected, as is also the external sculpture of the exine, about 6-8 μm high, 3-5 μm wide, and 25-40 μm long (Figs. 1, 3, 5, 7). Freshly collected spores are pale yellow, translusent, and in the herbarium materials are almost tan in color. The exine including perine is about 4 μm thick excluding projections, and is conspicuously striate in the transitional zone between the distal and the proximal face (Figs. 4, 6). Slightly undulated parallel ridges are running along the spore surface all around, except in the contact area, and are occasionally fused the ends of laesura arms (Figs. 1, 2, 5). These ridges are about 3-5 μm high and almost as wide as the base. Very often, the ridges show dichotomous-like branching (Figs. 1, 2). The valleys (grooves) between the parallel ridges were 6-9 μm wide on the distal face. So that the valleys are about twice as wide as the ridges. But several previous papers (Tardieu-Blot, 1966 ; Welman, 1970 ; Erdtman & Sorsa, 1971) showed that the valleys are about equal in breadth or narrower than the ridges. From these results and the present observations, the ornamentation is termed rivulate also can be used for striate (Kawasaki, 1973).

The unique filamentous projections or lanate ones can be seen all over the surface of the spores (Figs. 7, 11, 12). After acetolysis, the surface of both laesurae and ridges were cracked and peeled off partially or entirely stripped off all over the surface, and almost smooth exine is visible (Figs. 8, 9). This external membrane should be equal to the perine as pointed out by Erdtman (1957) and Lugardon (1974).

Spore material of No. 11) showed somewhat immature by the light microscopic observation. One of these unacetolyzed spores under the SEM can not observe well developed filamentous projections as shown in Fig. 11, but very faint sculptures are recognized on the surface (Fig.9).

The early developmental stage of tetrad is covered with somewhat thick granular-like layer under the light microscope (Fig. 13, arrow). While in sections, tetrad is surrounded with thick, laminate layer which is stained in dark blue by giemsa solution (Fig. 19, arrow). In the SEM observations, comparable stages as in Figs. 13 and 19 are shown in Figs. 14 and 20. The outer thick layer is closely attached mainly on the distal side (Figs. 14, 20, arrows). In sections, in the more growing younger sori, the tapetal deposition is clearly deposited on the young spore surface (Fig. 21. arrow). Comparative stages as in Fig. 21, the fairly hyaline layer adheres on the spore surface in the optical views of the light microscope (Fig. 15, 17, arrows). In the SEM observations, almost samely stages as in Figs. 15 and 17, the immature spores are covered with semitransparent layer, but this layer cracks and is worn off in places (Figs. 16, 18, 22, arrows).

In sections, the more advanced younger spores can be also observed somewhat hyaline, laminate layer on the ridges or on the valleys of the spore surface (Fig. 23, arrow). In the SEM, almost on the same stage as in Fig. 23, the outer layer is fairly cracked and detached here and there from the surface (Fig. 24, arrow). Furthermore, being advanced spores in the SEM observations, the abraded outer layer is almost detached from the surface, and both on the ridges and valleys are seen to be nearly smooth or faintly granular as seen in the proximal face (Figs. 25, 26). And just before mature spores, they have somewhat faintly filamentous projections on valleys in the distal face or on the contact area in the proximal face. This stage reminds the surface pattern as in Fig. 9. Very often some remains of the abraded outer layer is deposited on the surface of the filamentous projecting layer (Figs. 27, 28). Finally, the faintly filamentous projections or lanate ones are developed into unique filamentous projections as shown in the distal and proximal face of the mature spores (Figs. 29, 30).

Within the author's knowledge, the ontogenetical studies have not been employed on the *Ceratopteris* spores by the SEM. R. Tryon and A. Tryon (1973) investigated the outer spore layer which was regarded as perine originated from tapetal deposition by the SEM. Furthermore, they clarified the outer perine layer and inner echinate perine layer in the spore of *Pellaea ternifolia* var. *wrightiana*. The similar results have been obtained in the spores of *Adiantum pedatum* by Mitui (1978).

