Journ. Fac. Sci., Hokkaido Univ. Ser. V (Botany), **13** (1): 49-56, **1983.**

Apical organization of some genera of Fucales (Phaeophyta) from Japan

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Observations were made on the apical organization of the representative species of following genera: *Pelvetia, Fucus, Cystoseira, Coccophora, Myagropsis, Sargassum, Hizikia* and *Turbinaria*. The apical cell of *Fucus evanescens* was clearly four-sided in cross section, while in *Pelvetia wrightii* it was difficult to decide whether it was four-sided or three-sided. Other species studied here, belonging to the families Cystoseiraceae and Sargassaceae, all had apical cells three-sided in cross section.

Most families of the Fucales are characterized by their apical growth, and the mode of apical growth whether it is initiated by an apical cell or a group of apical cells is considered to have primary importance in discriminating the families (JENSEN 1974). Among the families with an apical cell, its shape is also very important characteristic, namely the apical cell is three-sided in cross section in the families Himanthaliaceae, Cystoseiraceae and Sargassaceae, and four-sided in corss section in the family Fucaceae. The apical organization has, however, been demonstrated in a few species, and in some genera it is not yet known. This work was carried out to consolidate the knowledge concerning the apical organization in Japanese representatives of the Fucales.

Materials and Methods

The species studied here are listed in Table 1. Apical portion of the stem in the families Cystoseiraceae and Sargassaceae or of the frond in *Fucus* and *Pelvetia* was fixed in 10% formalin sea water. Then the material was washed with fresh water. After a standard dehydration procedure in ethyl alcohol, it is embedded in paraffin. Sections were cut 7-10 μm in thickness, and stained in iron-alum-hematoxylin. Permanent mounts were made in Canada Balsam.

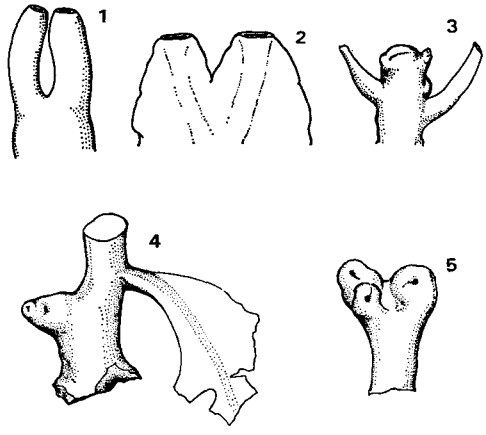
TABLE 1. Species examined in this study

Species	Locality	Date	Collector
Pelvetia wrightii	Cape Nosappu, Hokkaido	May 8, 1978	T. YOSHIDA
	Muroran, Hokkaido	Apr. 1981	K. MATSUE & H. TSUCHIYA
Fucus evanescens	Akkeshi, Hokkaido	May 9, 1978	T. YOSHIDA
Cystoseira hakodatensis	Oshoro, Hokkaido	Apr. 12, 1978	"
Coccophora langsdorfii	Rishiri I., Hokkaido	Mar. 26, 1980	S. NABATA
Myagropsis myagroides	Cape Nomo, Nagasaki	Dec. 12, 1977	T. YOTSUI
Sargassum patens	Iwaya, Fukuoka	Apr. 5, 1978	T. YOSHIDA
S. horneri	Oshoro, Hokkaido	May 23, 1980	M. MARUI
S. thunbergii	Oshoro, Hokkaido	Apr. 26, 1979	T. YOSHIDA
S. muticum	Matsushima Bay, Miyagi	Mar. 29, 1978	"
S. miyabei	Oshoro, Hokkaido	Apr. 12, 1978	"
S. confusum	Oshoro, Hokkaido	Apr. 12, 1978	"
S. serratifolium	Tatamigaura, Shimane	Jun. 9, 1978	"
S. sagamianum var. *yezoense*	Oshoro, Hokkaido	Nov. 19, 1980	M. MARUI
S. nigrifolium	Ohmi-jima, Yamaguchi	Jun. 8, 1978	T. YOSHIDA
Hizikia fusiformis	Iwaya, Fukuoka	Apr. 5, 1978	"
Turbinaria ornata	Naha, Okinawa	Aug. 1939	Y. NAKAMURA

