

A Scanning Electron Microscope
Survey of the Epidermis
of East African Grasses, I

*Patricia G. Palmer
and Alice E. Tucker*



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ABSTRACT

Palmer, Patricia G., and Alice E. Tucker. A Scanning Electron Microscope Survey of the Epidermis of East African Grasses, I. *Smithsonian Contributions to Botany*, number 49, 84 pages, 9 figures, 48 plates, 1981.—In developing a reference collection as a standard for using fossil grass cuticles as a paleoecological tool, we have examined leaf epidermal features of grasses with SEM. Anatomical structures are described, and a system of categorizing diagnostic features is proposed. Descriptions (abaxial and adaxial surfaces) of 24 East African species are presented comprising ten tribes: Bambuseae, Olyreae, Phareae, Streptogyneae, Oryzeae, Phyllorhachideae, Ehrharteae, Arundineae, Danthonieae, and Centosteceae.

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A Scanning Electron Microscope Survey of the Epidermis of East African Grasses, I

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Introduction

The taxonomic value of epidermal features of grass leaves in identifying and classifying members of the family is well established (Prat, 1932, 1936; Tateoka et al., 1959; Metcalfe, 1960; Jacques-Félix, 1962). Traditionally the microanatomy of grass leaves has been studied with light microscopy, but Palmer (1976) has shown that the diagnostic features of grass cuticles are remarkably well suited for study with scanning electron microscopy. Palmer (1976) applied this technique not only to modern day grasses but extended it to fossil grass cuticular fragments from East African lake sediments where the opaqueness of the charred cuticles makes observation with light microscopy inadequate.

The potential for the use of grass cuticles as a new paleoecological tool led to this present study. Grasses are an important element in many modern vegetation types in Africa, and recently Livingstone and Clayton (1980) have shown that there is high correlation between the percentage of C₄ grasses and temperature in East Africa. Better interpretation of grasses in the fossil record will allow clearer understanding of past vegeta-

tion of Africa and may even permit the reconstruction of paleotemperatures.

Pollen analysis by itself cannot provide all the information we need about the vegetational history of Africa, because grass pollen is identifiable only to family. Many lake core samples from East Africa, which are rich in grass pollen, contain charred fragments of grass epidermis identifiable to tribe or even to genus (Palmer, 1976). These charred fragments presumably were deposited during naturally occurring fires and in modern time during fires associated with the activities of man. Consequently, vegetation types prone to burning may be overrepresented in the fossil record. Many vegetation types, however, are both rich in grasses and subject to burning: steppe, grassland, savanna, and woodland. This technique will allow discrimination among these vegetation types.

The charred appearance may also be a result of chemical changes after deposition. In any case, the fossil material is very well preserved and is remarkably similar to modern leaves. Recent core samples from Lake Bosumtwi in Ghana, West Africa, have revealed macroscopic fossilized grass leaves in great abundance and so intact that in many cases when observed with the scanning electron microscope even the fragile apical cells of the bicellular microhairs are visible.

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The possibility of using grass cuticles in a stratigraphic analysis of African lake sediments has made it necessary to develop a reference collection of modern grasses as a standard of comparison. Since most of the available lake cores are from East Africa, we decided first to survey the genera of East African grasses with scanning electron microscopy. We delimit East Africa to include Uganda, Kenya, and Tanzania, the region dealt with in "Gramineae" by Clayton (1970, 1974, in prep.) in *Flora of Tropical East Africa*. We also follow the nomenclature of *Flora of Tropical East Africa*. As the need arises we can expand our reference collection to include other areas of Africa or the world where we are likely to be identifying fossil grass material. This paper presents the results of the first part of this survey and includes 24 genera representing ten tribes: Bambuseae, Olyreae, Phareae, Streptogyneae, Oryzaceae, Phyllorhachideae, Ehrharteae, Arundineae, Danthoniae, and Centothecae (Centosteceae, Soderstrom and Decker, 1973).

MATERIALS AND METHODS.—Leaf material for scanning electron microscopy (SEM) was taken from dried herbarium material. A section from the middle portion of a blade from an upper, mature, undamaged leaf was chosen for study. In a few cases, where the epidermis proved to have a heavy coat of epicuticular wax, the wax was removed by soaking in xylene from 12 to 14 hours. Two pieces of the leaf (one exposing the abaxial or lower surface, the other exposing the adaxial or upper surface) were mounted on stubs with double-coated Scotch tape. The specimens were sputter-coated with gold-palladium, observed with a JEOL T20 scanning electron microscope, and photographed using Polaroid P/N 665 film. The photomicrographs are deposited in the laboratory of D. A. Livingstone, Department of Zoology, Duke University.

Each specimen was analyzed at the microscope using a standard check sheet of diagnostic features. By comparing the photomicrographs and the check sheets, a complete description of each taxon was compiled. At least one species of each genus was examined, and for some large genera

several species were examined to determine intrageneric variability. In some cases more than one specimen of a species was examined to determine intraspecific variability.

ACKNOWLEDGMENTS.—We are especially grateful to D. A. Livingstone of the Zoology Department, Duke University, for research support and for encouragement in this study. We appreciate suggestions on this study and comments on the manuscript from T. Soderstrom, S. Renvoize, and D. Livingstone. V. Pearson deserves thanks for her assistance in the preparation of the manuscript. S. Hutchison provided assistance with technical aspects of this study including some scanning electron microscopy. We also wish to thank W. D. Clayton and S. Renvoize of the Kew Herbarium, T. Soderstrom of the National Herbarium, and G. Davidse of the Herbarium of the Missouri Botanical Garden for providing material for study. We are grateful for technical assistance by T. Caspar. This research was supported by NSF grants BMS75-03441 and DEB76-80426 to D. A. Livingstone.

Diagnostic SEM Features

The most complete compendium of descriptions of epidermal features of grasses is that of Metcalfe (1960). We have frequently referred to Metcalfe's study, and in particular we have used his system of cell orientation where the longitudinal axis of the leaf is referred to as the "horizontal" dimension and the direction at right angles to the long axis becomes "vertical" for descriptive purposes (see Metcalfe, 1960:xix). All photomicrographs are oriented so that the longitudinal axis of the leaf is "horizontal" in the field of view, but we have found it necessary to modify his terminology and develop a system more appropriate for features viewed with SEM. Scanning electron microscopy enables us to examine certain structures more clearly than with light microscopy, and some features have a different aspect when viewed with SEM as compared to light. We have established the following system of classification and terminology of epidermal

features. This system is used as a standard throughout our study, minor modifications being made as the need arises.

STOMATA

Each grass leaf stoma or opening is bounded by a pair of guard cells having narrow middles and enlarged ends and a subsidiary cell adjacent to each guard cell. The subsidiary cells have a distinctive shape and stand out sharply against the background of regular epidermal cells. Mature grass stomata can be classified according to the shapes of these subsidiary cells as seen in surface view. We recognize four types of subsidiary cells according to Metcalfe's (1960) system:

- Parallel-sided (Figure 1*a*)
- Low-dome (Figure 1*b*)
- Triangular (Figure 1*c*)
- High-dome (Figure 1*d*)

Special features of stomata are also described. In some genera (e.g., all of the tribe *Oryzaceae*) papillate subsidiary cells occur (Figure 1*f*). Occasionally, the stomata are obscured by overarched papillae (see section "Papillae") from adjacent epidermal cells (Figure 1*e*) or are sunken in grooves so that the shape of the subsidiary cells cannot be determined.

Frequency and distribution of stomata are useful characters. Frequency is indicated according to four categories: absent, infrequent, common, abundant. Stomata alternating with long cells (interstomatal cells) occur as one or more horizontal bands in the intercostal (between veins) zones. A band may consist of a single row or several adjacent rows of stomata. Distribution comprises the number of stomatal bands per intercostal zone as well as the number of rows per band.