From these results and the present study, it is concluded that the outer layer of the immature spores of *Ceratopteris thalictroides* should be equal to the outer perine layer and the filamentous or lanate layer enveloping the mature spores should be equal to the inner perine layer which clarified by R. Tryon and A. Tryon (1973).

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要　　　約

日本の各地から採集されたミズワラビの完熟胞子の形態と未熟胞子の外膜の発生過程を、光学顕微鏡と走査型電子顕微鏡（ＳＥＭ）で観察し、次のような結果を得た。まず完熟胞子の形態については、これまでに多くの報告があるが、筆者は特に胞子表面の微細彫紋に注目し、アセトリーシス法も併用して詳細に観察した。その結果、Erdtman (1957) や Lugardon (1974) らによって見出されている薄膜状の外被層 (perine) は、アセトリース後胞子本体から部分的に剥離したり、ほとんど離脱して滑らかな外壁 (exine) が見られるようになる。また Lugardon (1974) が外被層表面に絨毛状の突起を認めているが、ＳＥＭ像でもこの突起は完熟した胞子では溝 (valley) の部分で顕著に観察され、畝 (ridge) や条溝 (laesurae) の表面にも認められた。今回筆者はこの微細彫紋を繊維状突起 (filamentous projections) として記載した。一方未熟胞子の外膜の発生過程を観察した結果、４集粒あるいはその分裂直後と思われる胞子表面には、厚膜状の不透明な膜がおもに遠心極側をほぼ完全に、あるいは部分的に包囲している。胞子が多少発達してくるとこの外膜は半透明となり、部分的にひびが入ったり剥離してくる。丁度同じ頃の成長段階の切片法ではタペート組織の一部が若い胞子の表面に付着している部分が明確に観察された。この観察結果から未熟胞子に見られる不規則な外膜は R. Tryon & A. Tryon (1973) や、三井 (1978) らの記載している外側の外被層 (oufer perine layer) であると思われる。さらにＳＥＭで完熟胞子直前の胞子表面を観察すると、ターペト起源の厚い外膜は離脱あるいは吸収されて見られなくなり、胞子表面は滑らかな表面をもつ発達した畝が顕著となる。さらに完熟寸前の胞子になると、独特の繊維状突起がおもに溝の部分で認められるようになり、完熟した胞子では畝や条溝の表面にも見られるようになる。この独特の繊維状の突起をもち、アセトリーシスで離脱しやすい薄膜上の外被層は、Tryon らの述べている内側の外被層 (inner perine layer) に相当するものと思われる。

Explanation of Figures 1-12

Figs. 1-12. Scanning electron micrographs of mature spores of *Ceratopteris thalictroides*.

Figs. 1-2. Material No. 12). (Okinawa Pref.) ; Fig. 1. Polar view, proximal face showing laesurae. Fig. 2. Side view showing vertical ridges. Figs. 3-4. Material No. 8). (Kyoto Pref.) ; Fig. 3. Polar view, proximal face. Fig. 4. Side view showing horizontal ridges. Figs. 5-6. Material No. 3). (Ibaragi Pref.) ; Fig. 5. Polar view, proximal face. Fig. 6. Side view. Figs. 7-8. Material No. 8). (Kyoto Pref.) ; Fig. 7. Unacetolyzed spore surface, a part of proximal face showing filamentous projections. Fig. 8. Acetolyzed spore surface showing cracked and peeled off perine. Figs. 9-10. Material No. 11). (Saga Pref.) ; Fig. 9. Unacetolyzed spore surface showing a little immature perine. Fig. 10. Acetolyzed spore surface showing the surface of the exine. Fig. 11. Material No. 12). (Okinawa Pref.), unacetolyzed surface, a part of distal face. Fig. 12. Material No. 3). (Ibaragi Pref.), unacetolyzed spore surface, a part of distal face.

Explanation of Figures 13-24

Figs. 13-24. Immature spore surface of *C. thalictroides* by the light and the scanning electron microscopes.

