HOKKAIDO UNIVERSITY

Title	CONTRIBUTIONS TO THE MORPHOLOGY OF THE GENUS LAURENCIA OF JAPAN. II
Author(s)	SAITO, Yuzuru
Citation	北海道大學水産學部研究彙報, 15(4), 207-212
Issue Date	1965-03
Doc URL	http://hdl.handle.net/2115/23234
Type	bulletin (article)
File Information	15(4)_P207-212.pdf

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CONTRIBUTIONS TO THE MORPHOLOGY OF THE GENUS *LAURENCIA* OF JAPAN. II

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2. *Laurencia okamurai* Yamada

Plates I–IX

Yamada, 1931, p. 206, pl. 7, text-figs. J & K; in Okamura, 1936, p. 856; Higashi, 1935, p. 18; 1936, p. 9; Takamatsu, 1938, p. 66; 1939, p. 76; Hasegawa, 1949, p. 70; Ohshima, 1950, p. 150; Tanaka, 1950, p. 11; Imahori & Searashi, 1955, p. 73; Kawashima, 1955, p. 34; Saito, 1956, p. 106; Hirose, 1957, p. 103; 1958, p. 268; Segawa & Ichiki, 1959, p. 112; Segawa & Kamura, 1960, p. 61; Segawa & Yoshida, 1961, p. 19; Noda, 1964, p. 73; Noda & Kang, 1964, p. 43.

Japanese name. Mitsudesozo (Okamura).

Specimens collected. Growing on rocks in the lower littoral and upper sublittoral zones. *Hokkaido*: Oshoro, Shiribeshi Province, 19 July 1962 (sterile), 29 July 1963 (sterile), 20 July 1964 (sterile); Esashi, Hiyama Province, 31 July 1963 (⊕); Matsumae, Oshima Province, 3 August 1962 (♂ ♀ ⊕), 23 July 1963 (♂ ♀ ⊕), 29 July 1964 (♂ ♀ ⊕); Moheji, near Hakodate, Oshima Province, 16 August (♂ ♀ ⊕), 11 September (♀ ⊕), 28 September (♀ ⊕) 1962; 27 August (♂ ♀ ⊕), 5 September (♂ ♀ ⊕), 13 September (♂ ♀ ⊕) 1963. *Japan Sea coast of Honshu*: Nou, Echigo Province, 23 July 1960 (♀ ⊕); Shichirui, Idzumo Province, 21 June 1964 (sterile). All of the specimens were collected by Y. Saito.

Distribution. *Japan. Hokkaido*: Okushiri Island (Hasegawa, 1949). *Japan Sea coast of Honshu*: Mutsu Province (Takamatsu, 1938); Ugo Province (Takamatsu, 1939); Uzen Province (Higashi, 1936; Takamatsu, 1939); Echigo Province (Saito, 1956); Toyama Bay (Ohshima, 1950); Noto Province (Imahori & Searashi, 1955); Echizen Province (Higashi, 1936); Tajima Province (Hirose, 1958); Nagato Province (Yamada, 1931). *Pacific coast of Honshu*: Rikuchu Province (Kawashima, 1955); Iwaki Province (Noda, 1964); Awa Province, Sagami Province (Higashi, 1935); Kii Province (Yamada, 1931). *Kyushu*: Hizen Province (Yamada, 1931); Higo Province (Segawa & Ichiki, 1959; Segawa & Yoshida, 1961); Satsuma Province (Yamada, 1931); Make Island (Tanaka, 1950); Bungo Province (Yamada, 1931). *Shikoku*: Shiaku Islands (Hirose, 1957); Deba Island (Yamada, 1931). *Ryukyu* (Segawa & Kamura, 1960). *Korea* (Noda & Kang, 1964). *China* (Yamada,

1931).

The present species was established by Yamada (1931) on the basis of the tetrasporiferous specimens from southern Japan and China. According to the reports on the present species by the above listed workers, this species is distributed all around the coast of Japan. However, there has been no information on the sexual plants to date. So the writer wishes to report here the results of his observations on the male and female plants as well as the asexual plant of the present species.

The fronds are erect, nearly 20 cm. high, with several erect axes densely tufted below with entangled and somewhat coalescing basal branches (Pl. I, Pl. II, Fig. 4). The erect axes are cylindrical, 820–1230 μ diam., 4.8–18.8 cm. high (10.1 cm. high on the average among 77 individuals), and paniculately branched. The branching is alternate, opposite or verticillate; the branches are 630–800 μ diam. The fronds are generally purplish green, sometimes dark purple, in colour, fleshy to cartilaginous but not so rigid in texture, and adhere to paper when dried. In surface view, the cortical cells in the main axis are irregularly elongated longitudinally, 11–16 μ wide and about 1.6–4.3 times as long as the width (Pl. V, Fig. 4), while in the basal portion of the branch slightly elongated longitudinally and somewhat larger, 26–35 μ wide and 1.3–2.2 times as long as the width (Pl. V, Fig. 3); they are nearly round, about 23–32 μ diam. (Pl. V, Fig. 2) in the upper part of a branch, but small, roundish and slightly elongated laterally (Pl. V, Fig. 1) in the apical portion of an ultimate branchlet. The cortical cells, in transverse section, are neither elongated radially nor arranged as a palisade, being 20–32(–44) μ long radially, and (14–)24–37 μ wide (Pl. V, Fig. 5); they are not projected above the frond surface as clearly seen in longitudinal section (Pl. VI, Fig. 2). The lenticular thickenings of the cell walls are present in the medulla (Pl. V, Fig. 5). They are especially abundant at the forked portions of the frond and at the base of cystocarps (Pl. IV, Fig. 7, Pl. VIII, Fig. 7), but rather rare in younger tissues such as the apical portion of an ultimate branchlet. The apical cell of the ultimate branchlet is situated at the bottom of the apical depression, and it cuts off, by oblique walls, wedge-shaped segments which form the axial cell-row. All of the cells in the branchlet including those of the trichoblast and of the young reproductive organs are linked directly or indirectly to the axial cells by the pericentral cells (Pl. III, Figs. 1–3 & 6–8, Pl. IV, Figs. 1, 5 & 6, Pl. VI, Fig. 2, Pl. VII, Fig. 5, Pl. VIII, Fig. 1, Pl. IX, Fig. 1). The trichoblast arises from a young pericentral cell near the apical cell, and is gradually displaced toward the periphery of the apical depression with the advance of growth, branching dichotomo-alternately (Pl. III, Fig. 8, Pl. VI, Figs. 1 & 2).

