原　　著

Pollen morphology of Japanese *Quercus* (Fagaceae) by means of scanning electron microscope

Norio MIYOSHI*

走査電子顕微鏡による日本産コナラ属（ブナ科）の花粉の形態

三好教夫*

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Introduction

According to Kitamura and Murata (1979), fourteen species of *Quercus* are native in Japan and these species are divided into two subgenera of *Quercus* (= *Lepidobalanus*) and *Cyclobalanopsis*. The seven species belong to subgenus *Quercus*, and all of them are deciduous except *Q. phillyraeoides*, which is evergreen and distribute at the coasts mainly in the western Japan. Deciduous subgenus *Quercus* is originally distributed in the temperate zone, and *Q. mongolica* var. *grosseserrata* is a typical species of the deciduous broadleaved forests with *Fagus crenata* in Japanese vegetation. Though some species of this group such as *Q. serrata* and *Q. actissima* are often dominant in the secondary forests of the warm-temperate zone. The other seven species belong to subgenus *Cyclobalanopsis*. They are all evergreen and distribute in the warm-temperate zone, in which *Q. acuta and Q. glauca* are the dominant species of the evergreen broad leaved forests and compose the climax forest with *Castanopsis cuspidata*, *C. cuspidata* var. *sieboldii* and etc., namely the laurel forests. As mentioned above, the present species of *Quercus* have a different geological distribution and ecological demand, and Japanese forest vegetations can not be discussed without *Quercus* trees.

Quercus pollen are also a very important member for the palynology in Japan, because the fossil pollen are commonly found at all the level of the Quaternary and even the Tertiary deposits. If the fossils can be determined to the specific level palynologicaly, it will be considered to be a most valuable indicator for the research of vegetational and climatic history. Already a study with the size-frequency on *Quercus* pollen was carried out by Nakamura (1956), who noted that the group of deciduous species have larger pollen in general than the evergreen group, and it is possible to distinguish into two groups by size-frequency, though considerable overlap in size range existed in each group and specific distinction was

* Biological Laboratory, Okayama University of Science, Ridai-cho, Okayama 700, Japan. （岡山理科大学生物学教室　〒700 岡山市理大町1－1）

hardly possible. The fine structures of *Quercus* pollen were studied by Yamazaki and Takeoka (1959) with TEM, and by Matsuoka and Maeda (1975) with SEM. Both reports have been suggesting the possibility to distinguish to some groups with fine sculptures by EM. The present paper deals with the description on fine sculptures of *Quercus* pollen in Japan by SEM and aims to examine the possibility of identification to the lower rank of pollen taxon as some groups or even specific levels palynologicaly.

Materials and methods

The pollen grains of twelve species were treated with 10% KOH and were acetolysed. The acetolysed materials were fixed in Carnoy's fluid (ethylalcohol 3 : acetic acid 1) during one day. The fixed materials were washed with ethylalcohol and then with xylene. A drop of the washed materials was putted on a brass stage and were dried naturally. The dried materials were coated with Au-Pd target during eight minutes in the Ion Sputter Fine Coat (JEC-1100, JEOL LTD, Tokyo, Japan). For the scanning electron microscopical work, JSM-35 (JEOL LTD) has been used. Technical data are as follow: electron accelerated voltage 10KV, magnification for taking photomicrographs 2,000 times. The equatorial diameter and polar axis of five to ten grains were measured from the film pictures by an enlarger. The results were shown as polar axis (the shortest-the longest) × equatorial diameter (the shortest-the longest). On the grossary, most of the descriptive terms used in this work were taken from the literatures on pollen morphology such as the works of Iversen & Troels-Smith (1950), Erdtman (1952), Tsukada (1964), Moore & Webb (1978) and Ueno (1978).

Results and discussion

Subgenus *QUERCUS* L. (= *LEPIDOBALANUS* Endlicher)

Pollen grains 3-colporate, usually prolate spheroidal or rarely oblate spheroidal. Amb circular or subtriangular, and elliptical or rarely circular in equatorial view. Colpus convex lens shaped, crossing the equator at right angles, no clear sculpture on the surface of colpus. Porus elliptical iregularly or circular situating at the middle of colpus, sometimes rupturing largely and occupying the 1/3-1/2 area of colpus. Sculpture compeito-shaped (Yamazaki & Takeoka, 1959), granulate, scablate, striate or spinulate, some of them sculpturing on all over the pollen surface except colpi and pori in each species. Size 21-32μm in polar axis and 22-31μm in equatorial diameter in the deciduous subgenus *Quercus*, and 20-22μm in polar axis and 19-21μm in equatorial diameter in the evergreen subgenus *Quercus*.