Observations

Pelvetia wrightii OKAMURA (Figs. 1, 6-8)

Thallus is dichotomously branched in one plane, compressed except the basal part. Apical depression is slit shaped 100-150 μm deep (Fig. 1), and filled with mucilagenous substance. In the longitudinal section, an apical cell locates in the bottom of the apical depression (Fig. 6). It is rectangular with rounded corners and its outer cell wall is convex. It measures ca 30 μm high and 25-33 μm wide. Its height is similar to adjacent segment cells, but it is wider than neighbouring cells. In cross section (Figs. 7, 8), the apical cell is discernible by its larger size and deep staining. It cuts off segment cells basally and laterally. Because the cutting surfaces are rather variable in direction, it is difficult to say that its shape is triangular or rectangular in cross section.



Figs. 1–5. Apical parts of several species examined.
1. *Pelvetia wrightii.* 2. *Fucus evanecsens.*
3. *Myagropsis myagroides.* 4. *Sargassum serratifolium.*
5. *Sargassum nigrifolium.*

Fucus evanescens C. AGARDH (Figs. 2, 9, 10)

Dichotomously branched thallus is flat with slightly elevated midrib. Apical depression is linear slit shaped extended in the plane of flattening and 100–150 μm deep (Fig. 2). Usually two apical cells are observed at the bottom of an apical depression. They soon develop to individual branch apex to have each apical depression. The apical cell is thin walled and is rectangular in cross section (Fig. 9, 10). It cuts off segment cells successively with a wall parallel to the plane of flattening of the frond and perpendicular to the plane. It also gives rise to segment basally.

Cystoseira hakodatensis (YENDO) FENSHOLT (Figs. 11, 12)

The stem is cylindrical. Near the apex of the stem, lateral branches are successively formed in spiral sequence. Apical depression is round and funnel shaped, more than 800 μm deep (Fig. 12). An apical cell is easily discernible at the bottom of depression. It is thick lens shaped in longitudinal section, measuring 120 μm high and 90 μm wide. It cuts off segment cells with an oblique wall (Fig. 12). In cross section, it is triangular in shape (Fig. 11). The initial cell of the laterals differentiate near the apical cell of the stem. When the initials have passed out of the apical pit, each becomes lodged in a separate depression.

Coccophora langsdorfii (TURNER) GREVILLE (Fig. 13)

Stem is terete, rather short in length, branches several times, and later

its proximal part burried in common attaching disc. Apical depression is funnel shaped. In cross section, the apical cell is three sided, cutting off segments cells on each side (Fig. 13). Near the apical depression, several initials of laterals differentiate in spiral manner.

Myagropsis myagroides (TURNER) FENSHOLT (Figs. 3, 14–16)

The terminal part of the stem is complanated, giving off branches distichously disposed (Fig. 3). The apical depression is linear in external appearance, 350–480 μm deep (Fig. 14). An apical cell, situating at the bottom of the depression, is thick lenticular in shape in longitudinal section, and measures 110 μm high and 60 μm wide (Fig. 16). In cross section, the apical cell is depressed triangular in shape (Fig. 15).

Sargassum patens (C. AGARDH) C. AGARDH (Figs. 17, 18)

Stem is terete. Main branches arise spirally near the upper part of the stem. An apical depression is in the form of narrow slit. Apical cell is three-sided in cross section (Fig. 18). In longitudinal section, it is thick lenticular shaped, about 100 μm high and 70 μm wide (Fig. 17).

Sargassum horneri (TURNER) C. AGARDH (Fig. 19)

Stem is terete in younger stage of development and later becomes obtuse angular with several longitudinal ridges. Apical depression is funnel shaped. Apical cell is biconvex in longitudinal section and is three-sided in cross section (Fig. 19).

Sargassum thunbergii (MERTENS) KUNTZE (Fig. 20)

Stem is terete, about 2 mm in diameter. Lateral branches are formed densely near the upper part of the short stem. Three-sided apical cell situated at the bottom of funnel shaped apical depression (Fig. 20).