The terminal portion of an ultimate branchlet in the male plant is characteristically broadened, attaining 400–940 μ in diameter, and bears one to three, or more antheridial depressions, 140–290 μ in diameter, and 1.26–1.35 times as broad as the depth, which are furnished with many fertile and sterile trichoblasts (Pl. III, Figs. 1 & 2, Pl. VII, Fig. 5). The fertile trichoblast, or antheridium, consists of a dichotomo-alternately branched central axis and four pericentral cells, or spermatangial mother cells, on each axial cell (Pl. VII, Figs. 1 & 3). Each mother cell gives rise to 1–3 (or more) ovoid spermatangia, 6.9–9.7 μ long by 4.2–5.6 μ diam., which contain a large nucleus at their apices (Pl. III, Figs. 4 & 5, Pl. VII, Figs. 1, 3 & 4). Some of the axial cells are occasionally found to give rise directly to a spermatangium as a pericentral cell (Pl. VII, Fig. 1). A pericentral cell from a lower segment of the axis usually produces a corymbose branch and a tuft of spermatangia (Pl. VII, Fig. 4). The terminal cell of the axis of a fertile trichoblast is vesicular in appearance, ovoid in shape, and often very large, up to 42 μ long by 35 μ diam. (Pl. III, Figs. 4 & 5, Pl. VII, Fig. 1).

The ultimate branchlets in the female plant are cylindrical while sterile, but they become clavate with the development of the procarps and cystocarps (Pl. II, Fig. 2, Pl. IV, Figs. 5 & 6). The initial cell of the procarp arises from a pericentral cell of the fertile branchlet and acts as the fertile central cell of the procarp. This fertile cell is linked to the axial cell of the branchlet through the pericentral cell which gradually becomes elongated and filamentous below, with the growth of the branchlet tissues (Pl. IV, Fig. 1, Pl. VIII, Fig. 1). The fertile central cell cuts off the supporting cell of the carpogonial branch on the inside, i.e. toward the growing point of the branchlet. The four-celled carpogonial branch is formed inside on the supporting cell (Pl. IV, Figs. 1 & 2, Pl. VIII, Figs. 1 & 2) and on the opposite side a sterile cell is also formed (Pl. IV, Fig. 2, Pl. VIII, Fig. 2). The fertile central cell also cuts off the sterile cell toward the outer side and on the inside beneath the central cell (Pl. IV, Figs. 1 & 2, Pl. VIII, Figs. 1–3). These sterile cells later divided into several cells which contribute to the growth of the gonimoblast and also form a part of the pericarp. After fertilization a large auxiliary cell is cut off from the supporting cell on the upper side (Pl. IV, Fig. 2, Pl. VIII, Fig. 2) and it fuses with the carpogonium, and then the supporting cell fuses with the fertilized auxiliary cell to form a fusion-cell (Pl. VIII, Fig. 3). This fusion-cell gives rise to a process or the first gonimoblast cell toward the above mentioned sterile cell which is situated near the fusion-cell, and they fuse with each other. The fusion-cell continues to fuse with other sterile cells and also with the surrounding cells including the central cell and the gonimoblast cells formed in earlier stages, then it becomes larger and irregular in shape

(Pl. IV, Figs. 3–7, Pl. VIII, Figs. 4–7). The pericarp originates from the sterile cells which have been formed as pericentral cells of the fertile central cell of the procarp. Before fertilization, the procarp is covered by young pericarp but the carpogonial branch is still naked on its inner side (Pl. IV, Figs. 1 & 2, Pl. VIII, Figs. 1–3). With the growth of the branchlet, the developing procarp is gradually displaced toward the periphery of the apical depression, and some cortical cells of the branchlet contribute to the growth of the outer portion of the pericarp (Pl. IV, Figs. 5 & 6). Thus the developed pericarp consists of cells of two different origins. The ripe cystocarp is situated on the lateral surface of the branchlet (Pl. II, Fig. 2), ovoid in shape, up to 820 μ diam., and is provided with a carpostome. The cystocarpic cavity is filled with a stratified mucilaginous substance which stains well with ferric haematoxylin. The innermost cells of the pericarp which originated from the pericentral cells of the fertile central cell of the procarp become markedly thin and filamentous in shape, indicating that they probably supplied nutrition to the gonimoblast through the fusion-cell. The terminal cells of the gonimoblast enlarge and become carpospores (Pl. IV, Fig. 7, Pl. VIII, Figs. 6 & 7).

The tetrasporophyte is provided at maturity with the stichidia converted from the ultimate branchlets. The stichidia are cylindrical, 450–550 μ diam., and are beset in the upper portion with many dark purplish spots or tetrasporangia scattered over their surfaces. After the shedding of the spores, these spots become colourless and the stichidia look undulate on the surface (Pl. II, Fig. 1). The tetrasporangium originates from a pericentral cell near the growing apex in the apical depression of a branchlet. The fertile pericentral cell cuts off a sporangium and a cover-cell, and then become elongated and filamentous below with the growth of the branchlet tissues (Pl. III, Fig. 1, Pl. IX, Fig. 1). The fertile pericentral cell is also linked by means of secondary pit-connections with some of the subcortical cells which have been derived from the divisions of neighbouring pericentral cells lying beneath it. The cover-cell cut from the fertile pericentral cell covers the sporangium from the inside, and other cover-cells which originate from the subcortical cells cover it from the outside and on the lateral side (Pl. IX, Figs. 1 & 2). The elongated pericentral cell is later divided into several segments. The first nuclear division of the sporangium can be observed while the sporangium is at the periphery of the apical depression, whereas the second division can be observed when the sporangium is not in the depression but on the lateral surface of the stichidial branchlet (Pl. III, Fig. 6, Pl. IX, Fig. 2). The division of the sporangium is tetrahedral (Pl. IX, Fig. 2).