LONG CELLS

There are two types of epidermal cells in grasses: long cells and short cells. The bulk of the intercostal zone consists of long cells, which usually are much longer horizontally than vertically,

the horizontal axis being parallel to the longitudinal axis of the leaf. We recognize the following shapes of long cells:

- Square (cell about as long horizontally as it is wide vertically; Figure 2*a*)
- Rectangular (cell about two to three times as long as wide; Figure 2*b*)
- Pentagonal (Figure 2*c*)
- Hexagonal (Figure 2*d*)
- Long and narrow (cell more than three times as long as wide, width uniform; Figure 2*e*)
- Long and narrow (cell more than three times as long as wide, width non-uniform, usually wider in the middle and tapered at ends; Figure 2*f*)

The outline of the long cell walls as they abut cells in an adjacent horizontal row is categorized as non-sinuuous (Figure 2*e*); slightly sinuous (Figure 3*a*); markedly sinuous, interlocking, raised (Figure 3*b*); or markedly sinuous, interlocking, flat (Figure 3*c*).

The presence or absence of papillae on long cells is noted. If papillae are present, the number, distribution (i.e., row or rows, paired, irregular), shape (globose or elongate), and size (uniform or variable) are described (see section "Papillae").

INTERSTOMATAL CELLS

The long cells that occur in the same horizontal row as the stomata and that separate individual stomata are termed interstomatal cells or interstomatals (i.e., cells between stomata). Several categories of shapes of these cells are recognized: square, rectangular, pentagonal, hexagonal, long and narrow with uniform width, or long and narrow with non-uniform width (see section "Long Cells"). The manner in which the end walls fit against the stomata is described as straight to convex (Figure 3*d*); slightly concave or U-shaped (Figure 3*e*); or markedly concave or V-shaped (Figure 3*f*).

The outline of the interstomatal walls as they abut cells in an adjacent horizontal row is categorized as non-sinuuous; slightly sinuous (Figure 3*a*); markedly sinuous, interlocking, raised (Figure 3*b*); or markedly sinuous, interlocking, flat (Figure 3*c*).

The presence or absence of papillae on interstomatal is noted. If papillae are present, the number, distribution, shape, and size are described (see sections "Papillae" and "Long Cells").

PAPILLAE

Protrusions from the outer walls of epidermal cells are termed papillae. Papillae occur primarily on long cells, including interstomatal, but we have observed papillate cork cells, subsidiary cells, and even macrohairs with papillate shafts. In some instances, the papillae seem to be very thin-walled and fragile with a collapsed or deflated appearance. On the other hand, papillae may be very thick and heavily cutinized (Metcalf, 1960) or silicified (Clark and Gould, 1975) and remain rigid rather than becoming collapsed.

Since papillae protrude from the cell surface, they are well-suited for examination with SEM, and we believe that the taxonomic importance of papillae may be greater than realized with light microscopy.

For various cells that possess papillae—notably the long cells—we indicate the number of papillae per cell. The number varies from a single papilla per cell (Figure 4a) to a pair to many (Figure 4b,c,d,f). We note the distribution of the papillae on a cell: papillae occurring in a single row (Figure 4b) or in several rows; occurring in pairs; irregularly distributed (Figure 4c). Two shapes are recognized: globose (Figure 4b,c,d) and elongate (Figure 4e). Size is denoted as uniform (Figure 4b) or variable (Figure 4c). In some instances we note whether the papillae are large (Figure 4c,d) or extremely small giving a warty appearance (Figure 4f). Although a papilla is usually a single structure, there are examples of compound ones, especially double or forked (Terrell and Wergin, 1979) (Figure 4d).

SHORT CELLS

Epidermal cells that contain silica bodies (silica cells) or that are suberized (cork cells) are referred

to as short cells. In many cases these cells are about as long as wide (unlike long cells that are commonly longer than wide), but their dimensions can vary.

Note is made of the location of short cells, i.e., costal (over the vein) or intercostal (between veins), and the distribution in each zone is described as solitary, paired (usually a cork cell and a silica cell), three to five cells per row, or more than five cells per row. When the short cells occur in rows, the cork and silica cells usually alternate. The frequency of silica cells and cork cells is indicated by four categories: absent, infrequent, common, and abundant. For all features of short cells, it is important to make clear in the description whether the cells are costal or intercostal, since in a single leaf the costal short cells may be very different from the intercostal ones.

Cork cells are not so easily detected with SEM as with light and may sometimes be overlooked. When advisable the specimen is checked under light for verification.

SILICA BODIES

A silica cell usually contains a silica body that may or may not assume the same shape as the cell. Differences in the shape of the silica body within the silica cell have great taxonomic value. We assume that the shape seen on the surface with SEM is that of the silica body and recognize the following types, which are basically those of Metcalfe (1960) with a few minor modifications. Our categories are based as much as possible on well-known geometrical shapes, and we have eliminated the use of generic names to describe types:

- Tall and narrow (a shape described by Metcalfe, but not yet encountered in this study)
- Crenate-vertical (Figure 5a)
- Figure-eight (Metcalf's *Oryza* type; Figure 5b)
- Saddle-shaped (Figure 5c)
- Elliptical (Figure 5d)
- Round (Figure 5d)
- Crescent-shaped (Figure 5d)
- Cross-shaped (Figure 5e)
- Acutely-angled (Figure 5f)

- Square (Figure 6a)
- Oblong (Figure 6b)
- Elongate-smooth (a shape described by Metcalfe, but not yet encountered in this study)
- Elongate-sinuuous (Figure 6c)
- Nodular (Figure 6d)
- Dumbbell (Figure 6e,f)
 - Ends rounded (Figure 6f), or straight (Figure 6f), or concave (Figure 6e)
 - Middle wide (Figure 6e,f) or middle narrow
 - Middle long (Figure 6f) or middle short (Figure 6e)

MICROHAIRS

Microhairs are small, usually two-celled (sometimes unicellular), epidermal appendages comprised of a basal cell and an apical cell. The cells of the microhair are very thin and fragile, particularly the apical cell, which is often missing or when present is often deflated and distorted. Microhairs are found in the intercostal zone, both in and between stomatal bands.

The features of microhairs that are useful for diagnostic purposes are presence or absence (the Pooid grasses and other occasional genera lack microhairs), number of cells (one or two), proportional length of basal and apical cells, length-width ratios of cells, and nature of apex (rounded or tapered). This last feature can be determined only when the apical cell is neither collapsed nor distorted.

The diagnostic characters that we recognize are the following:

- One-celled (Figure 7a)
- Two-celled, basal and apical equal in length, short (cells one to two times as long as wide) (Figure 7b)
- Two-celled, basal and apical equal in length, medium (cells three to four times as long as wide) (Figure 7c)
- Two-celled, basal and apical equal in length, long (cells five or more times as long as wide) (Figure 7d)
- Two-celled, basal longer than apical (Figure 7e)
- Two-celled, basal shorter than apical (Figure 7f)
- Nature of apex
 - Rounded (Figure 7c)
 - Tapered (Figure 7e)

PRICKLES

Prickles are robust, usually sharply pointed, epidermal appendages with swollen bases. Met-

calfe (1960) refers to these as prickle-hairs. These appendages occur in both costal and intercostal zones. We note the absence or presence of prickles and, if present, their frequency of occurrence—infrequent, common, or abundant—and location. This quantitative character of frequency of prickles may not be as reliable as the qualitative characters, since we and others (Metcalfe, 1960; Stewart, 1965a,b) have observed that the abundance of prickles varies from one specimen to another within a species.

We recognize two main types of prickle-like appendages: prickles are large with a pointed apex and a swollen base and more often occur costally (Figure 8a,b); hooks are smaller, with a more abruptly pointed apex and a more prominently swollen base and usually occur in the intercostal region (Figure 8a (arrow),c). The two often intergrade and in some cases it is difficult to decide whether an appendage should be categorized as a prickle or a hook.

In addition to the more common prickles and hooks, we have occasionally encountered unusual prickle-like appendages. In *Asthenatherum*, for example, there are large, straight, bluntly pointed appendages without swollen bases that resemble short macrohairs (see section "Macrohairs") (Figure 8d). Another unusual prickle-like appendage observed in *Asthenatherum* is a short, unpointed appendage with a swollen base that we describe as a papillate prickle since it resembles a papilla (Figure 8e). In a few cases we have found what appears to be a bicellular prickle (Figure 8f).