1. *Quercus dendata* Thunberg (Pl. I : 1a-b)

Sculpture compeito-shaped and scabrate, the compeito (granulum with 3-7 fine spinulate projections) 0.5-1μm in diameter and distributing sparcely all over the surface except colpi. The scabrae covering densely on the surface among the compeito. Size 28-32μm in polar axis and 25-30μm in equatorial diameter.

Hiruzen-Heights, Okayama Pref. May, 1978. Y. Hada.

2．*Quercus acutissima* Carruthers (Pl. I : 2a-b)

Sculpture granulate and striate, the granula 0.5-1μm in diameter and distributing sparcely all over the surface except colpi. The striae 0.5-1μm long and 0.1-0.2μm wide, covering irregularly and densely on the surface among the granula. Size 23-28μm in polar axis and 23-32μm in equatorial diameter.

Tôhoku University, Sendai-city, May 8, 1978. M. Morita.

3．*Quercus mongolica* Fisher ex Turcz var. *grosseserrata* (Bl.) Rehder et Wilson (Pl. I : 3)

Identical with *Q. acutissima* except for the size range. Size 24-26μm in polar axis and 24-26μm in equatorial diameter.

Mt. Hakkôda, Aomori Pref. July, 1978. M. Morita.

4．*Quercus variabilis* Blume (Pl. II: 5a-c)

Sculpture identical with the preceding two species, but the granula densely distributing all over the surface except colpi and some granula unitting and 0.5-1.5μm in diameter. The striae covering irregularly on the surface among the granula. Size 27-30μm in polar axis and 25-29μm in equatorial diameter.

Hôkain, Okayama-city. Apr. 23, 1980. N. Miyoshi.

5．*Quercus serrata* Murray (Pl. I : 4)

Sculpture granulate, verrucate and striate, the granula and the striae identical with that of the preceding three species, but some granula fusioning each other and composing verrucate projection and 1-2μm in diameter. Size 21-27μm in polar axis and 22-27μm in equatorial diameter.

Handayama, Okayama-city, May 2, 1972. N. Miyoshi.

6．*Quercus phillyraeoides* Asa Gray (Pl. II: 6a-c)

Sculpture striate and granulate, the striae wider and longer than that of preceding four species, 0.1-0.2μm wide and 1-2μm long, entangling and covering all over the surface except colpi. The granula 0.5-1μm in diameter, cone-shaped or triangle cone-shaped covering with the striae, and as of dispersed rice-hulls (Yamazaki & Takeoka, 1959), Size 20-22μm in polar axis and 19-21μm in equatorial diameter.

Sanyo-town, Okayama Pref. Apr. 26, 1978. N. Miyoshi.

Subgenus *CYCLOBALANOPSIS Prantl*

Pollen grain 3-colporate, usually prolate spheroidal and rarely oblate spheroidal. Amb circular or subtriangular, and elliptical or rarely circular in equatorial view. Colpus thin convex lens-shaped, crossing the equator at right angles, the surface of colpus scablate, spinulate or psilate. Porus, circular or elliptical situating at the middle of colpus, namely on the equator. Sculpture curvimurate, spinulate or scablate all over the surface except or including colpi. Size 17-26μm in polar axis and 14-24μm in equatorial diameter in the evergreen subgenus *Cyclobalanopsis*.

7. *Quercus salicina* Blume (Pl. III: 7a-c)

Sculpture curvimurate and spinulate, the curved muri ca. 1μm wide and densely covering all over the

surface except colpus, the lumina narrower than 0.3μm wide. The fine spinulae distributing densely on the muri and also on the colpus sparsely except around pori. The surface sculpture as cauliflower-shaped (Yamazaki & Takeoka, 1959). Size 20-26μm in polar axis and 19-23μm in equatorial diameter.

Isl. Shodoshima, Kagawa Pref. M. Morita.

8 . *Quercus glauca* Thunberg (Pl. IV: 12)

Sculpture same to that of the preceding species, but the muri narrower than 0.7μm wide. Size 19-23μm in polar axis and 18-22μm in equatorial diameter.

Kôchi-city. May, 1977. M. Morita.