The above description is based on the specimens from Moheji, Hokkaido. It

agrees in general with the descriptions of the present species given by Yamada (1931) and other authors cited above, though the diameter of the main axis of the writer's specimens from Moheji and Oshoro is slightly smaller than that given by Yamada. The writer's specimens from Nou in Honshu also have thicker main axes than the specimens from Hokkaido.

The writer is greatly indebted to Professor J. Tokida for his valuable advice and kindness in reading the manuscript, and to Emer. Professor Y. Yamada for his kind guidance in identifying the species.

Summary

The present paper gives a morphological description of the fertile sexual and asexual specimens of the *Laurencia okamurai* Yamada, collected by the writer himself in Hokkaido and Honshu, Japan. The following characteristics are worthy of special mention.

1. The cavity of antheridial receptacles in the *Laurencia okamurai* is bowl-shaped and is deeper than that of *Laurencia venusta* Yamada (cf. Saito, 1964). The branching of the central axis of each antheridium is dichotomo-alternate.

2. The cystocarp is ovoid in shape. The carpogonial branch is still naked when the auxiliary cell is formed as observed in *Laurencia venusta* Yamada (cf. Saito, 1964).

3. The tetrasporangium-initial arises from a pericentral cell of the stichidial branchlet. The mature tetrasporangia are on the upper lateral of the stichidium and arranged parallel to its central axis as seen in the longitudinal section.

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(For further references, see the preceding report, I)

Explanation of Plates

PLATE I

Laurencia okamurai Yamada

Fig. 1. Habit of a herbarium female specimen (Moheji, 13 September 1963)

Fig. 2. Habit of a herbarium male specimen (Moheji, 13 September 1963)

Fig. 3. Habit of a herbarium tetrasporangial specimen (Moheji, 27 August 1963)

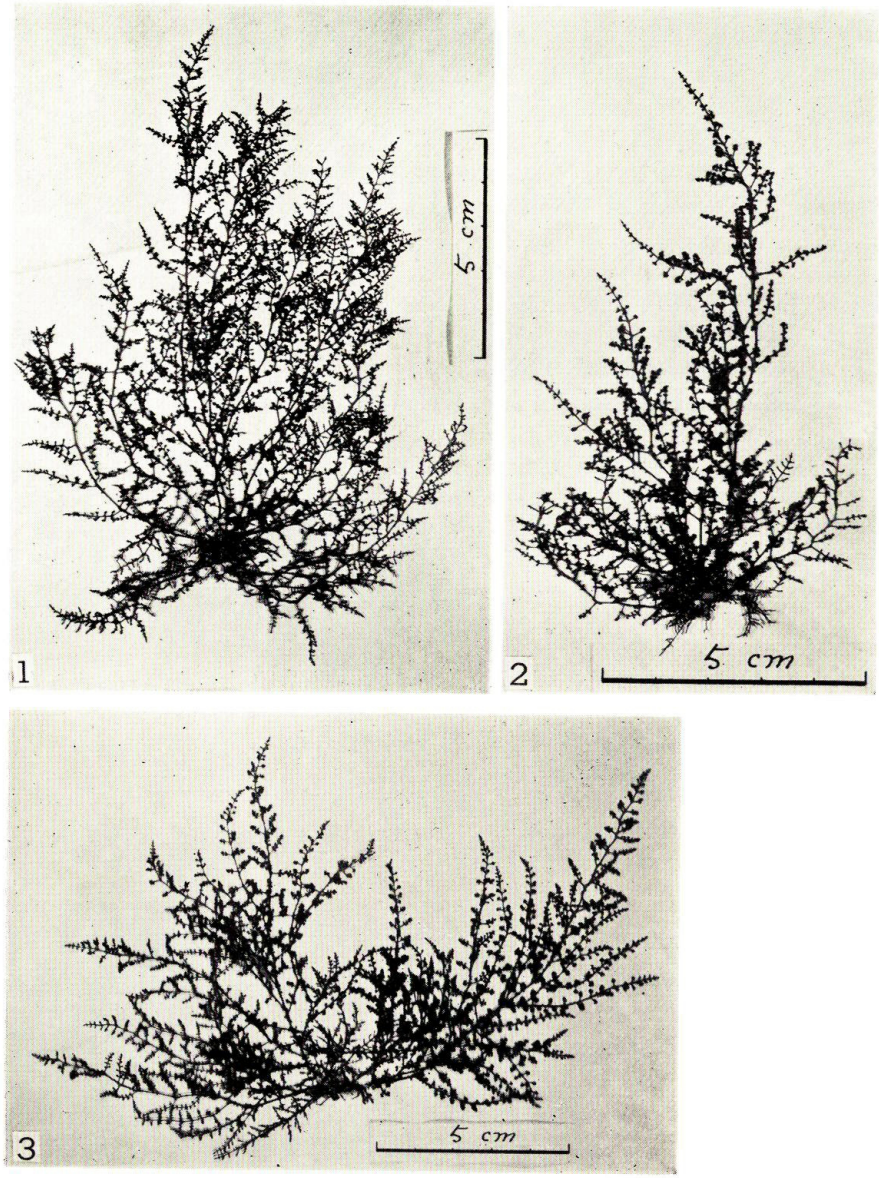

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PLATE II

Laurencia okamurai Yamada

Fig. 1. Part of a tetrasporangial plant ×7.5

Fig. 2. Part of a female plant ×7.5

Fig. 3. Part of a male plant ×7.5

Fig. 4. Habit of a tetrasporangial plant preserved in formalin-seawater ×1

PLATE III

Laurencia okamurai Yamada

Figs. 1 & 2. Longitudinal section through the antheridial receptacle, to show various stages of their development ×80

Fig. 3. Part of the apical portion of a longitudinal section through the antheridal receptacle, showing the growing point and an antheridium-initial ×640

Figs. 4 & 5. A group of young (Fig. 4) and mature (Fig. 5) antheridia from a smeared preparation ×320