MACROHAIRS

Macrohairs are larger than the microhairs described earlier, and often they can be seen with the unaided eye or with very low magnification ($\times 5-10$). Unlike the bicellular microhairs, macrohairs are usually one-celled, although specialized basal epidermal cells may be associated with them.

The presence or absence of macrohairs is determined for both the costal and intercostal zones.

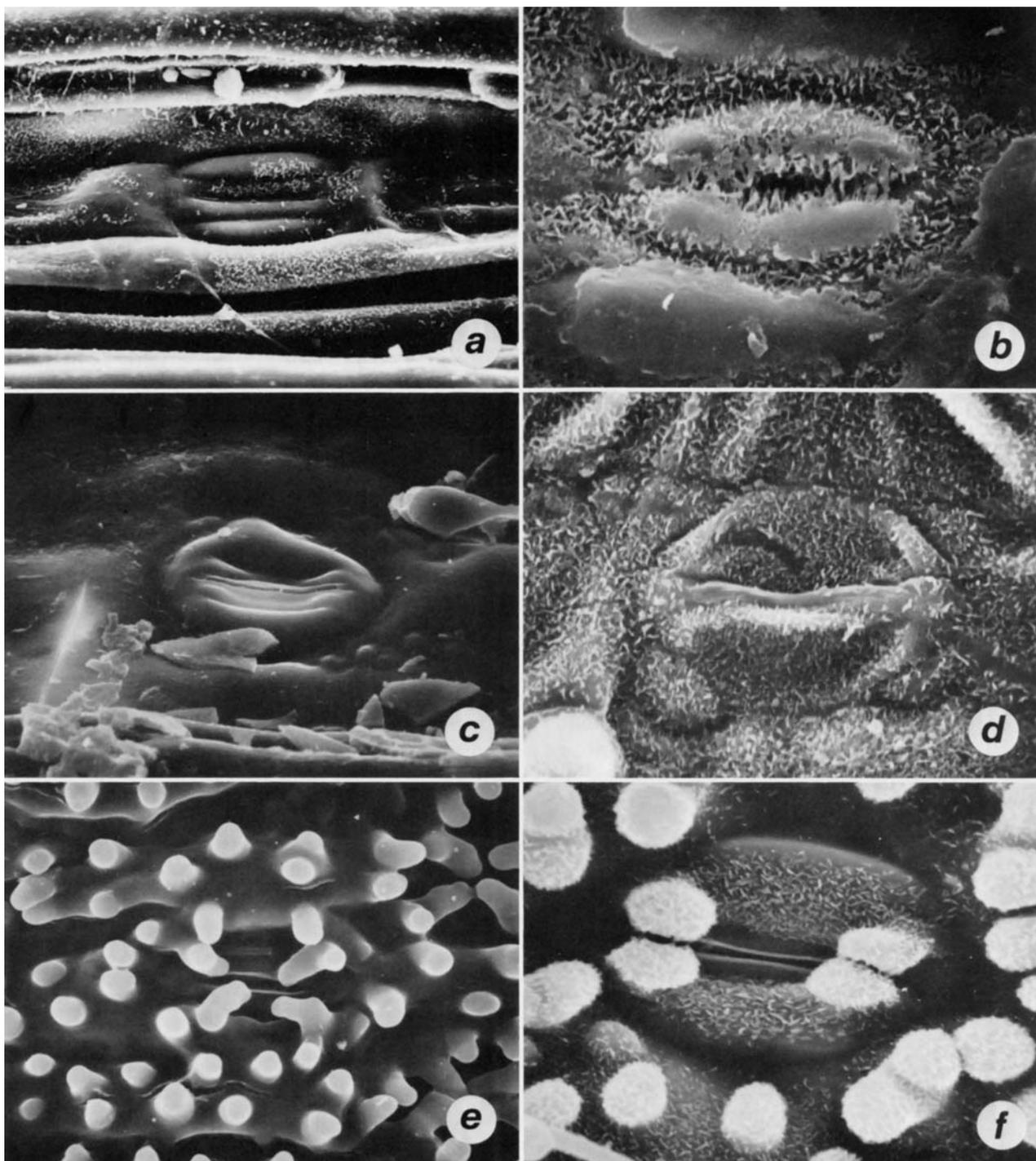


FIGURE 1.—Stomatal features: *a*, parallel-sided subsidiary cells, abaxial *Helictotrichon elongatum* (A. Richard) Hubbard, Liebenberg 12, $\times 867$; *b*, low-dome subsidiary cells, abaxial *Echinochloa pyramidalis* (Lamarck) Hitchcock and Chase, Ortaggeup 372, $\times 1696$; *c*, triangular subsidiary cells, abaxial *Eleusine coracana* (Linnaeus) Gaertner, de Wet 3833, $\times 1285$;

d, high-dome subsidiary cells, abaxial *Chlorocalymma cryptocantha* Clayton, Greenway and Kanuri 13980, $\times 1696$; *e*, stoma obscured by overarching papillae, abaxial *Arundinaria alpina*, Mayer 7750, $\times 1285$; *f*, papillate subsidiary cells, abaxial *Maltebrunia leersioides*, Humbert 5783, $\times 2970$.