9 . *Quercus acuta* Thunberg (Pl. IV: 9a-b)

Sculpture same to that of the preceding two species, but the muri narrower than 0.5μm wide and disapper around the colpi, instead of it covering with the fine spinulate or striate sculpture. Size 19-23μm in polar axis and 20-24μm in equatorial diameter.

Kôchi-city, May, 1977. M. Morita.

10. *Quercus myrsinaefolia* Blume (Pl. III: 8a-c)

Sculpture scablate, the scablae distributing densely all over the surface except colpus, some scabrae

Table. 1. A comparison of pollen characters and life form of Japanese *Quercus* (Fagaceae).

Characters / Species		Sculptures		Size (μm)		Life form
		Main char.	Secondary char.	P*	E**	
Subg. *Quercus*	*Quercus dendata*	Compeito-shaped	Scablate	28-32	25-30	Deciduous broad-leaved tree
	Q. acutissima	Granulate (sparsely)	Striate	23-28	27-32	〃
	Q. mongolica var. *grosseserrata*	〃 (〃)	〃	24-26	24-26	〃
	Q. variabilis	〃 (densely)	〃	27-30	25-29	〃
	Q. serrata	Verrucate	Granulate Striate	21-27	22-27	〃
	Q. phillyraeoides	Striate	Granulate	20-22	19-21	Evergreen broad-leaved tree
Subg. *Cyclobalanopsis*	*Q. salicina*	Curvimurate (Muri 1μm wide)	Spinulate	20-26	19-23	〃
	Q. glauca	〃 (〃 0.7μm 〃)	〃	19-23	18-22	〃
	Q. acuta	〃 (〃 0.5μm 〃)	〃	19-23	20-24	〃
	Q. myrsinaefolia	Scablate	Spinulate	20-23	19-23	〃
	Q. gilva	〃	〃	18-24	16-24	〃
	Q. sessilifolia	〃	〃	17-21	14-20	〃

*P : Polar axis. **E : Equatorial diameter.

jointing each other. No clear cauliflower-shaped sculpture. Size 20-23μm in polar axis and 19-23μm in equatorial diameter.

Kawauchi, Sendai-city, May 19, 1978. M. Morita.

11. *Quercus gilva* Blume (Pl. IV:10a-b)

Sculpture identical with that of the preceding species. Size 18-24μm in polar axis and 16-24μm in equatorial diameter.

None-town, Kôchi Pref. May 15, 1953. J. Nakamura.

12. *Quercus sessilifolia* Blume (Pl. IV: 11)

Sculpture scablate, but the scablae smaller than that of the preceding two species. Size 17-21μm in polar axis and 14-20μm in equatorial diameter.

Mt. Tsurugi, Tokushima Pref. May 16, 1953. J. Nakamura.

A comparison of the above mentioned characters such as pollen species in Japanese *Quercus* is summarized in Table 1.

It was reported Yamazaki & Takeoka (1959) based on the reprica method that in a group of deciduous broadleaved trees belonging to subgenus *Quercus,* the surface of pollen membrane is covered with irregularly aranged granula, and on the surface of them fine spinulae are distributing. The sculpture, namely kompeito-shaped, recognized typically on the pollen surface of *Q. dendata* by means of SEM in this work. Furthermore, the following sculptures are recognized in the deciduous subgenus *Quercus*. The granulate sculpture is observed sparcely on the pollen surface of *Q. acutissima* and *Q. mongolica,* and densely of that of *Q. variabilis*, and the verrucate one on that of *Q. serrata*. These four species have also fine striate sculpture among the above mentioned granulate or verrucate projections. *Q. phillyraeoides*, which is the only evergreen broadleaved tree belonging to subgenus *Quercus*, has a unique sculpture on the pollen surface, namely striate and granulate one, which is composing cone-shaped or triangle cone-shaped projections covering with the striae. This pattern is mentioned "as of dispersed rice-hulls among the linear protrutions" by Yamazaki & Takeoka (1959). Same authors reported that in a group of the evergreen broadleaved trees belonging to subgenus *Cyclobalanopsis*, the surface of pollen membrane has a structure resembling the cauliflower, and on the surface of its protrusions the fine spinulae are projecting. The pattern is observed on the pollen surface of *Q. salicina*, *Q. glauca* and *Q. acuta* in the work. Moreover scablate sculpture is recognized on the pollen surface of *Q. myrsinaefolia, Q. gilva* and *Q. sessilifolia*. Thus, according to the result of the work it is considered adequately to classify the sculptures of pollen surface of twelve species of Japanese *Quercus* into six different types, namely four types in subgenus *Quercus* and two types in subgenus *Cyclobalanopsis*.