Figs. 13, 15 and 17. Optical views by the light microscope. Fig. 13. Early developmental tetrad stage showing thick granular-like layer (arrow). Figs. 15 and 17. Young spores just after divided from the tetrad showing fairly hyaline layer (arrow). Figs. 14, 16 and 18. Scanning electron micrographs of young spores soon after divided from the tetrad. Fig. 14. Thick outer layer is deposited on the distal side (arrow). Fig. 16. Proximal face showing semitransparent outer layer (arrow). Fig. 18. Distal face showing semitransparent outer layer (arrow). Figs. 19, 21 and 23. Sections of immature spores by the light microscope. Fig. 19. Tetrad is surrounded with thick laminate layer (arrow). Fig. 21. Tapetal deposition is clearly deposited on the young spore surface (arrow). Fig. 23. Somewhat thick and hyaline layer is closely adhered mainly on the valleys (arrow). Figs. 20, 22 and 24. The feature of the outer layer by the SEM observations. Fig. 20. Young spores just after divided from the tetrad showing thick outer layer mainly on the distal side (arrow). Fig. 22. Thick and semitransparent outer laver is cracked and detached here and there (arrow). Fig. 24. A part of distal face, outer layer is fairly cracked and peeled off at random (arrow).

Explanation of Figures 25–30

Figs. 25–30. Scanning electron micrographs of the process of formation of the unique filamentous projections from the surface of the perine.

Figs. 25–26. The surface of the fairly advanced immature spores. Fig. 25. A part of distal face showing smooth perine surface, the abraded outer layer is almost detached on this stage. Fig. 26. A part of proximal face, contact area showing nearly smooth perine surface with laesurae. Figs. 27–28. Just before mature spore surface. Fig. 27. A part of distal face showing faintly filamentous projections and some remains of the abraded outer layer. Fig. 28. A part of proximal face, contact area showing faintly filamentous projections and some remains of adhered outer layer. Figs. 29–30. A part of mature spore surface. Fig. 29. A part of distal face showing thick filamentous projections. Fig. 30. A part of contact area showing thick filamentous projections.

☆ 新著紹介　石崎　達編：花粉アレルギー　その実態と治療

近年わが国において花粉症の症例が急増し、いわゆる公害病として注目される一方、医学界においても花粉によるアレルギーと治療法の研究が急速に進歩している。この時期に花粉学の専門家とアレルギーの専門家が協力して花粉症に関する最初の刊行物として企画されたのが本書である。医師・患者家族一般社会の人々に本症に対する正しい認識に役立つもので、現在日本の花粉症の全体を明確・簡単に述べた良書である。

編集委員：石崎　達・幾瀬マサ・長野　準・斉藤洋三・信太隆生・上野実朗

執筆者：浅井貞宏・藤崎洋子・古内一郎・降矢和夫・幾瀬マサ・石崎　達・加藤英輔・勝田満江・小林敏男・松山隆治・三国郁夫・水谷民子・宮本昭正・長野　準・中川俊二・中村　晋・奥田　稔・斉藤洋三・沢田幸正・信太隆生・清水章治・鶴谷秀人・上野実朗・宇佐神　篤・我妻義則・油井泰男

内容：花粉症の歴史と定義・花粉の構造と機能・空中花粉の生態（採集と同定、花粉カレンダー、花粉の空中浮遊）・花粉症の疫学・花粉症の病態生理・花粉症の臨床（症状、診断、治療）・各論　木本花粉症（スギ、マツ、ハンノキ、シラカンバ、コナラ、ケヤキ、クルミ）草本花粉症（イネ科、ブタクサ、ヨモギ、ヒメガマ、カラムシ、カナムグラ）職業性花粉症（概要、イチゴ、バラ、テンサイ、ジョチュウギク、シイタケ、ヒカゲノカズラ、モモ、リンゴ）