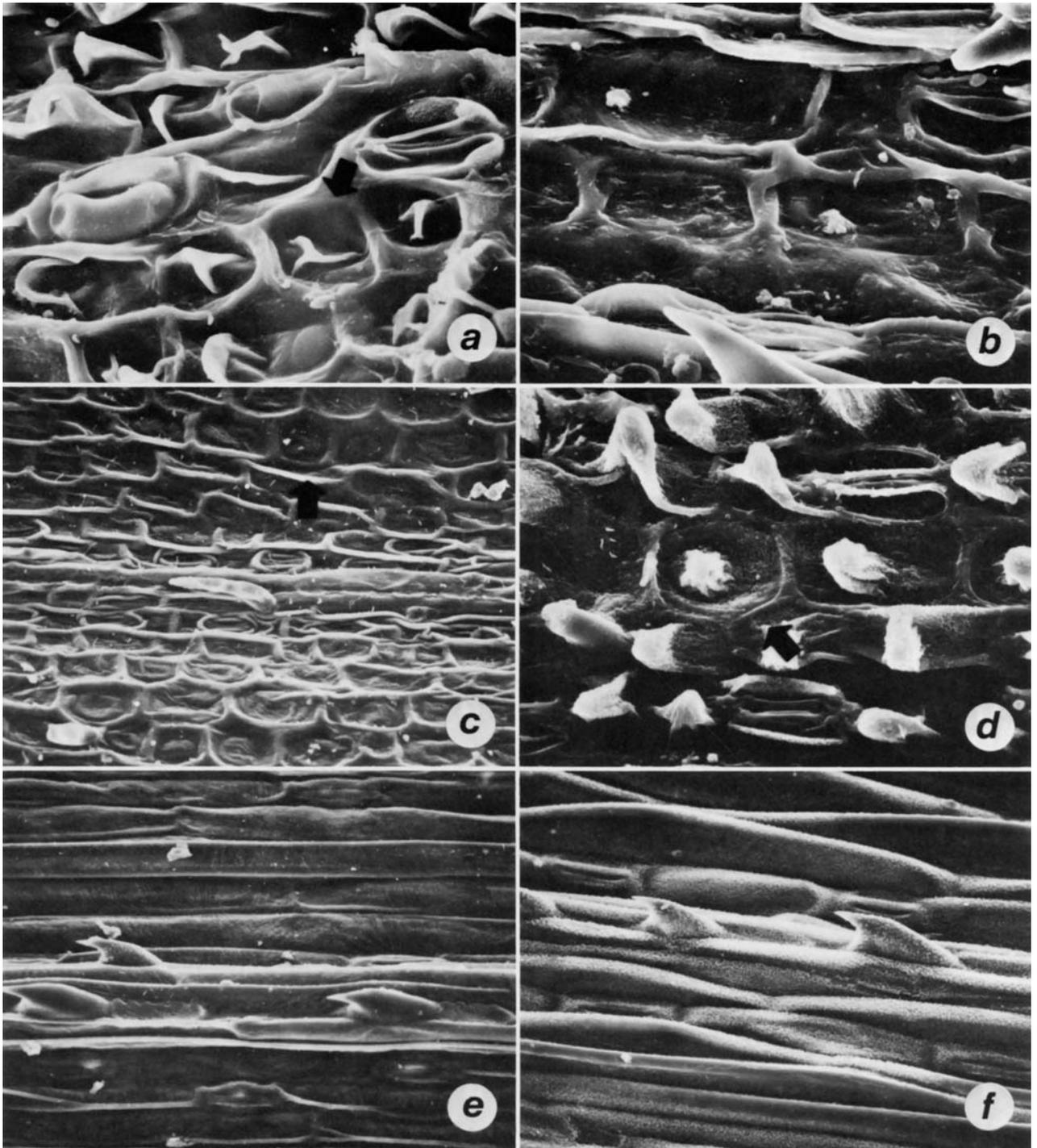


FIGURE 2.—Long cell shapes: *a*, square, abaxial *Coelachne africana* Pilger, Schlieben 4161, $\times 867$; *b*, rectangular, adaxial *Crinipes abyssinicus* Gay s.n., $\times 867$; *c*, pentagonal, abaxial *Commelinidium mayumbense* (Franchet) Stapf, Chandler 1859, $\times 295$; *d*, hexagonal, abaxial *Sacciolepis africana* Hubbard and

Snowden, Thomas 4544, $\times 867$; *e*, long, narrow, width uniform, abaxial *Avena abyssinica* A. Richard, Pappi 4901, $\times 295$; *f*, long, narrow, width non-uniform, abaxial *Dactylis glomerata* Linnaeus, Gillett 15753, $\times 416$.

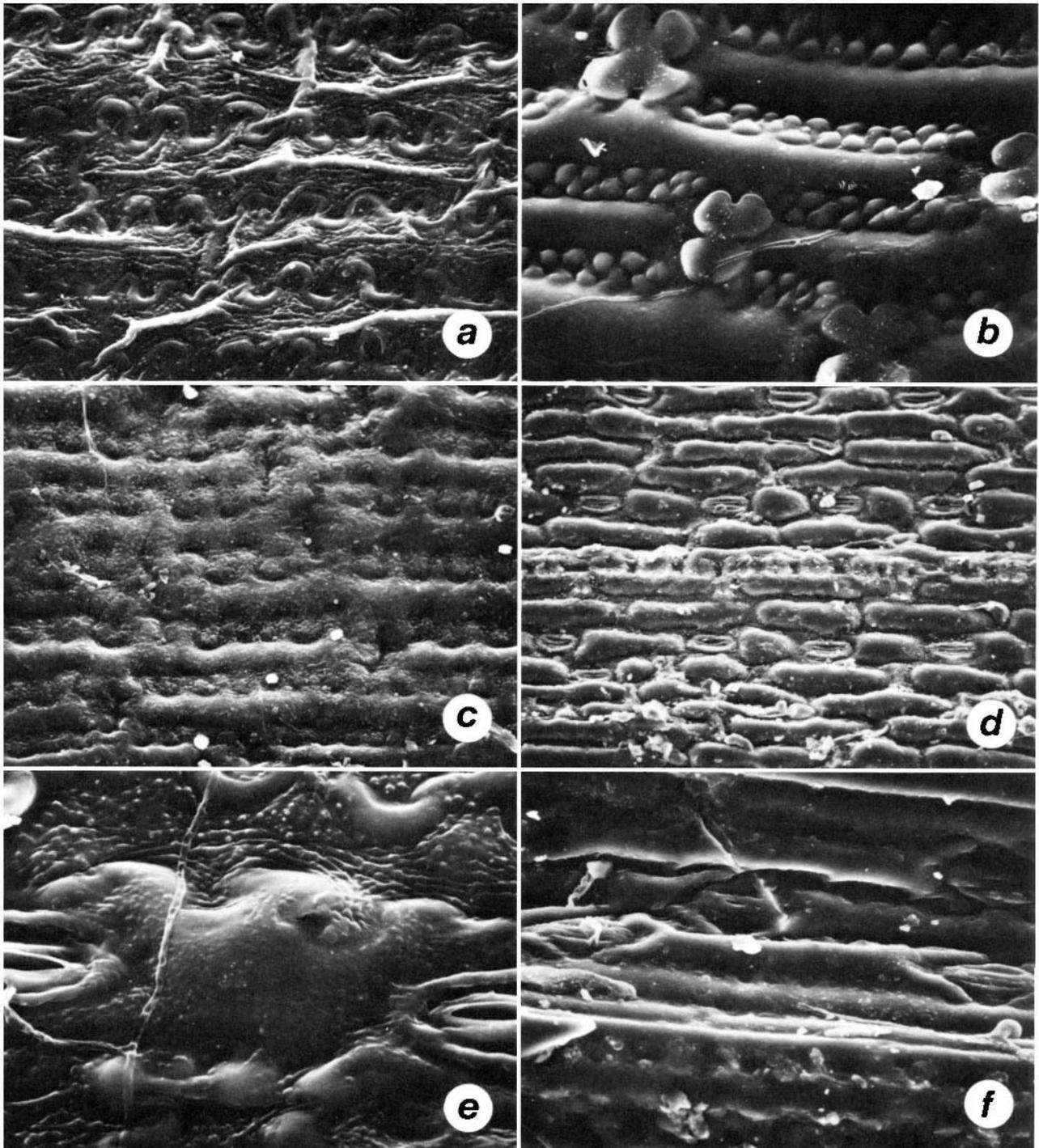


FIGURE 3.—Long cell wall outlines (*a-c*) and end walls of interstomatal cells (*d-f*): *a*, slightly sinuous, abaxial *Orthoclada africana*, Paterson *s.n.*, $\times 867$; *b*, markedly sinuous, interlocking, raised, abaxial *Phacelurus huillensis* (Rendle) Clayton, Webster T238, $\times 867$; *c*, markedly sinuous, interlocking, flat,

adaxial *Olyra latifolia*, Palmer 901, $\times 867$; *d*, straight to convex, abaxial *Sorghum arundinaceum* Stapf, Myre 26, $\times 295$; *e*, slightly concave, abaxial *Orthoclada africana*, Paterson *s.n.*, $\times 1696$; *f*, markedly concave, *Triraphis fleckii* Hackel, Schweickerdt 2115, $\times 625$.