Fig. 6. Longitudinal section through a stichidial branchlet ×80

Fig. 7. Part of apical portion of longitudinal section through a stichidial branchlet, showing a tetrasporangium-initial on an elongated pericentral cell which is connected with an elongated axial cell (cf. Pl. IX, Fig. 1) ×800

Fig. 8. Part of longitudinal section through the apical portion of a sterile branchlet, showing the central axis, apical cell and the origin of a trichoblast ×320

PLATE IV

Laurencia okamurai Yamada

Fig. 1. Part of apical portion of longitudinal section through a fertile branchlet of a female plant, showing a procarp before fertilization attached to the top of the elongated pericentral cell which is connected to the elongated axial cell (cf. Pl. VIII, Fig. 1) ×800

Fig. 2. Longitudinal section through a procarp after fertilization, showing the auxiliary cell formed on the supporting cell (cf. Pl. VIII, Fig. 2) ×800

Fig. 3. Longitudinal section through a more developed procarp, showing the fusion-cell and the arrangement of sterile cells (cf. Pl. VIII, Fig. 4) ×320

Fig. 4. Longitudinal section through a young cystocarp, showing the initial stage of gonimoblast development ×320

Figs. 5 & 6. Longitudinal section through the apical portion of a fertile branchlet of a female plant, showing various stages of cystocarp development ×160

Fig. 7. Median longitudinal section through a ripe cystocarp (cf. Pl. VIII, Fig. 7) ×80

PLATE V

Laurencia okamurai Yamada

Figs. 1–4. Surface view of the cortical cell arrangement in the upper part of the ultimate branchlet (Fig. 1), upper (Fig. 2) and basal (Fig. 3) parts of the branch, and in the main axis (Fig. 4)

Fig. 5. Part of a transverse section through a branchlet

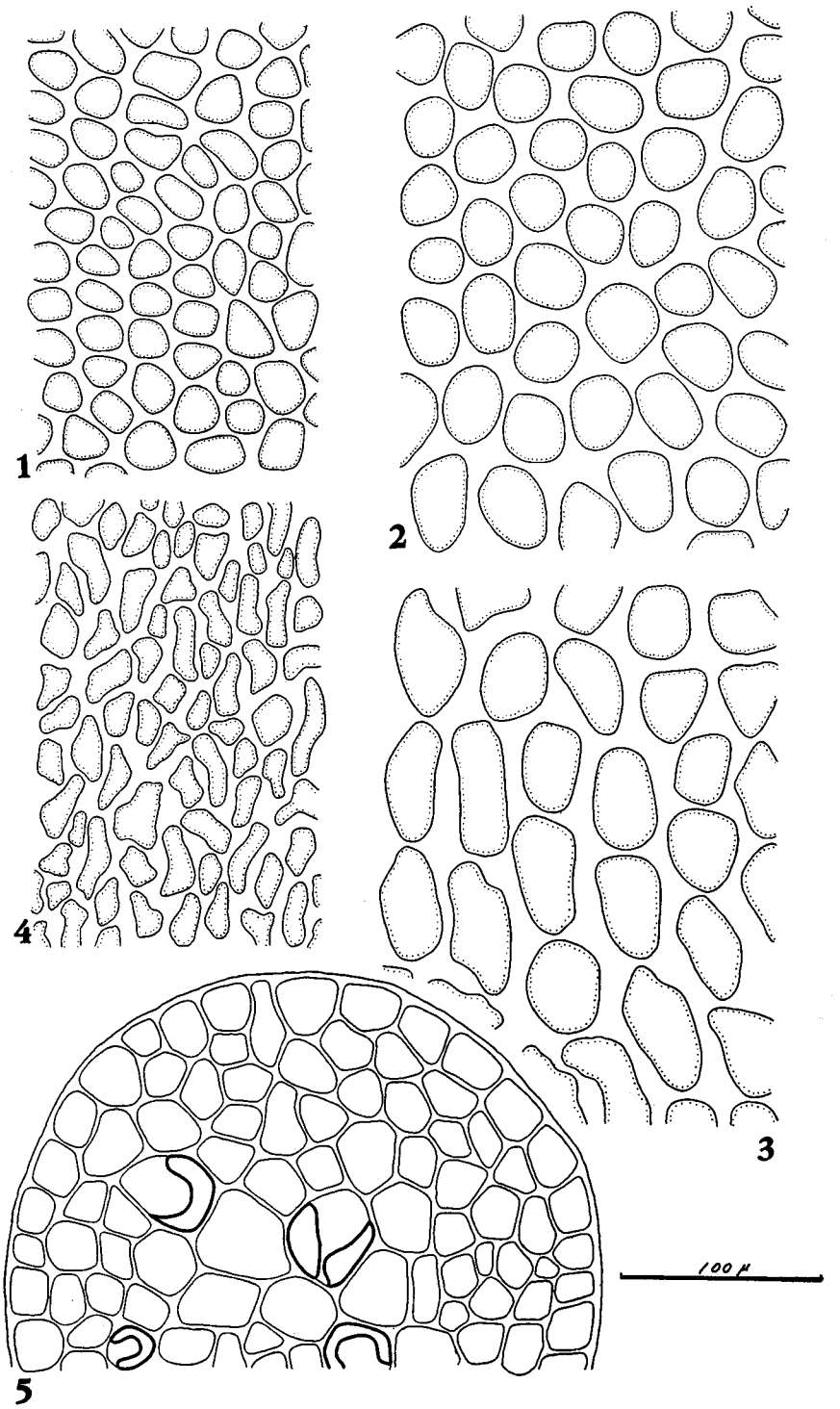

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PLATE VI

Laurencia okamurai Yamada

Fig. 1. A young trichoblast

Fig. 2. Part of median longitudinal section through the apical portion of a branchlet