花粉および花粉症文献・その他の引用文献

特に花粉生態学からみて、花粉症発症のために空中浮遊条件の研究は面白い。しかし単に落下花粉の個体数計算だけでなく、上野が測定したように、空気湿度と関連して乾燥による花粉の容積・重量の変化および花粉が粘膜上における吸水圧なども考慮すべきである。この点からの花粉物理学の題題は花粉学者にとって興味あり、しかも重要な新しい研究分野であろう。

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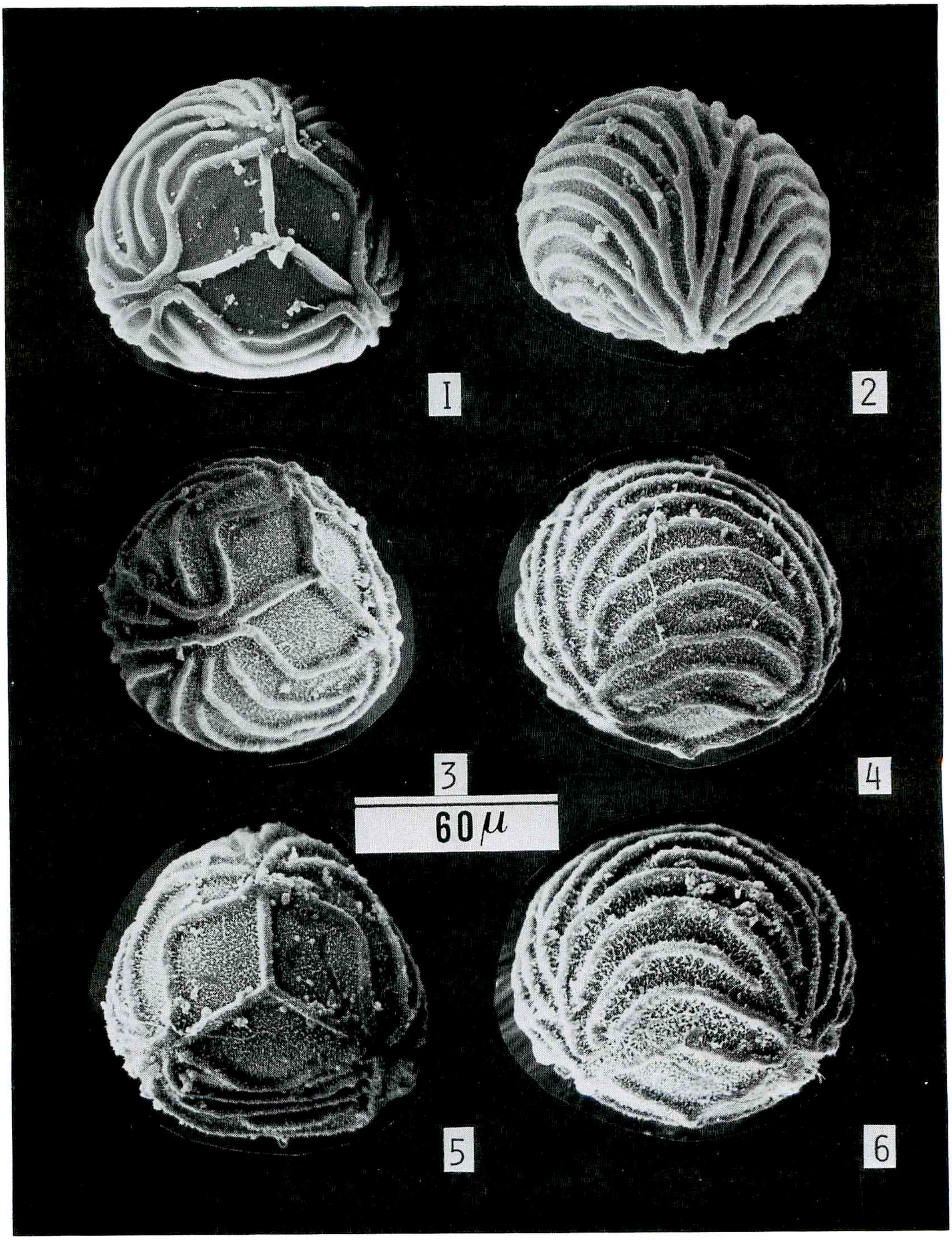