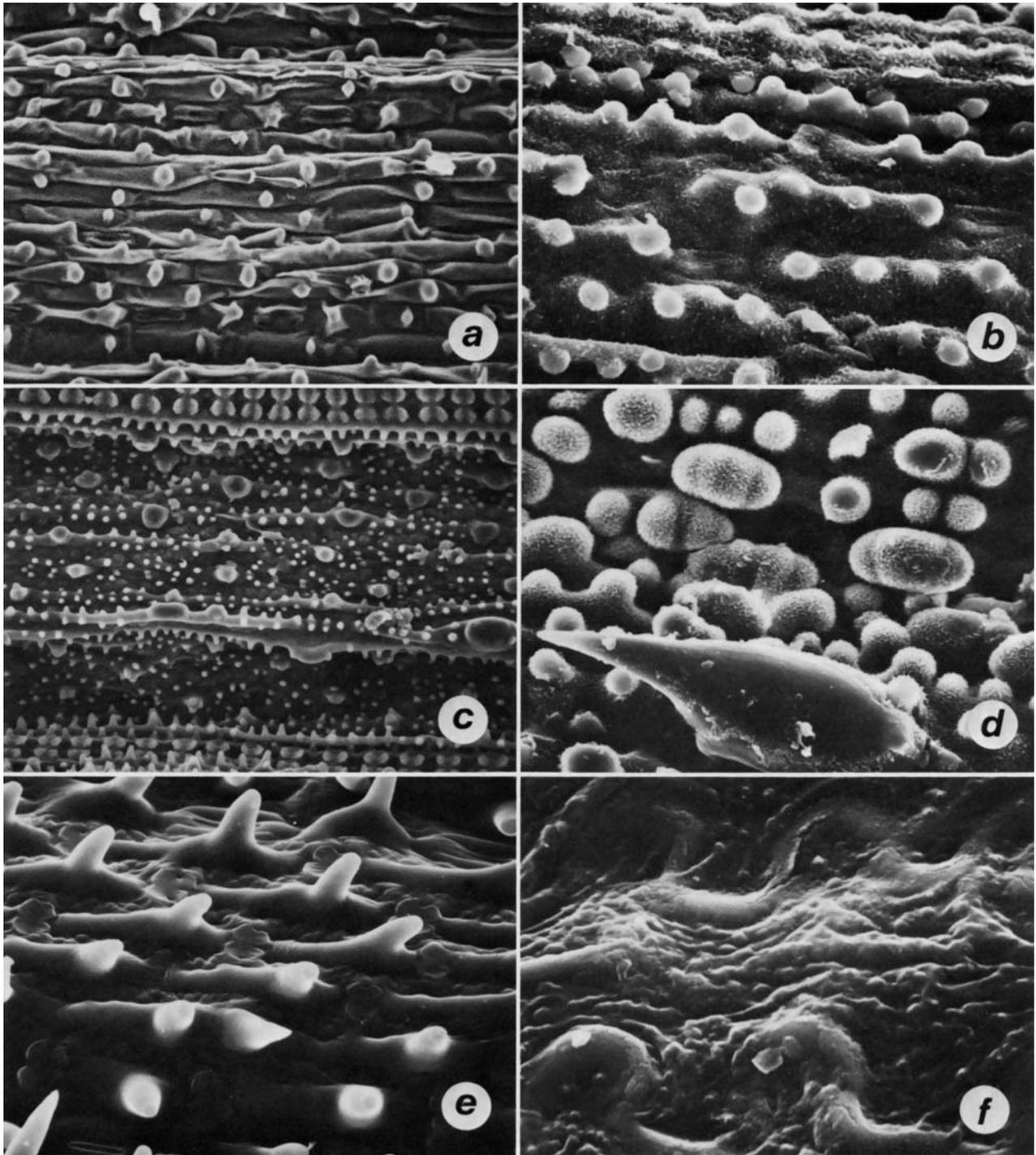


FIGURE 4.—Papillae: *a*, single papilla per long cell, abaxial *Echinochloa colona* (Linnaeus) Link, de Wet 5416, $\times 295$; *b*, single row of papillae per long cell, abaxial *Daknopholis boivinii* (A. Camus) Clayton, Croat 30897, $\times 867$; *c*, numerous papillae per long cell, size variable, abaxial *Oryza barthii* A. Chevalier, de Wet 633, $\times 416$; *d*, globose and compound

papillae, adaxial *Lepturus repens* (G. Forster) R. Brown, Bogdan 3642, $\times 867$; *e*, elongate papillae, abaxial *Vossia cuspidata* (Roxburgh) Griffith, Meyer 7503, $\times 867$; *f*, small, variable-sized papillae giving surface a warty texture, abaxial *Orthoclada africana*, Paterson s.n., $\times 2970$.

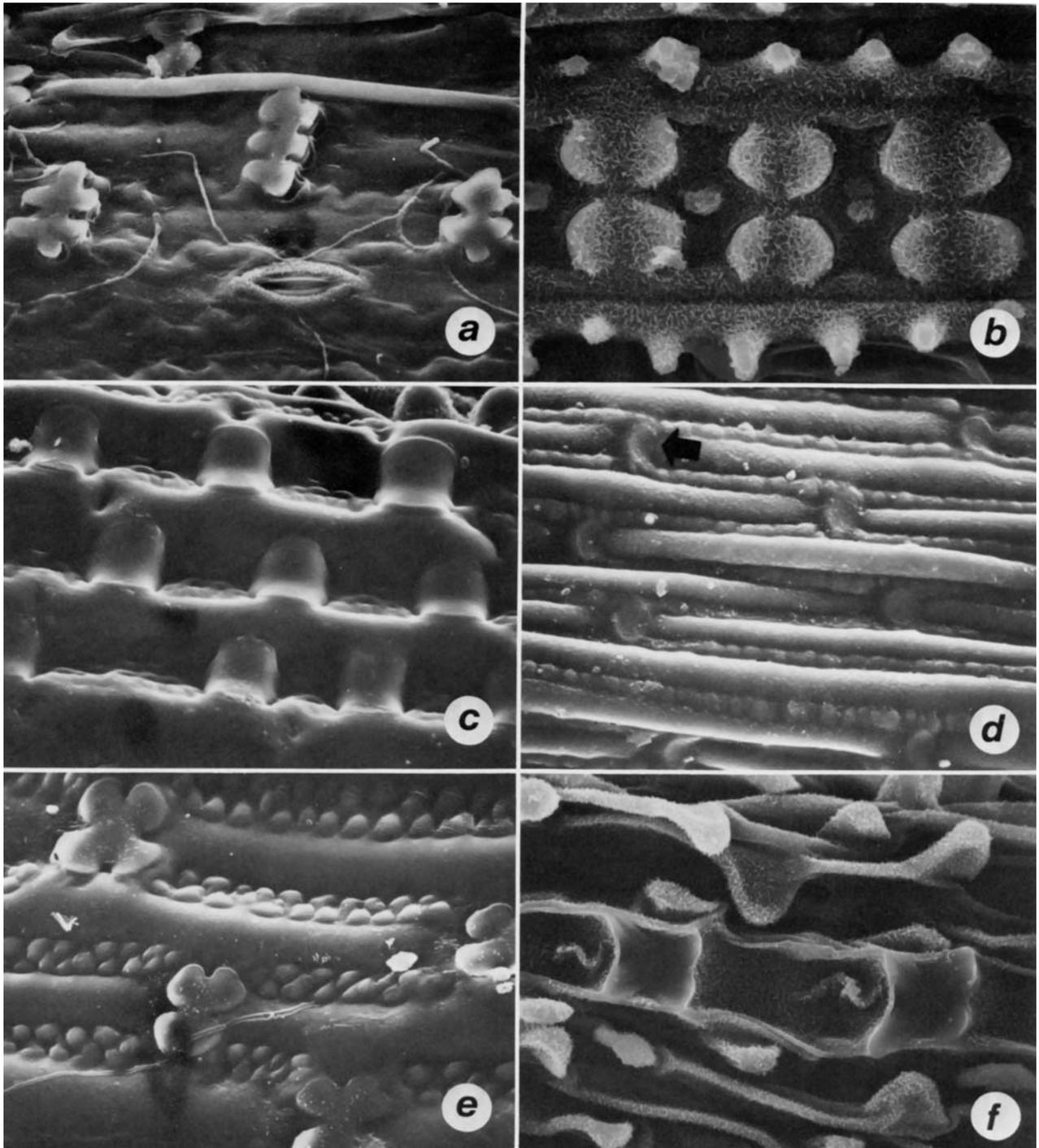


FIGURE 5.—Silica bodies: *a*, crenate-vertical, abaxial *Olyra latifolia*, Palmer 901, $\times 867$; *b*, figure-eight, abaxial *Oryza barthii* A. Chevalier, de Wet 626, $\times 1285$; *c*, saddle-shaped, abaxial *Chrysochloa hindsii* Hubbard, Lewalle 4841, $\times 867$; *d*, crescent-shaped (arrow), elliptical to round, abaxial *Stipa*

drageana Steudel, Schweickerdt 1818, $\times 867$; *e*, cross-shaped, abaxial *Phacelurus huillensis* (Rendle) Clayton, Webster T238, $\times 867$; *f*, acutely-angled, adaxial *Heteroanthoecia guineensis* (Franchet) Robyns, Simon and Williamson 1925, $\times 1696$.