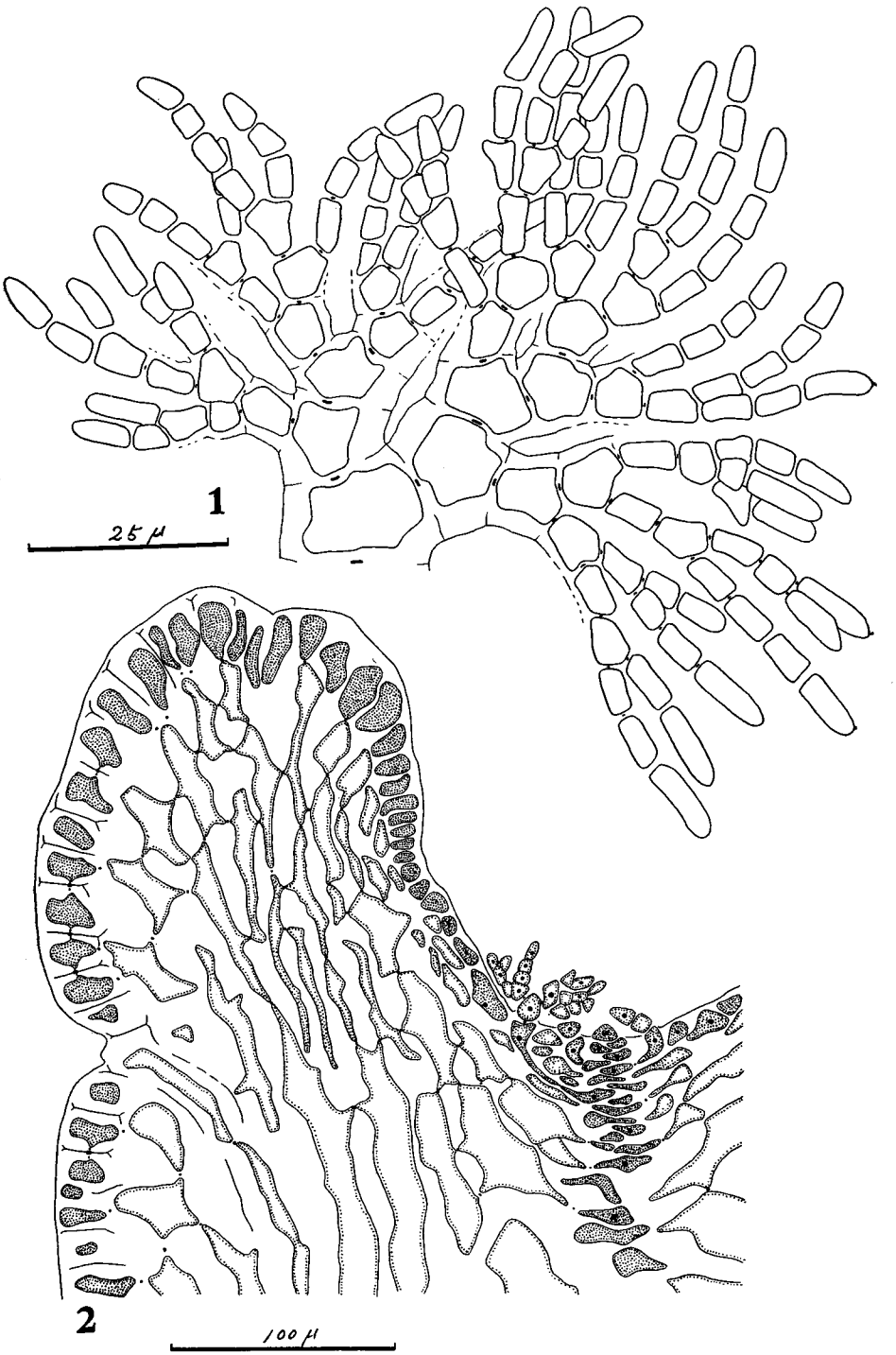

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PLATE VII

Laurencia okamurai Yamada

Figs. 1 & 2. Apical portion of a mature (Fig. 1) and a young (Fig. 2) antheridium in a smeared preparation

Fig. 3. Transvease section of an antheridium

Fig. 4. A tuft of spermatangia from the lower portion of a mature antheridium in a smeared preparation