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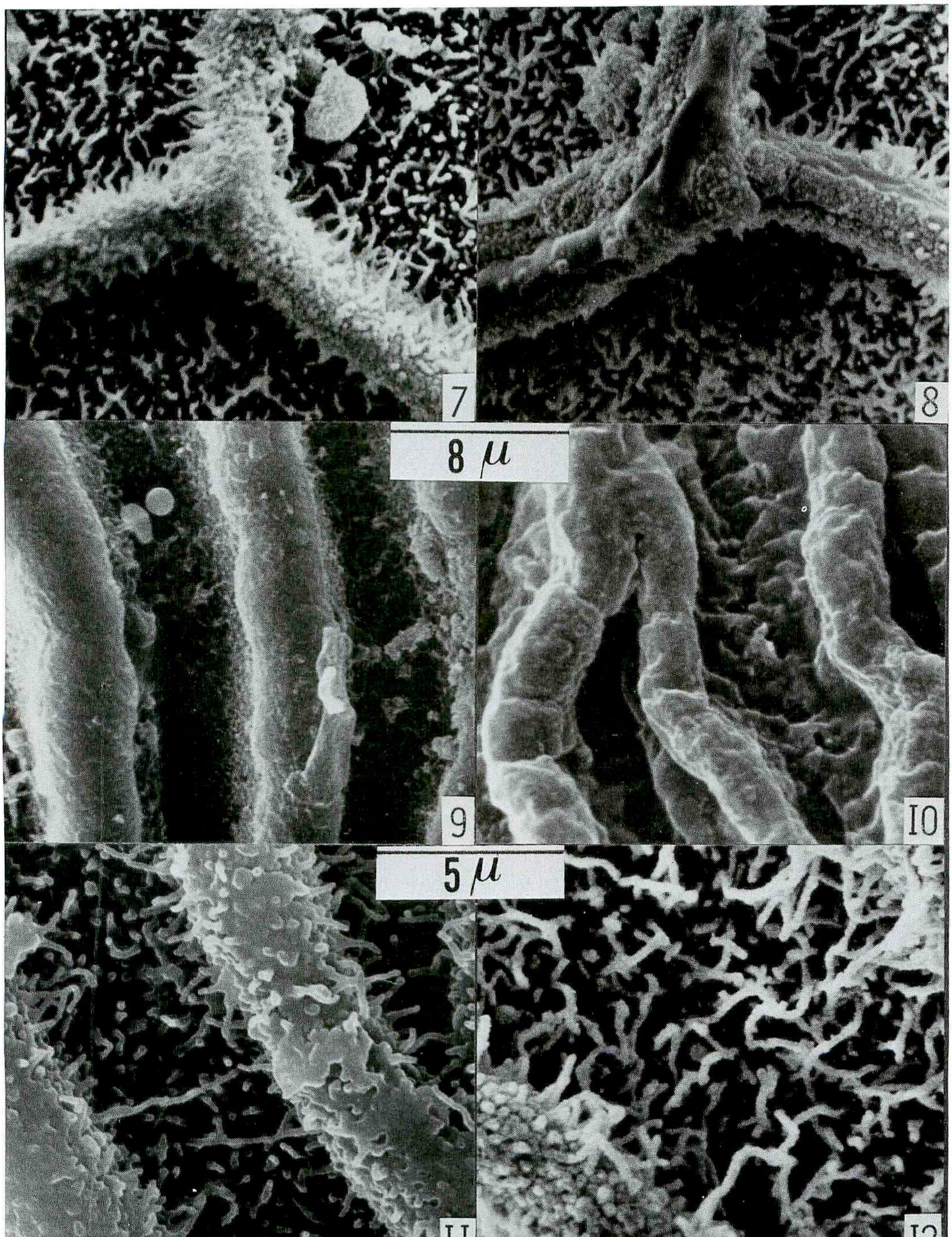
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