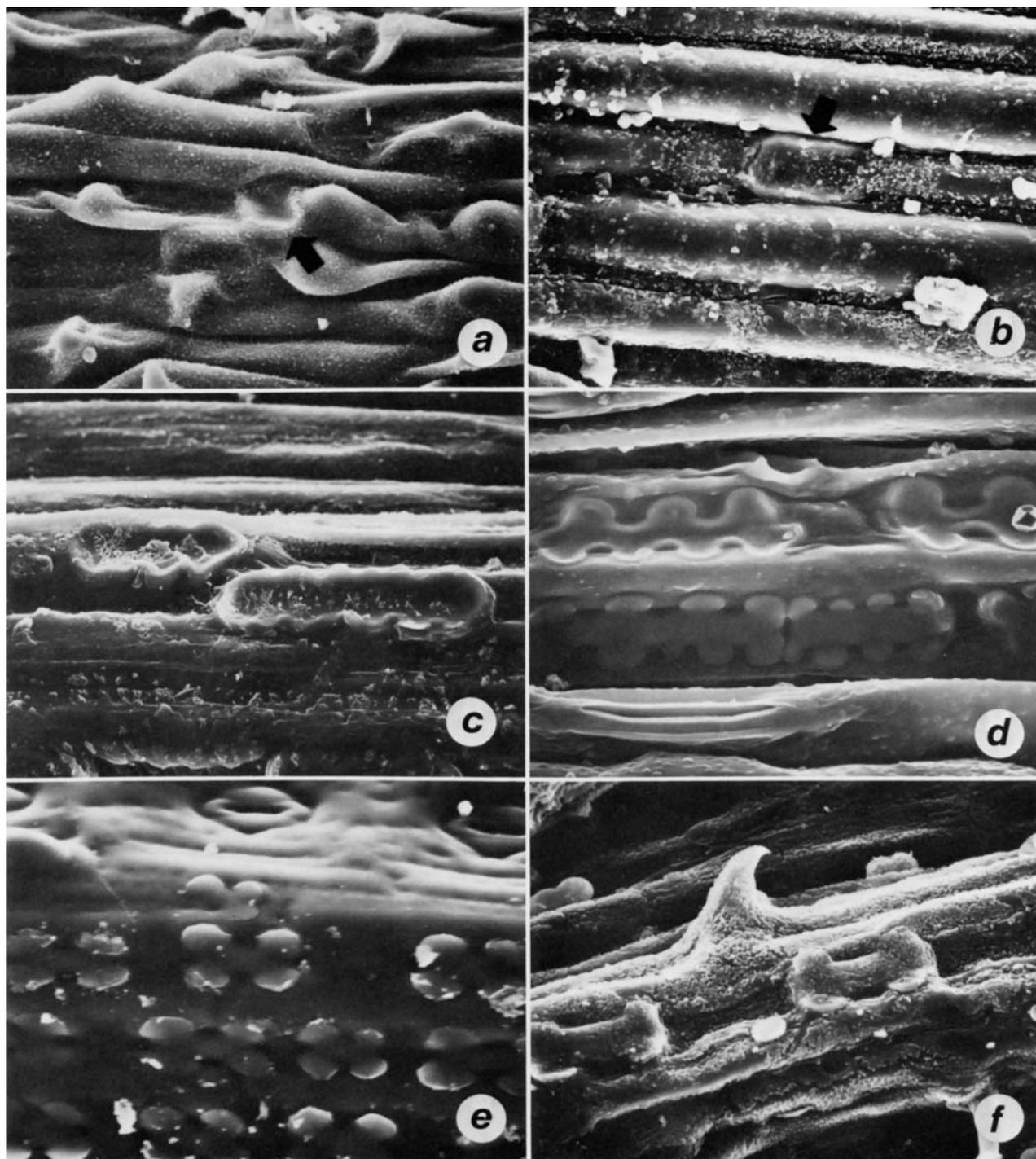


FIGURE 6.—Silica bodies: *a*, square, abaxial *Colpodium chionogeiton* (Pilger) Tzvelev, Wood 923, $\times 867$; *b*, oblong, abaxial *Triticum aestivum* Linnaeus, Harshberger 1139, $\times 867$; *c*, elongate-sinuuous, abaxial *Avena abyssinica* Hochstetter, Pappi 4901, $\times 867$; *d*, nodular, abaxial *Elytrophorus globularis*,

Schweickerdt 2158, $\times 867$; *e*, dumbbell, ends concave, middle wide, short, abaxial *Schmidtia bulbosa* Stapf, Brass 17909, $\times 867$; *f*, dumbbell, ends straight to rounded, middle wide, long, abaxial *Trichoneura mollis* (Kunth) Ekman, Napper 550, $\times 867$.

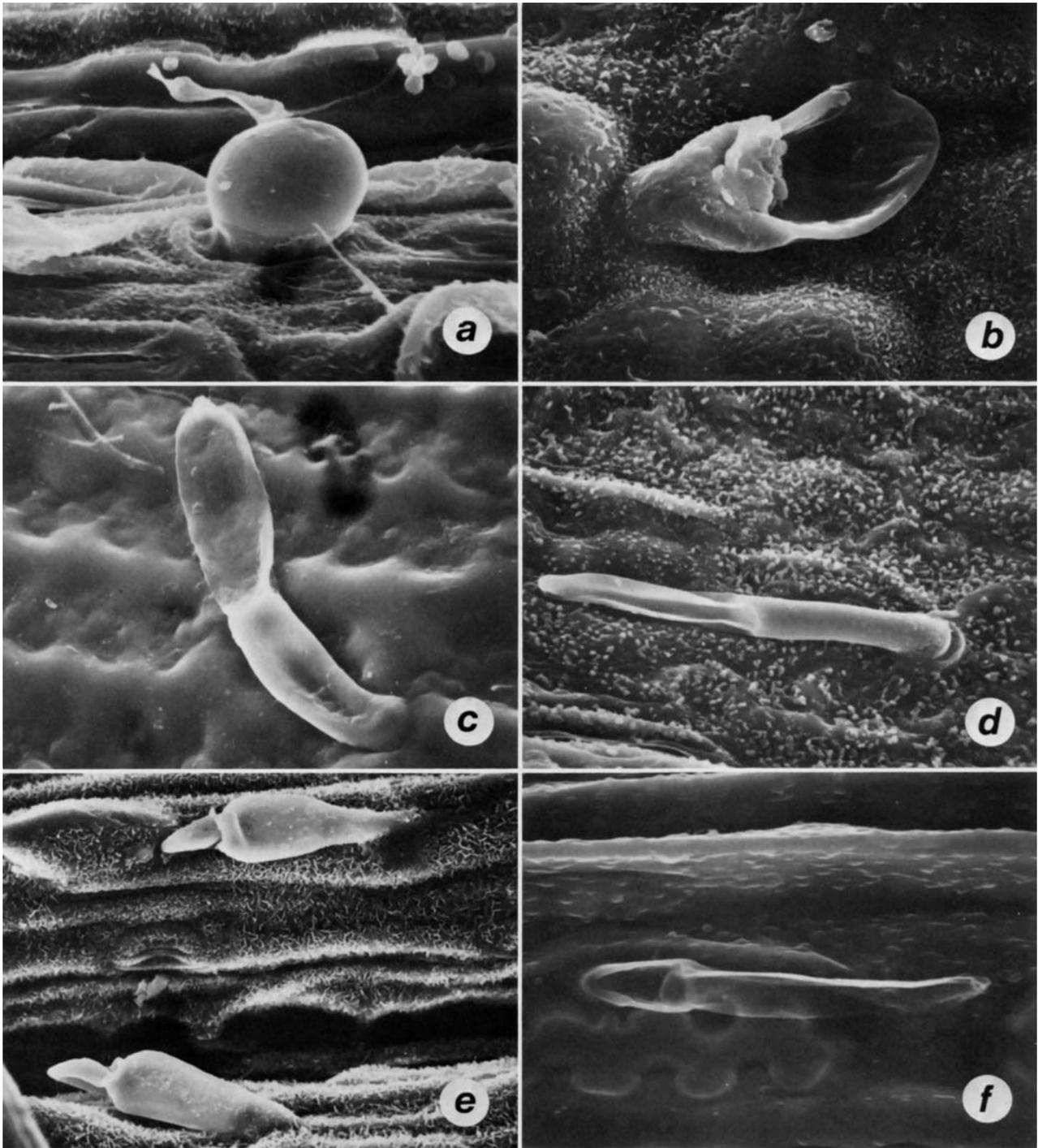


FIGURE 7.—Microhair types: *a*, one-celled, abaxial *Dactyloctenium giganteum* Fisher and Schweick, Bullock 305, $\times 1696$; *b*, two-celled, basal and apical equal, short, apex rounded, abaxial *Cynodon dactylon* (Linnaeus) Persoon, Hitchcock 24507, $\times 2970$; *c*, two-celled, basal and apical equal, medium, apex rounded, abaxial *Humbertochloa greenwayi*, Wingfield 1680, $\times 1285$;

d, two-celled, basal and apical equal, long, apex tapered, abaxial *Orthoclada africana*, Paterson *s.n.*, $\times 1285$; *e*, two-celled, basal longer, apical shorter, apex tapered, abaxial *Harpachne schimperii* Hochstetter, Milne-Redhead and Taylor 8828, $\times 867$; *f*, two-celled, basal shorter, apical longer, apex tapered, abaxial *Elytrophorus globularis*, Schweickerdt 2158, $\times 1285$.