Fig. 5. Part of median longitudinal section through an antheridial receptacle

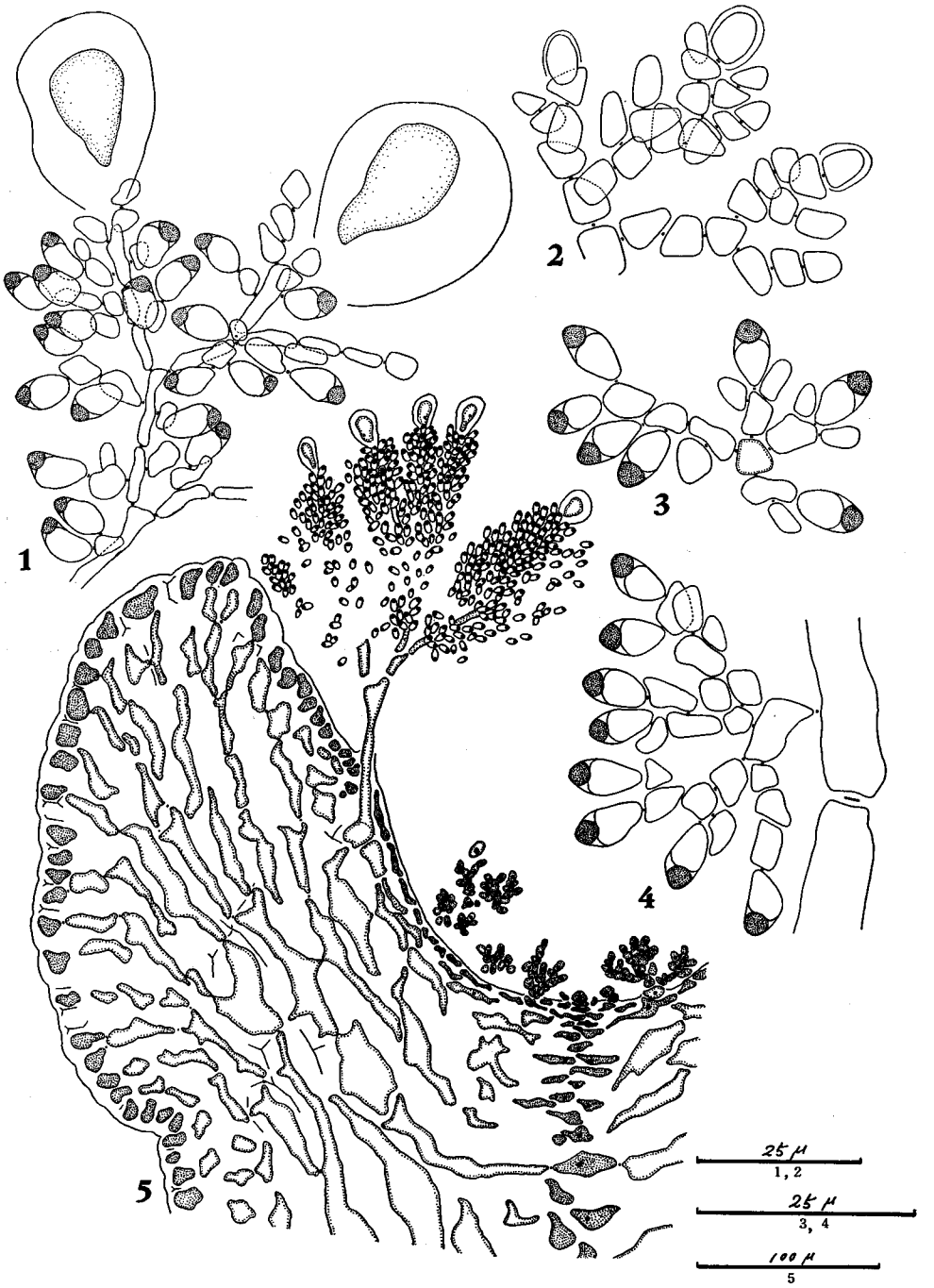

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PLATE VIII

Laurencia okamurai Yamada

Fig. 1. Part of apical portion of median longitudinal section through a fertile branchlet of a female plant, showing a procarp before fertilization attached to the top of the elongated pericentral cell which is connected to the elongated axial cell (cf. Pl. IV, Fig. 1)

Fig. 2. Longitudinal section through a procarp after fertilization, showing the auxiliary cell formed on the supporting cell (cf. Pl. IV, Fig. 2)

Fig. 3. Longitudinal section through a procarp, showing the fusion between the supporting cell and the auxiliary cell

Fig. 4. Longitudinal section through a more developed procarp, showing the fusion-cell and the arrangement of sterile cells (cf. Pl. IV, Fig. 3)

Fig. 5. Longitudinal section through a young cystocarp, showing the initial stage of gonimoblast development

Fig. 6. Longitudinal section through a further developed young cystocarp

Fig. 7. Median longitudinal section through a ripe cystocarp (cf. Pl. IV, Fig. 7)