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要　　約

日本産コナラ属（ブナ科）12種の現生花粉の形態を走査電子顕微鏡で観察した。その結果コナラ属コナラ亜属の6種はコンペイトウ状型(カシワ)、粒状型（クヌギ、ミズナラ、アベマキ)、イボ状型（コナラ)、線状型（ウバメガシ）の4型に大別できる。コナラ属アカガシ亜属の6種は湾曲ウネ状型（ウラジロガシ、アラカシ、アカガシ）と微小突起状型（シラカシ、イチイガシ、ツクバネガシ）の2型に大別できる。これらのことからコナラ属の化石花粉は従来落葉型と常緑型の2型に分けられていたが、さらに詳細に同定できる可能性がある。

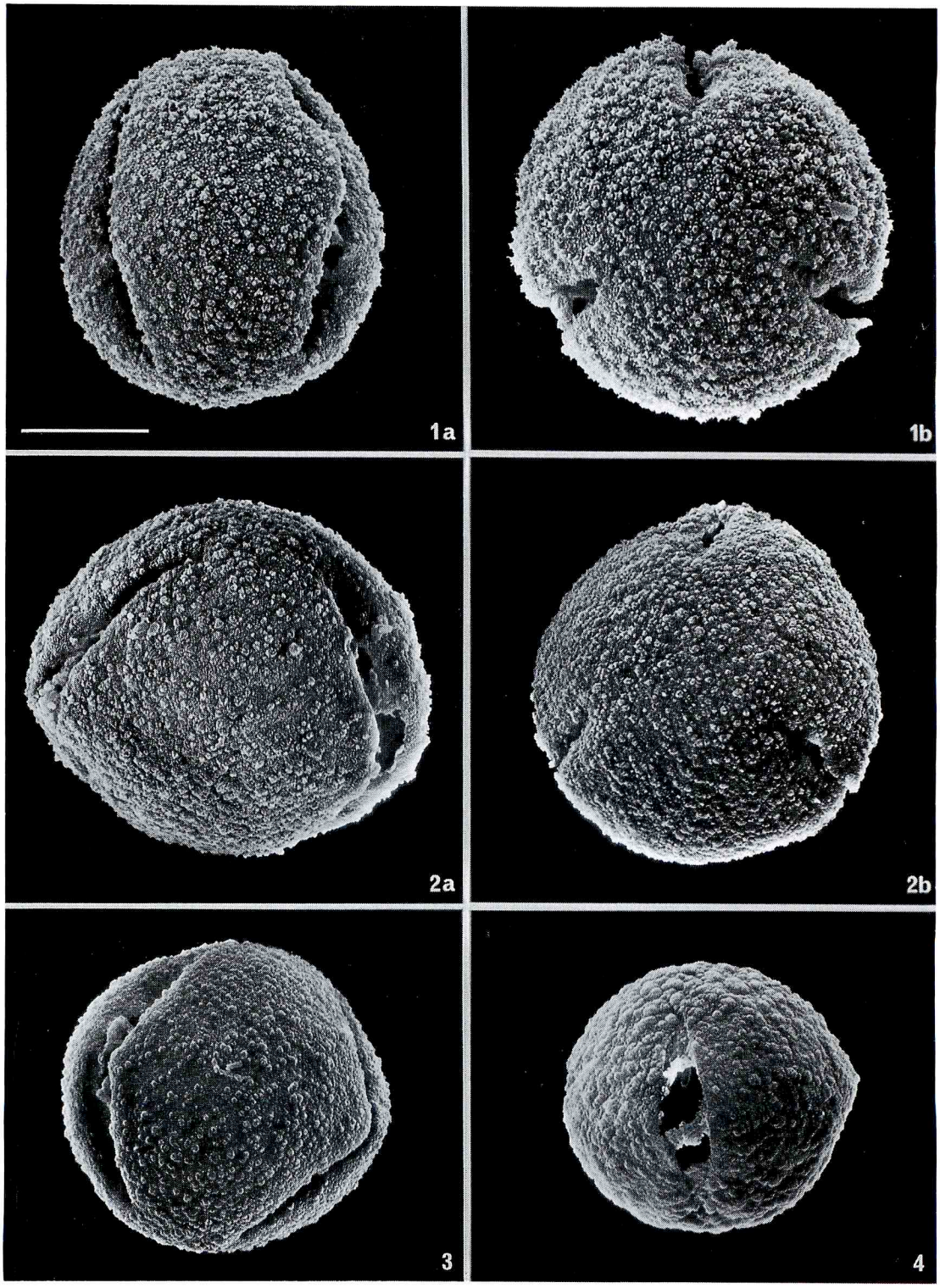
Explanation of plates

Pl. I. 1a-b : *Quercus dendata*, × 2,000. 2a-b : *Q. acutissima*, × 2,000. 3 : *Q. mongolica* var. *grosseserrata*, × 2,000. 4 : *Q. serrata*, × 2,000. (Line denotes 10μm)

Pl. II. 5a-c : *Quercus variabilis*, × 2,000. 6a-c : *Q. phillyraeoides*, × 2,000.

Pl. III. 7a-c : *Quercus salicina*, × 2,000. 8a-c : *Q. myrsinaefolia*, × 2,000.