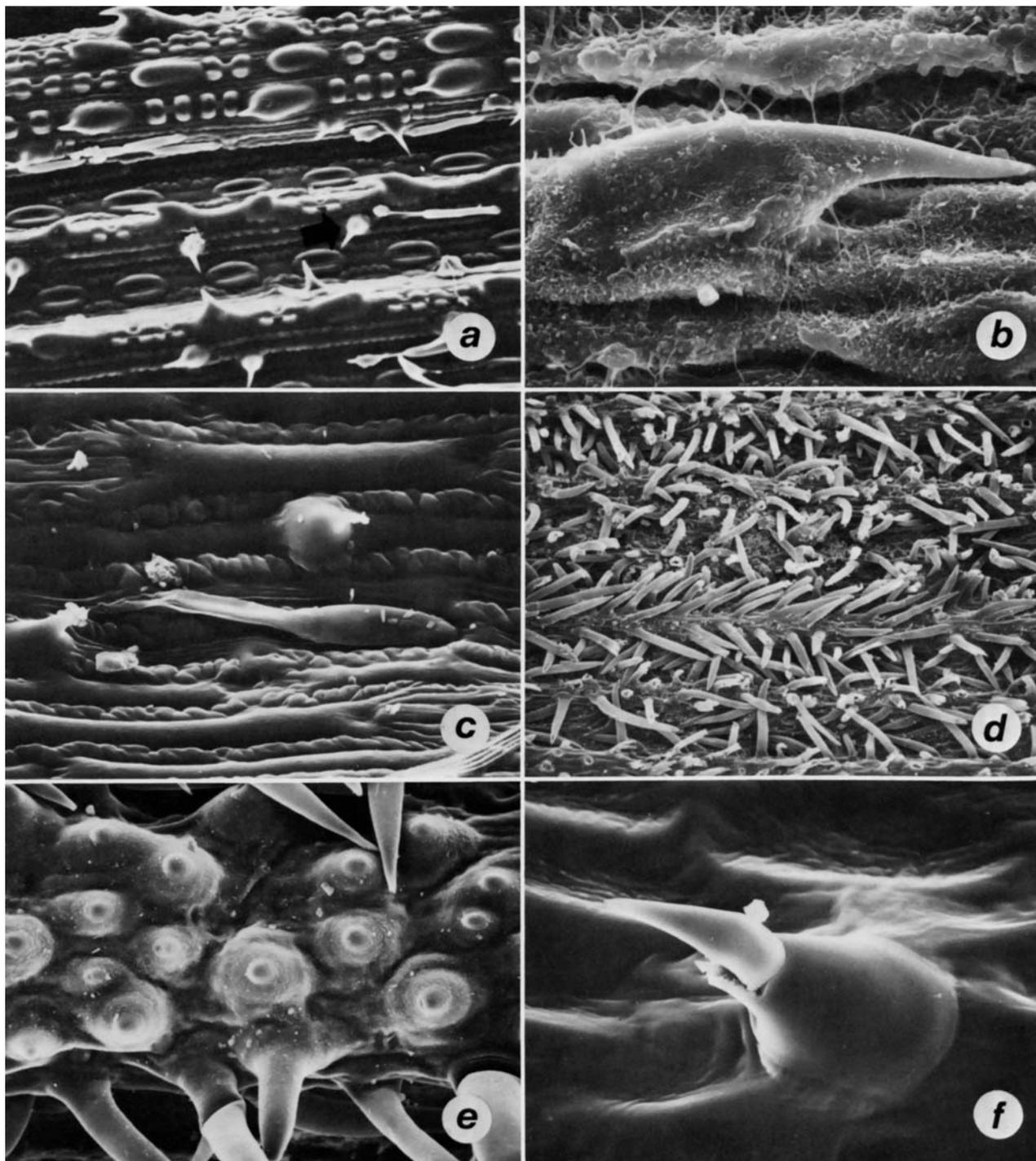


FIGURE 8.—Prickles: *a*, costal prickles and intercostal hooks (arrow), abaxial *Sehima nervosum* (Rohburgh and Willdenow) Stapf, Hudson 217, $\times 295$; *b*, costal prickle, abaxial *Dichanthium aristatum* (Poiret) Hubbard, Eyles 2210, $\times 1285$; *c*, intercostal hook, abaxial *Brachiaria brizantha* Stapf, Hitchcock 24884 $\times 867$; *d*, short macrohair-like prickles, large,

straight, stiff, ends blunt, bases not swollen, abaxial *Asthenatherum forskalii* (Vahl) Nevski, Mandaville 388, $\times 63$; *e*, papillate prickles, short, unpointed with swollen bases, adaxial of *Asthenatherum forskalii*, Mandaville 388, $\times 295$; *f*, bicellular prickle, adaxial *Megastachya mucronata*, Faden 74/345, $\times 867$.