Sargassum muticum (YENDO) FENSHOLT (Fig. 21)

Basal part of the thallus is somewhat similar to *S. thunbergii* in appearance, but more robust in *S. muticum*. Apical depression is funnel shaped. Apical cell is three-sided in cross section (Fig. 21).

Sargassum miyabei YENDO (Fig. 22)

Stem is terete, 1–1.5 mm in diameter. Apical depression is funnel shaped. Apical cell is three-sided in cross section (Fig. 22).

Sargassum confusum C. AGARDH (Figs. 23–25)

Stem is terete or somewhat compressed. Ramification of the stem is very rare. Apical depression is funnel shaped, rather widely open, about

200 μm deep, and filled with mucilage (Fig. 23). Apical cell is biconvex in longitudinal section, 150 μm high (Fig. 24). In cross section it is three-sided (Fig. 25).

Sargassum serratifolium (C. AGARDH) C. AGARDH (Figs. 4, 26)

Terete stem, 5 mm in diameter, ramifies several times. Apical depression is funnel shaped (Fig. 4). Apical cell is three-sided in cross section (Fig. 26).

Sargassum sagamianum var. *yezoense* YAMADA (Fig. 27)

Stem is terete, branches irregular dichotomously and is prostrate on the substratum. Apical depression is funnel shaped or somewhat short linear. Apical cell is three-sided in cross section (Fig. 27).

Sargassum nigrifolium YENDO (Figs. 5, 28)

Stem is terete and branches dichotomously, sending off main branches upwardly, as in *S. sagamianum* var. *yezoense*. Apical depression is funnel shaped (Fig. 5). Apical cell is three-sided in cross section and is depressed horizontally (Fig. 28).

Hizikia fusiformis (HARVEY) OKAMURA (Figs. 29, 30)

Stem is short in length and terete. Apical depression is funnel shaped, about 450 μm deep, filled with mucilage. Apical cell is thick lens shaped in longitudinal section and measures 130 μm high and 100 μm wide (Fig. 30). It is three-sided in cross section (Fig. 29).

Turbinaria ornata (TURNER) J. AGARDH (Fig. 31)

Stem is terete and usually unbranched. Apical depression is funnel shaped. Apical cell is three sided in cross section (Fig. 31).

Discussion

Apical organization was already studied in the european and american species of *Fucus* and *Pelvetia*. In *Fucus evanescens*, similar results to those of *F. furcatus* (WOODWORTH 1888) and *F. vesiculosus* (OLTMANNS 1922) were obtained as to the apical organization as shown above. But the apical cell in *F. evanescens* was more narrow rectangular than *F. furcatus* and *F. vesiculosus*. As in *Pelvetia canaliculata* (SUBRAHMANYAN 1956) and *P. fastigiata* (MOORE 1928), segmentation of apical cell in *P. wrightii* was less regular, and it was difficult to determine the segmentation occurred in three-sided or four-sided manner as seen in Figs. 7, 8. This situation of *Pelvetia* as for the shape of apical cell might suggest that this was an intermediate state, when the reported transition of apical cell from three-sided to four-

sided segmentation in the course of development in *Fucus* was taken into consideration.

Other species studied here had apical cells triangular in cross section. Among the genera of the Cystoseiraceae, *Myagropsis myagroides* has a tendency to bilateral branching, and its apical depression is slit shaped and rather deep, while *Cystoseira hakodatensis* and *Coccophora langsdorfii* have spiral arrangement of laterals with funnel shaped apical depression. Another member of the Cystoseiraceae, *Hormophysa triquetra*, is known to have similar apical organization (MAIRH and KRISHNAMURTHY 1970). JENSEN (1974) reported the presence of three-sided apical cell in *Bifurcaria* and *Bifurcariopsis*.

Genera of Sargassaceae studied here, *Sargassum*, *Hizikia* and *Turbinaria*, also have a similarity in the shape of apical cell. Other members of this faimily, *Anthophycus* and *Oerstedtia* are also reported to have three-sided apical cell (JENSEN 1974). More recently, the genus *Cladophyllum* was added to the Sargassaceae. Apical cell was not mentioned in this genus (BULA MEYER 1980).