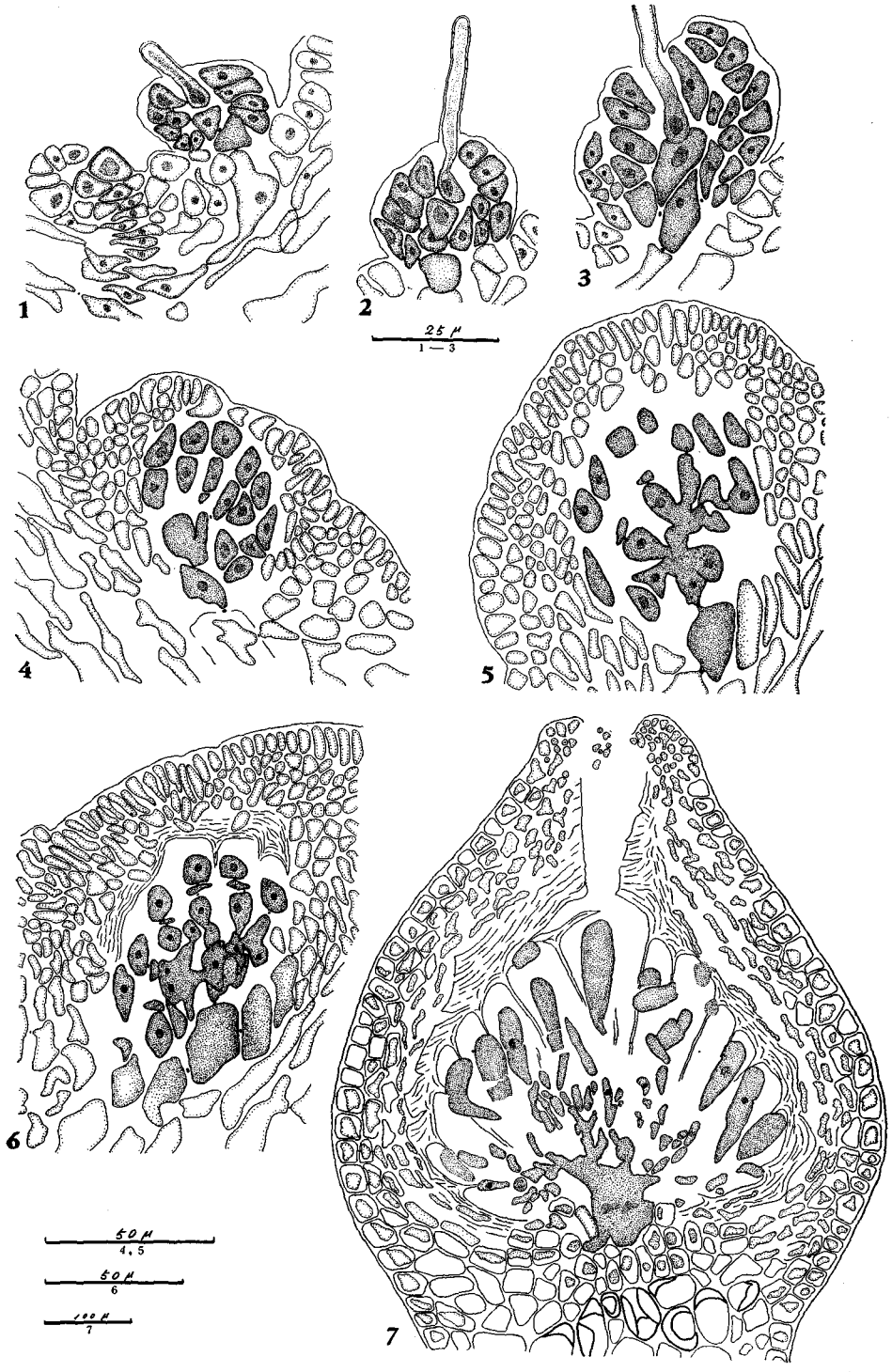

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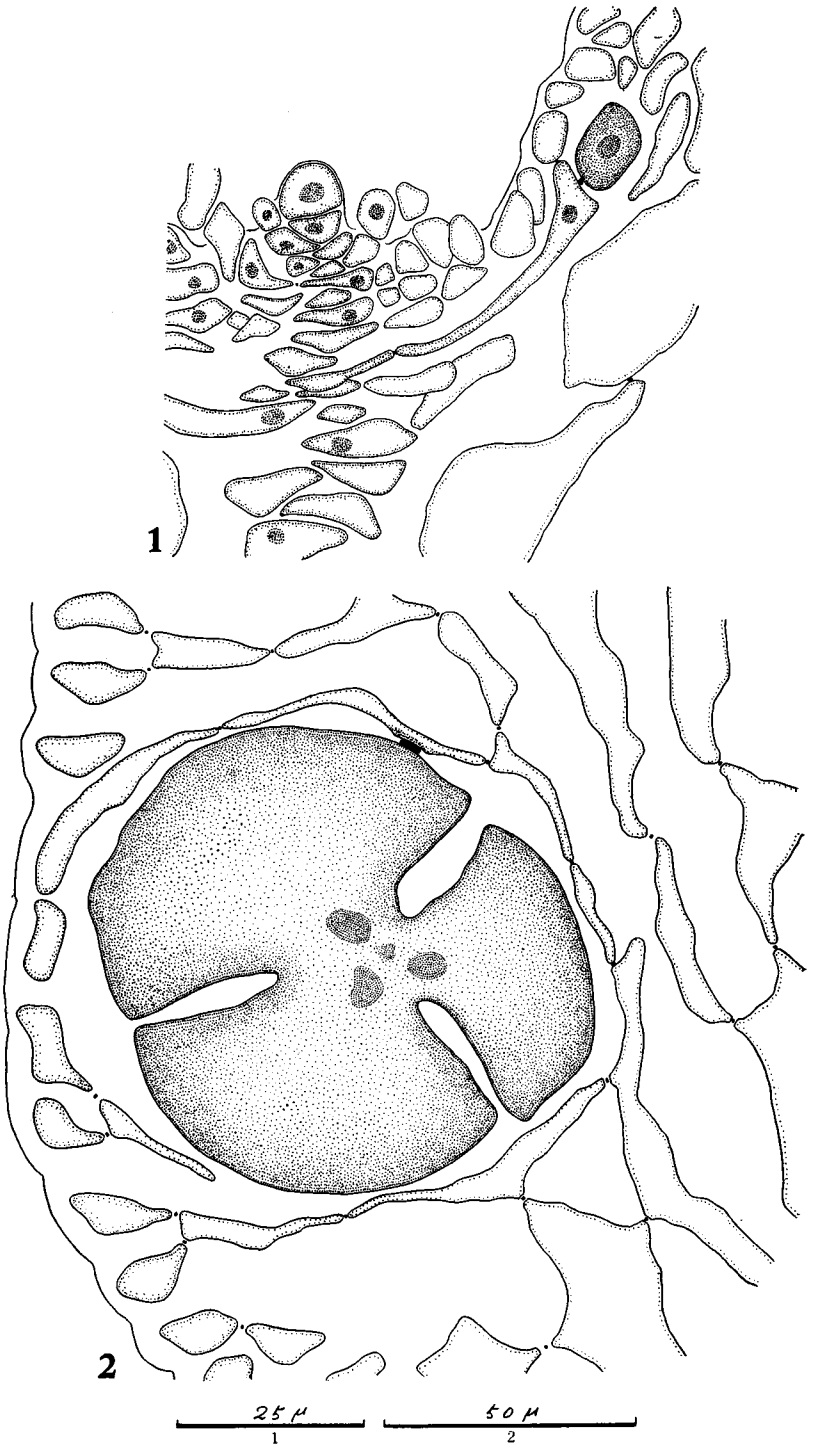
PLATE IX

Laurencia okamurai Yamada

Fig. 1. Part of apical portion of median longitudinal section through a stichidial branchlet, showing a tetrasporangium-initial on the elongated pericentral cell which is connected with the elongated axial cell (cf. Pl. III, Fig. 7)

Fig. 2. Ditto, showing a divided tetrasporangium on the lateral side of the stichidial branchlet