Pl. IV. 9a-b : *Quercus acuta*, × 2,000. 10a-b : *Q. gilva*, × 2,000. 11 : *Q. sessilifolia*, × 2,000. 12 : *Q. glauca*, × 2,000.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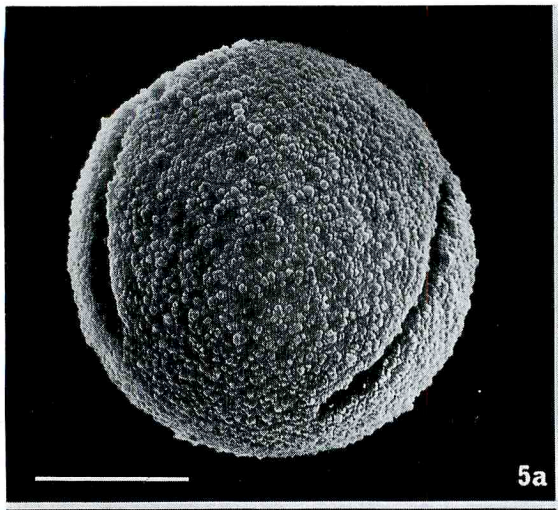
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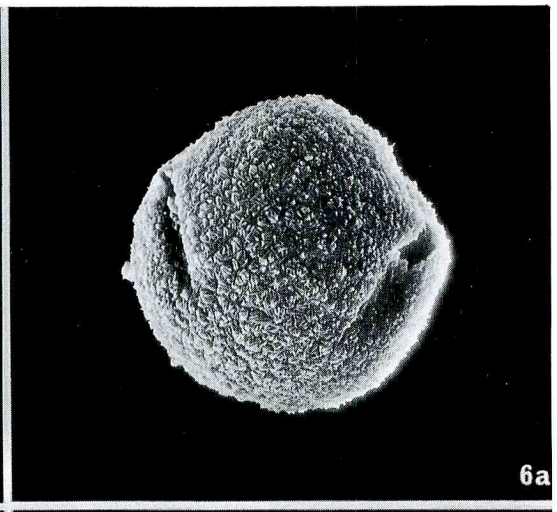
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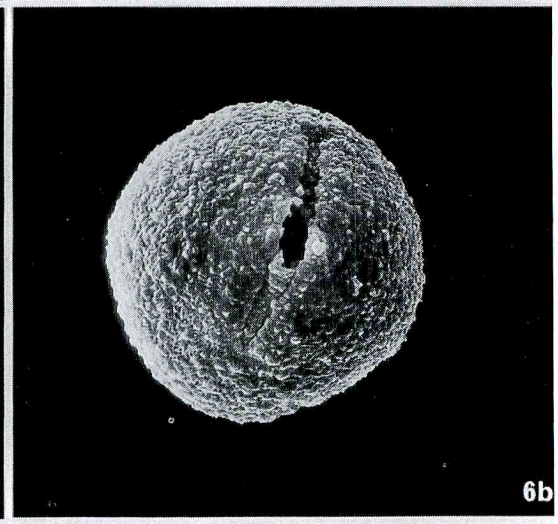
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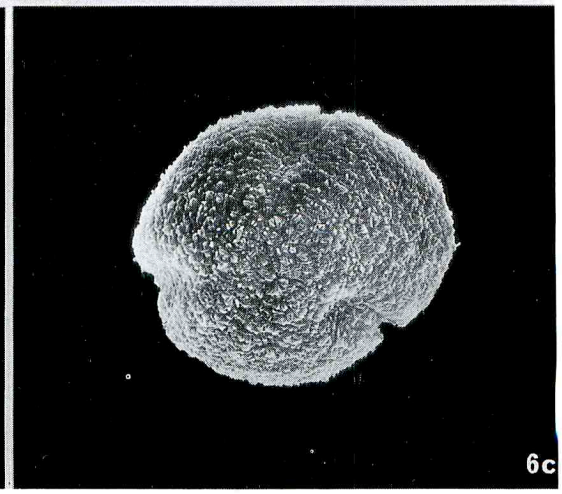