Here we treated the apical organization of stem of the Cystoseiraceae and Sargassaceae. The similar apical cells were observed in younger leaves or receptacles, though they were smaller in size. The reliability of this character in defining the families in the order Fucales is confirmed by presence of three-sided apical cells in the genera *Myagropsis*, *Coccophora* and *Hizikia*.

We wish to thank Professor Munenao KUROGI, Hokkaido University, for his kind encouragement throughout this study and criticizing the manuscript.

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Plate I

Figs. 6–8. *Pelvetia wrightii.*

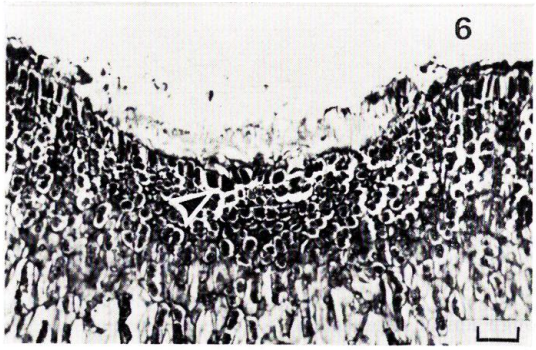
6. Longitudinal section through apical depression. Arrow head indicates apical cell.
7, 8. Cross section of apical cell (a).

Figs 9, 10. *Fucus evanescens.* Cross section.

Figs. 11, 12. *Cystoseira hakodatensis.*

11. Cross section of apical cell.
12. Longitudinal section through apical depression.

Scale 50 μm.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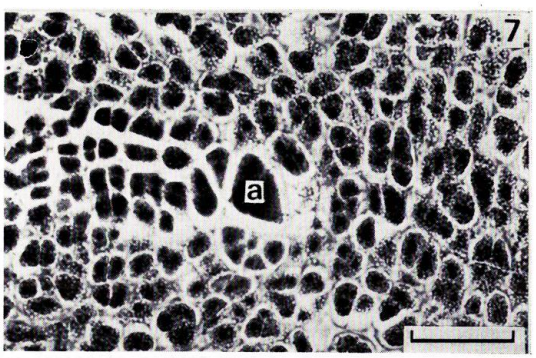
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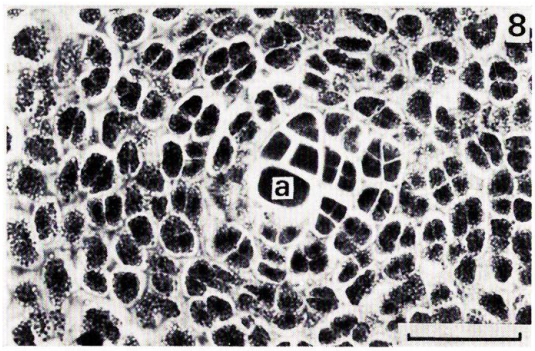
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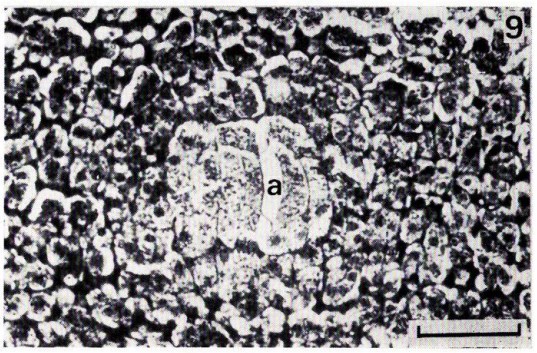
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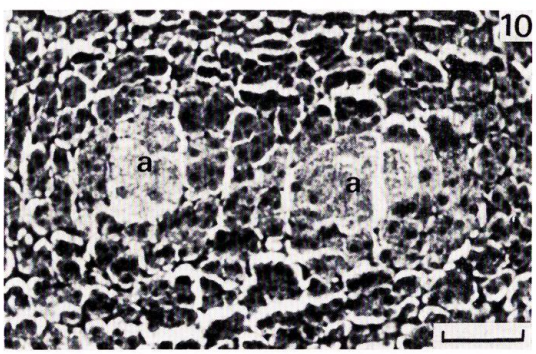
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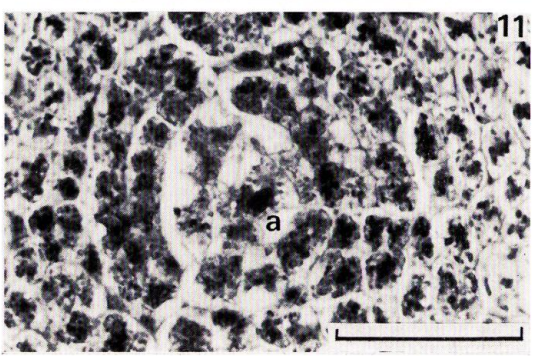
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Plate II