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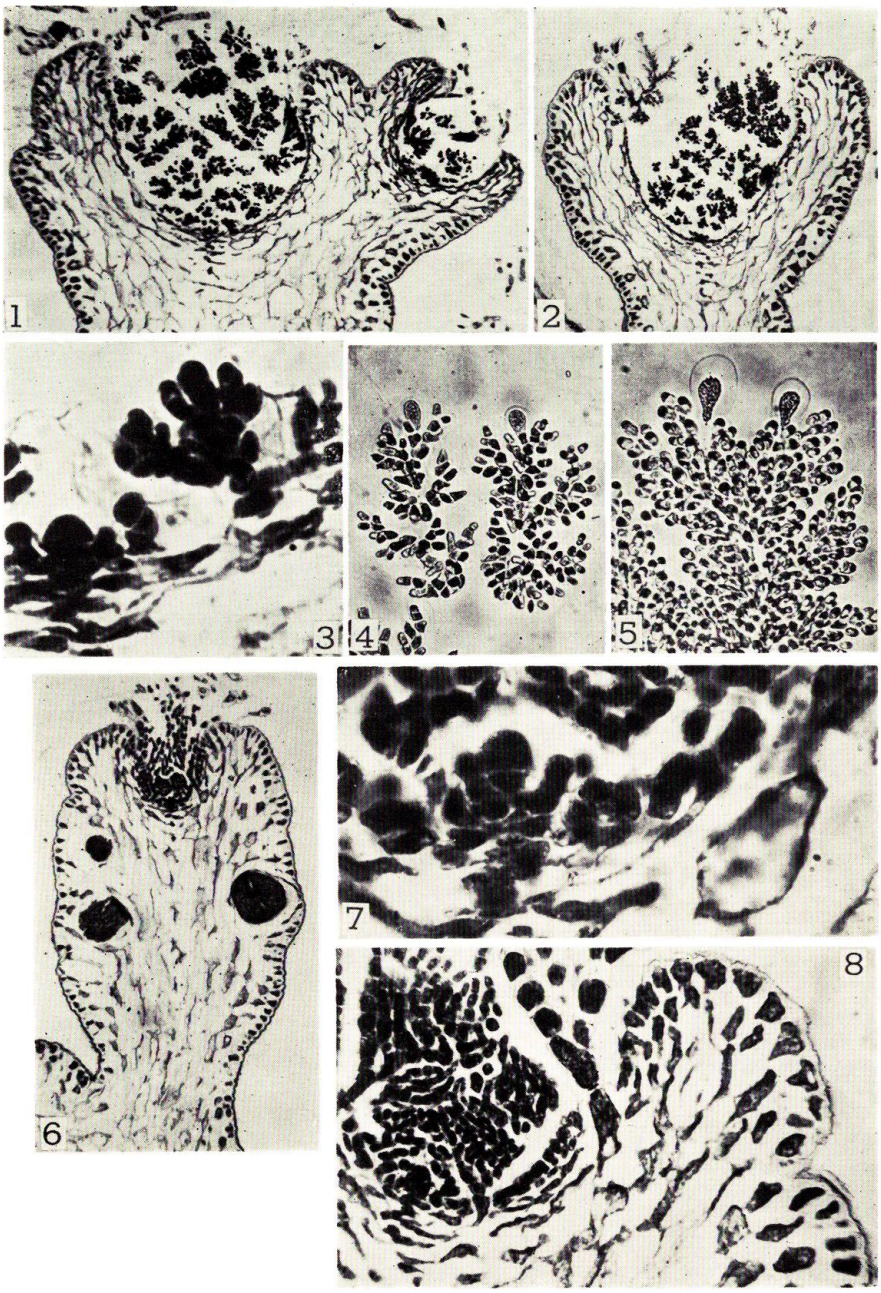

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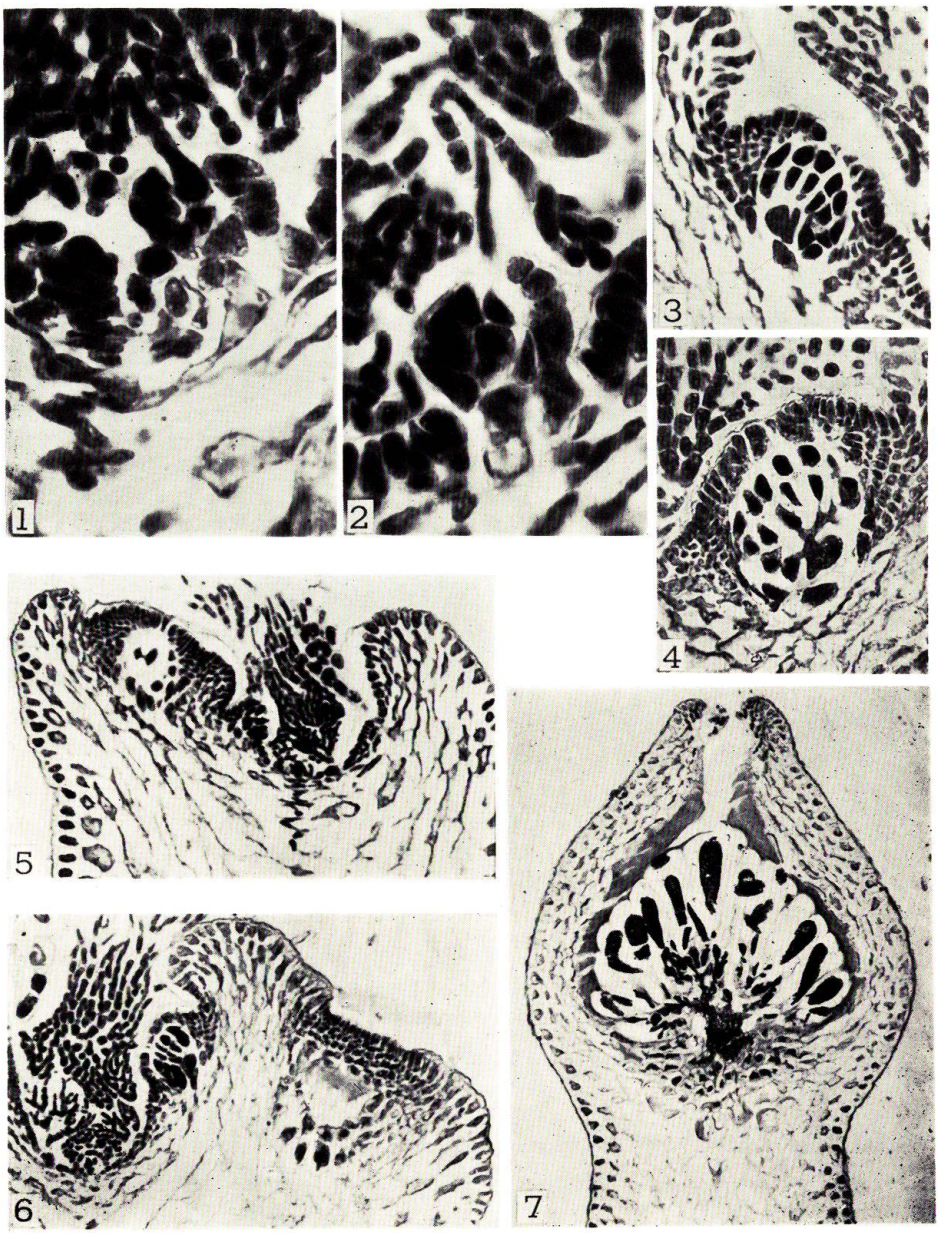

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