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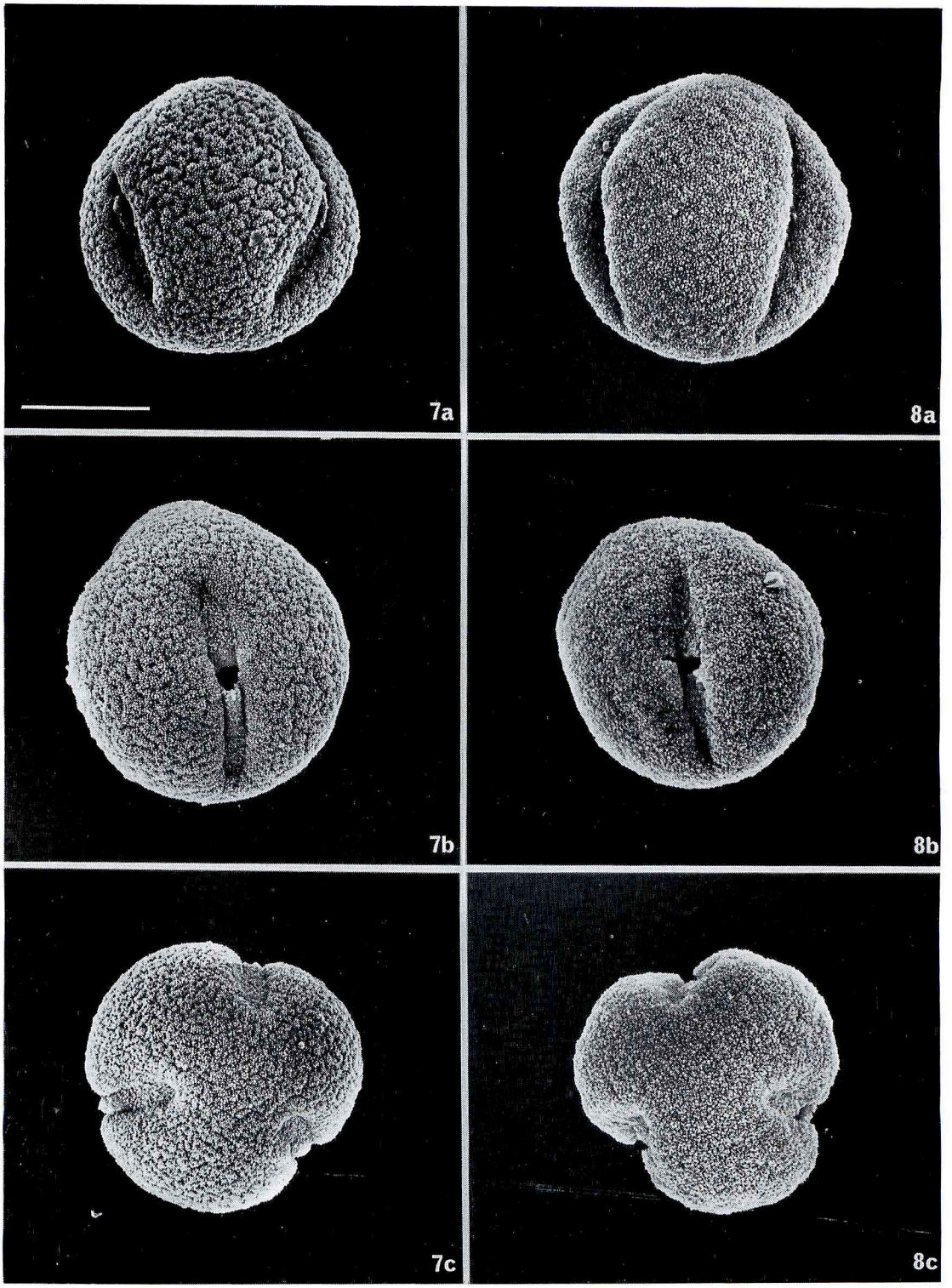
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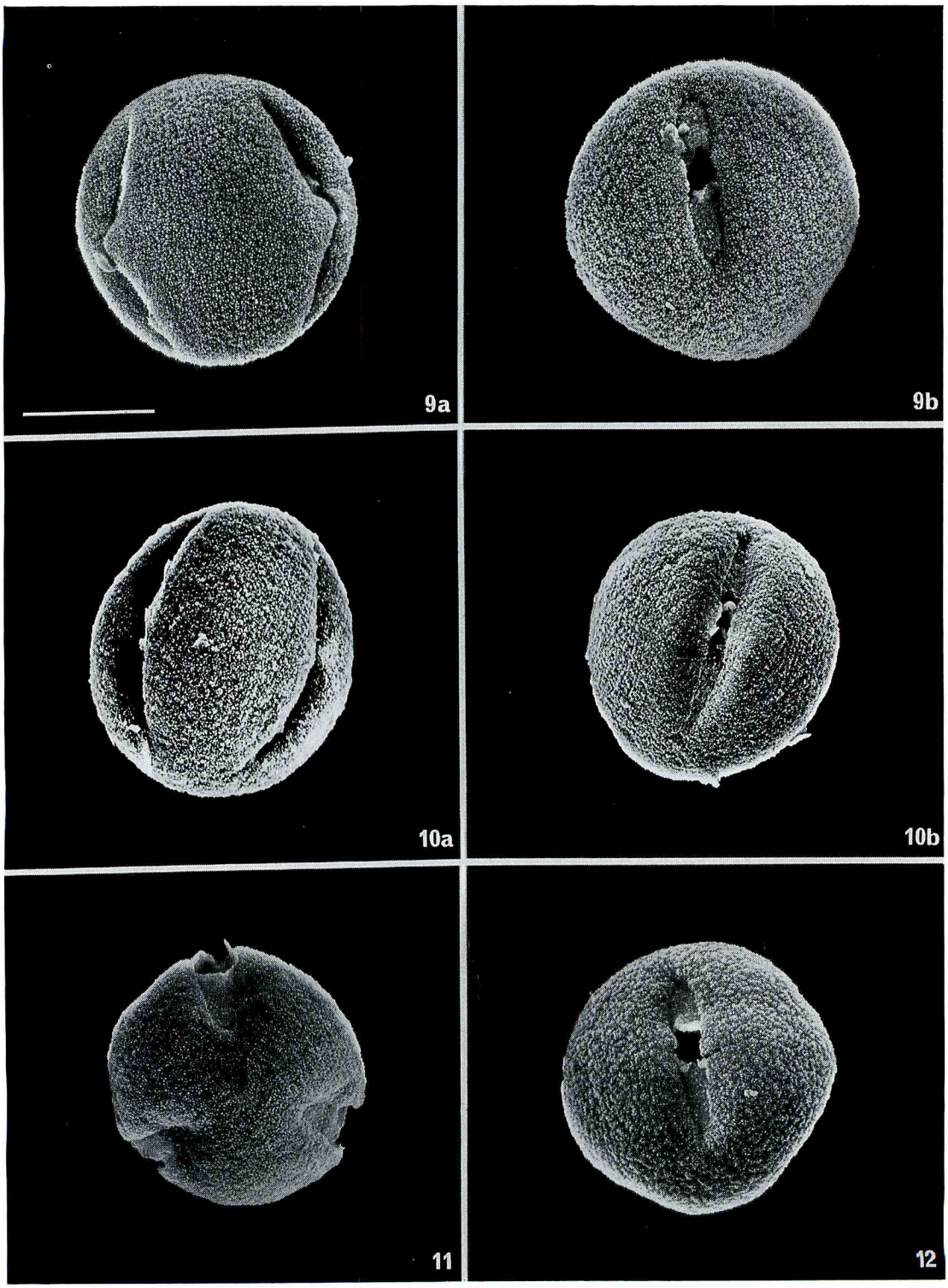
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