Fig. 13. *Coccophora langsdorfii.* Cross section.

Figs 14–16. *Myagropsis myagroides.*

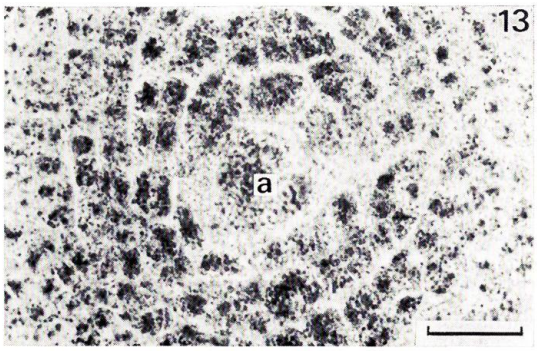
14, 16. Longitudinal section through apical depression.
15. Cross section of apical cell.

Figs. 17, 18. *Sargassum patens.*

17. Longitudinal section through apical depression.
18. Cross section of apical cell.

Fig. 19. *Sargassum horneri.* Cross section.

Scale 50 μm.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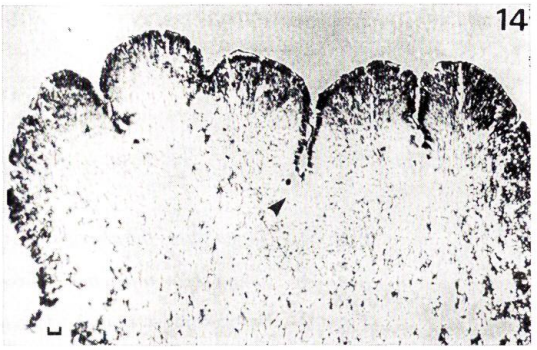
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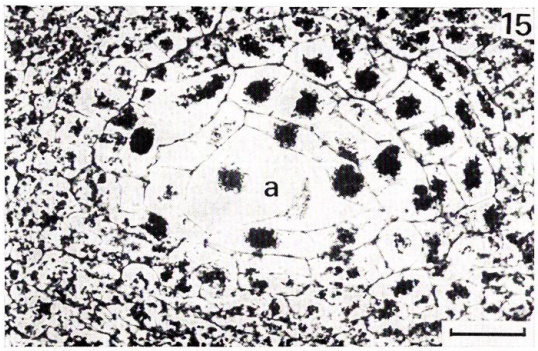
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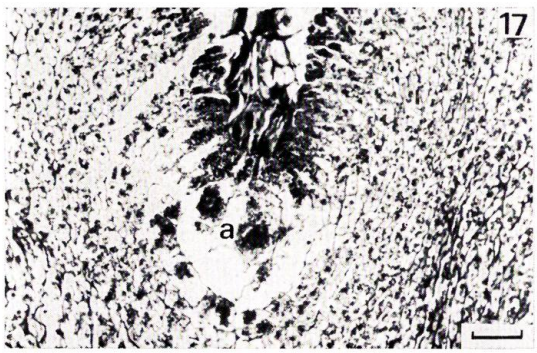
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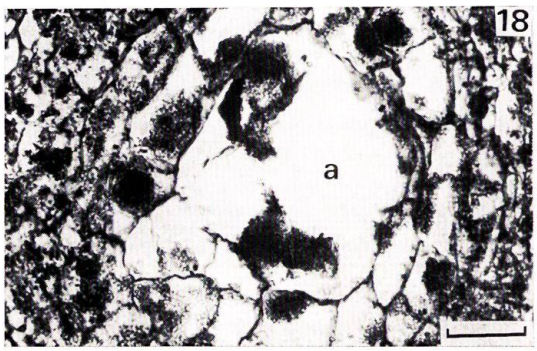
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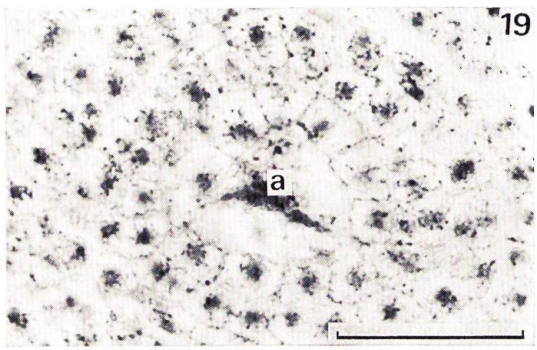
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Plate III