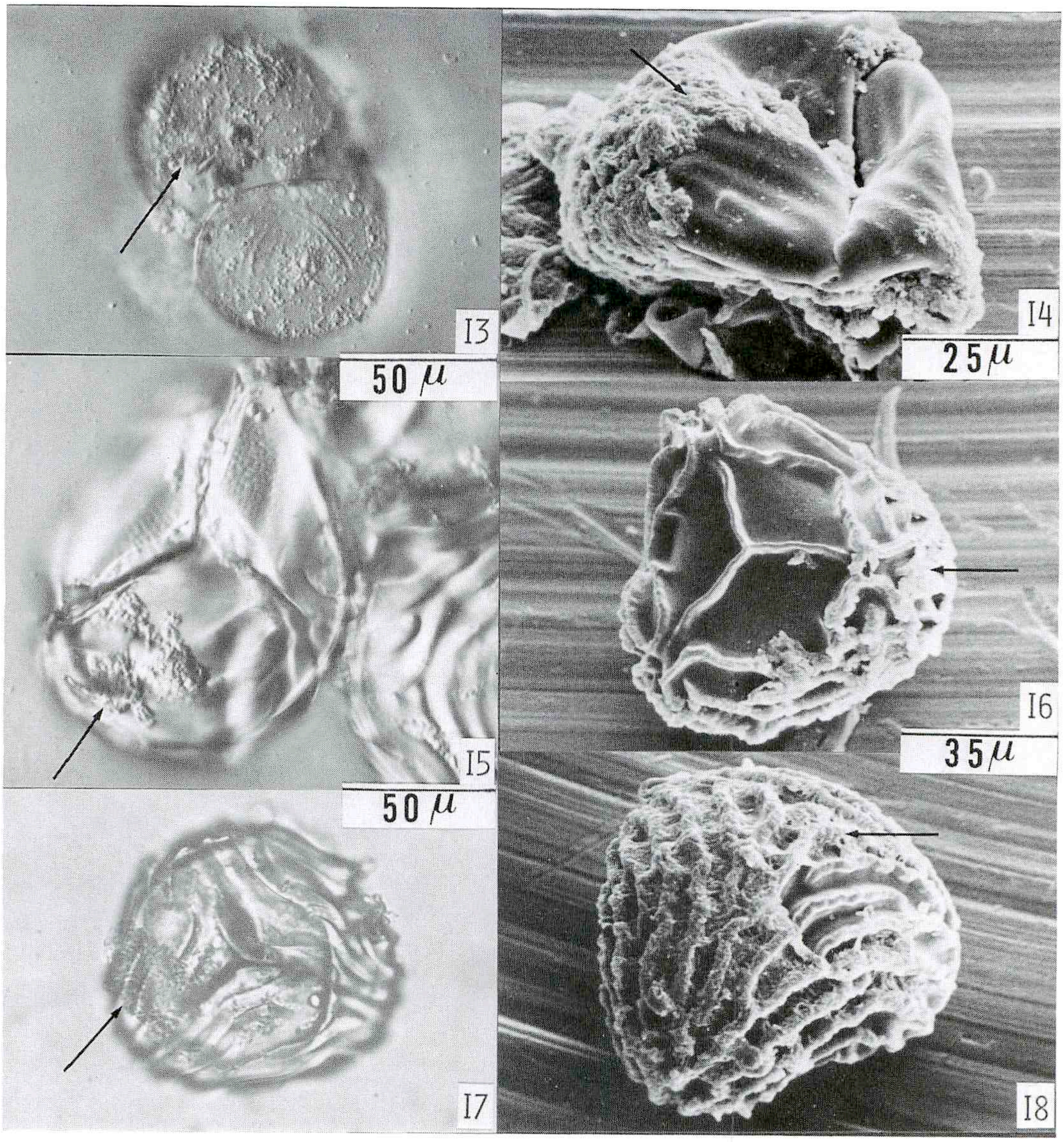
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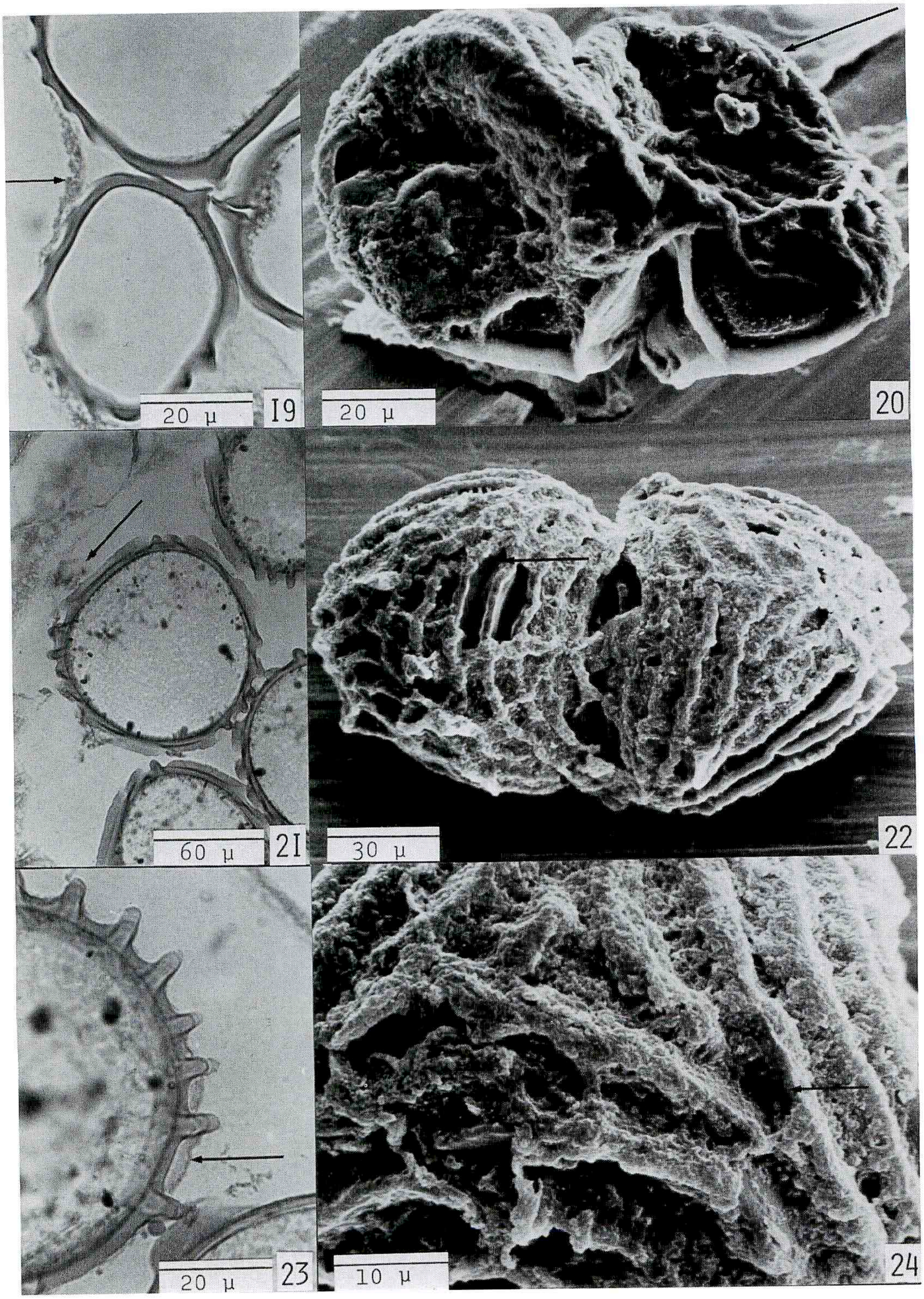