Fig. 20. *Sargassum thunbergii.* Cross section.

Fig. 21. *Sargassum muticum.* Cross section.

Fig. 22. *Sargassum miyabei.* Cross section.

Figs. 23-25. *Sargassum confusum.*

23, 24. Longitudinal section through apical depression.

25. Cross section of apical cell.

Fig. 26. *Sargassum serratifolium.* Cross section.

Scale 50 μm.

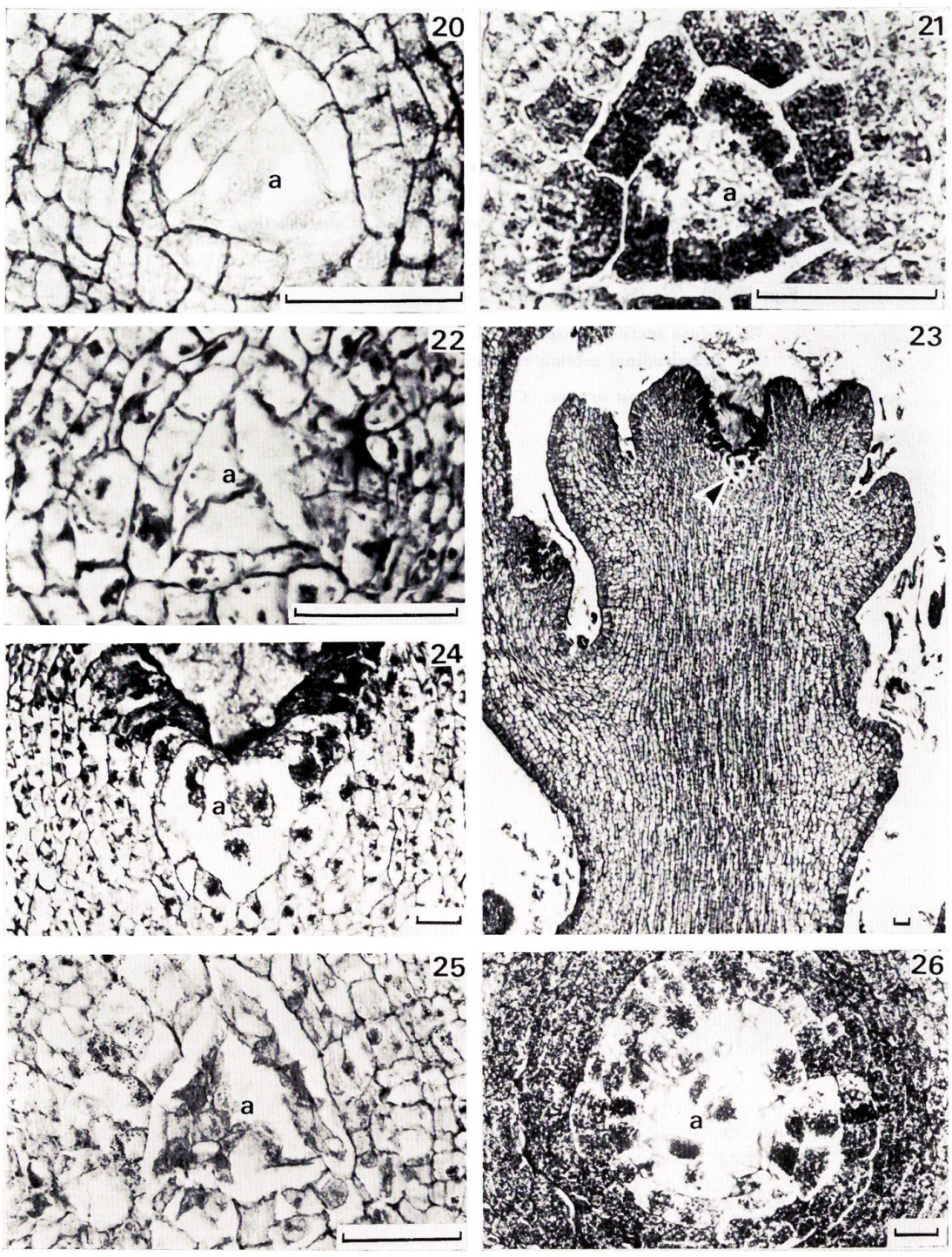
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Plate IV

Fig. 27. *Sargassum sagamianum* var. *yezoense*. Cross section.

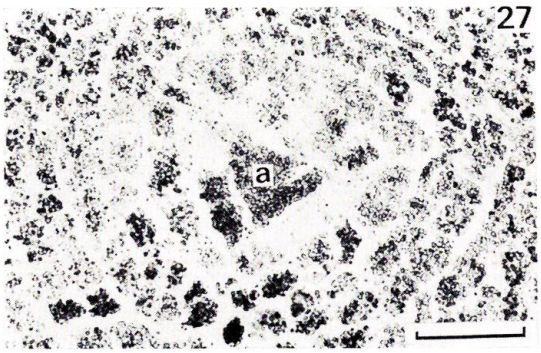
Fig. 28. *Sargassum nigrifolium*. Cross section.

Figs 29, 30. *Hizikia fusiformis*.

29. Cross section of apical cell.
30. Longitudinal section through apical depression.

Fig. 31. *Turbinaria ornata*. Cross section.

Scale 50 μm.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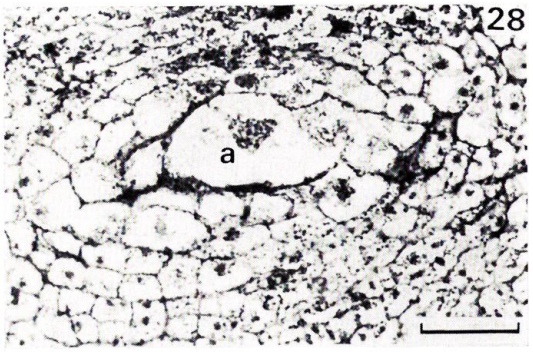
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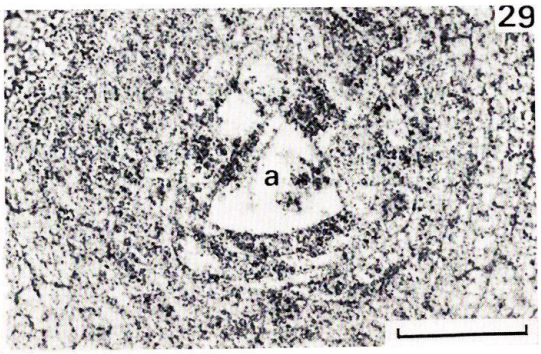
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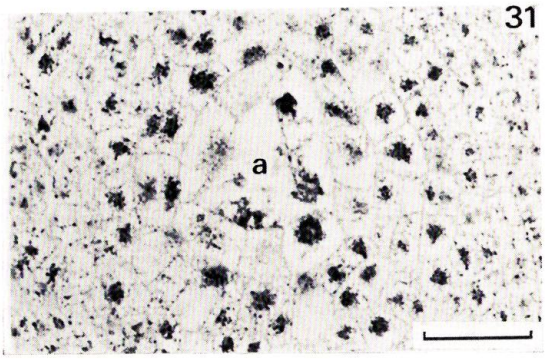
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