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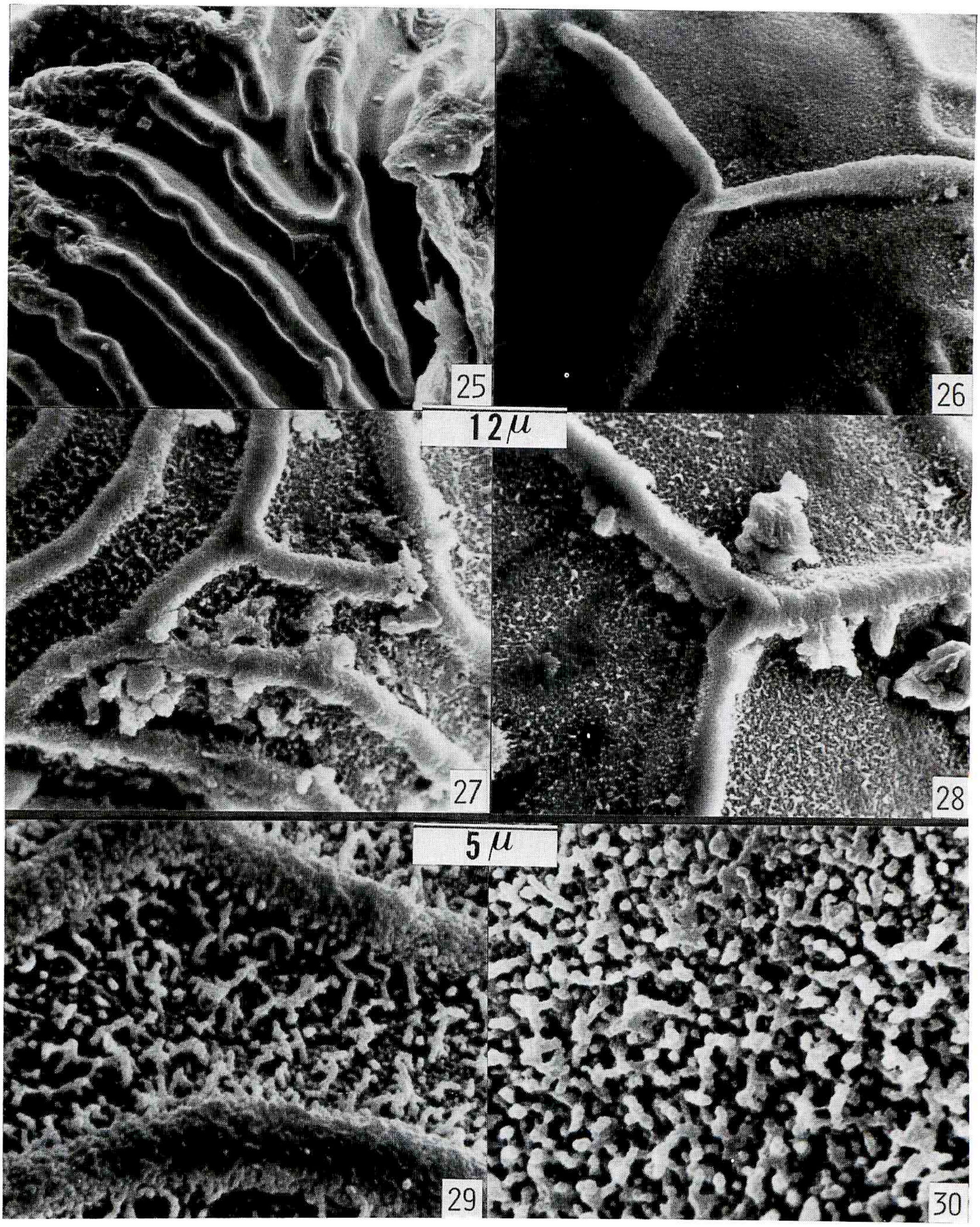
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