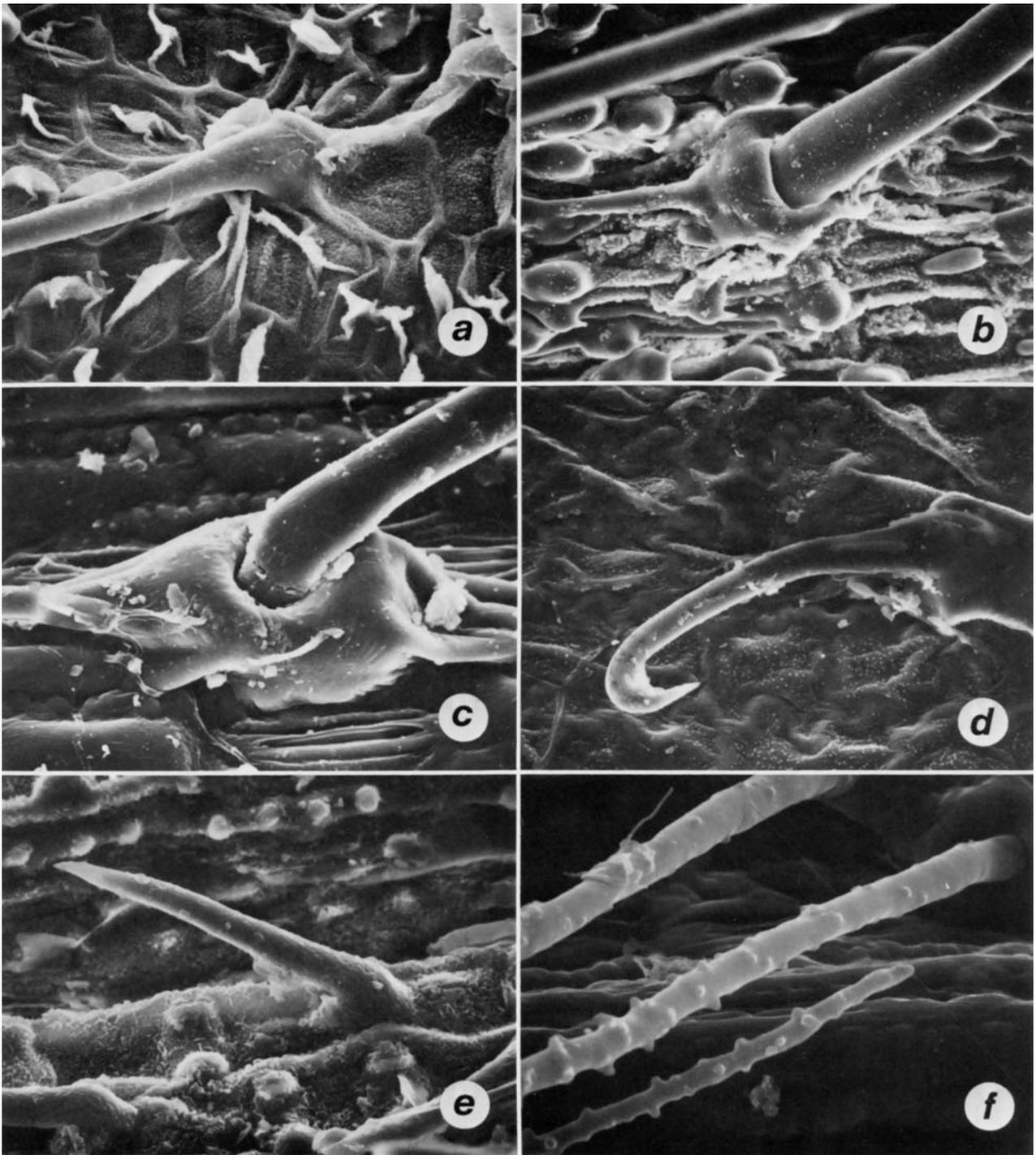


FIGURE 9.—Macrohairs: *a*, raised basal cells absent, abaxial *Isachne buettneri* Hackel, Baldwin 6718, $\times 867$; *b*, basal cells slightly raised, abaxial *Andropogon stolonatus* (Pursh) Hubbard, Wiehe N/293, $\times 416$; *c*, basal cells markedly raised, abaxial *Cleistachne sorghoides* Benth, Thomas 1325, $\times 867$; *d*, end

of macrohair curved, adaxial *Orthocladia africana*, Paterson s.n., $\times 625$; *e*, short macrohair, adaxial *Oropetium thomaeum* (Linnaeus) Trinius, Olufsen 393, $\times 867$; *f*, papillate shaft of macrohair, abaxial *Danthoniopsis viridis* (Rendle) Hubbard, Verhoon 1373, $\times 1285$.

When present, the frequency is divided into three categories: infrequent, common, and abundant. Sometimes there is quantitative variation within a species, and therefore, as with prickles, this character may not be as taxonomically valuable as other features. Note is made of the presence (Figure 9*b,c*) or absence (Figure 9*a*) of raised epidermal cells at the base of the macrohairs and, when present, whether the cells are slightly (Figure 9*b*) or markedly (Figure 9*c*) raised.

Occasionally, we have seen structures that are intermediate between macrohairs and prickles (Figure 9*e*). In such cases, the feature is assigned to one category and cross-reference is made to the other.

In our survey of grass epidermis we have encountered some specialized features of macrohairs. In *Orthoclada africana* C. E. Hubbard, the tip of the macrohair is curved forming a fishhook type macrohair (Figure 9*d*). Another unusual feature is the papillate shaft of the macrohair in *Danthoniopsis viridis* (Rendle) Hubbard (Figure 9*f*).

Format for Species Descriptions

STOMATA.—Frequency; subsidiary cell shape; distribution; special features.

INTERSTOMATAL CELLS.—Shape; end walls; outline of walls. *Papillae*: Number/cell, distribution on each cell, shape, size.

LONG CELLS.—Shape; outline of walls. *Papillae*: Number/cell, distribution on each cell, shape, size.

PRICKLES.—Frequency; location and type.

SHORT CELLS.—Location and distribution. *Silica Cells*: Location and frequency. *Cork Cells*: Location and frequency.

SILICA BODIES.—Location and shape.

MICROHAIRS.—Frequency; number of cells; shape; shape of apex.

MACROHAIRS.—Frequency; location; nature of base.

SPECIAL FEATURES.—Description of unique features not covered in other categories.

Tribe BAMBUSEAE

Arundinaria alpina K. Schumann

PLATES 1–2

ABAXIAL

STOMATA.—Common; appears to be high-dome but not clear because of overarching papillae; 1 stomatal band/intercostal zone, 1 or sometimes 2 rows/band (Plate 1*a,b*).

INTERSTOMATAL CELLS.—Long, narrow, width uniform; ends indeterminable because of overarching papillae; markedly sinuous, interlocking, flat to slightly raised. *Papillae*: Many, usually single row, globose, uniform, or sometimes none seen (Plate 1*a*).

LONG CELLS.—Long, narrow, width uniform; markedly sinuous, interlocking, flat to slightly raised. *Papillae*: Many, usually single row, globose, uniform, or sometimes none seen (Plate 1*c,e*).

PRICKLES.—Infrequent; intercostal prickles (Plate 1*d*).

SHORT CELLS.—Costal >5/row; intercostal solitary or paired. *Silica Cells*: Costal common; intercostal abundant. *Cork Cells*: Costal common; intercostal abundant (Plate 1*c,e*).

SILICA BODIES.—Costal dumbbell, ends rounded to straight, middle wide and short; intercostal saddle-shaped (?), not very distinct, shape difficult to ascertain (Plate 1*c,e*).

MICROHAIRS.—Infrequent, found near the margin only; two-celled; basal and apical equal in length, medium; apex rounded (Plate 1*f*).

MACROHAIRS.—None seen.

ADAXIAL

STOMATA.—Infrequent; probably high-dome but not clear because of overarching papillae; distribution indeterminable because stomata too infrequent (Plate 2*a*).

INTERSTOMATAL CELLS.—Long, narrow, width uniform; ends indeterminable because of overarching papillae; markedly sinuous, interlocking, flat to slightly raised. *Papillae*: Many, single row,

globose, uniform or sometimes none seen (Plate 2*b*).

LONG CELLS.—Long, narrow, width uniform; markedly sinuous, interlocking, flat or slightly raised. *Papillae*: Many, single row, globose, uniform or sometimes none seen (Plate 2*c*).

PRICKLES.—Infrequent; intercostal prickles or hooks (somewhat intermediate between prickles and hooks) (Plate 2*d*).

SHORT CELLS.—Costal >5/row; intercostal solitary or paired. *Silica Cells*: Costal common; intercostal abundant. *Cork Cells*: Costal common; intercostal abundant; some appear cross-shaped (Plate 2*e,f*).

SILICA BODIES.—Costal dumbbell, ends straight to concave, middle wide and short; intercostal tall and narrow (Plate 2*e,f*).

MICROHAIRS.—None seen.

MACROHAIRS.—None seen.

Oreobambos buchwaldii K. Schumann

PLATES 3-4

ABAXIAL

STOMATA.—Abundant; appears high-dome but not clear because of overarching papillae; 2 stomatal bands/intercostal zone, 3 rows/band (Plate 3*a,b*).

INTERSTOMATAL CELLS.—Square to rectangular; ends indeterminable because of overarching papillae; outline of walls indeterminable. *Papillae*: Many, irregular, globose, variable (Plate 3*b*).

LONG CELLS.—Rectangular to long, narrow, width uniform; outline of walls indeterminable. *Papillae*: Many, irregular, globose, variable (Plate 3*a,e*).

PRICKLES.—Common; intercostal prickles (Plate 3*a*).

SHORT CELLS.—Costal paired or 3-5/row; intercostal paired. *Silica Cells*: Costal and intercostal abundant. *Cork Cells*: Costal and intercostal abundant (Plate 3*c,d*).

SILICA BODIES.—Costal saddle-shaped; intercostal saddle-shaped, cross-shaped, or somewhat like the figure-eight type (Plate 3*c,d*).

MICROHAIRS.—Abundant; two-celled; basal longer, apical shorter; apex rounded (often deflated) (Plate 3*e*).

MACROHAIRS.—Common; costal; basal cells slightly raised; papillate around the base (Plate 3*f*).

ADAXIAL

STOMATA.—Infrequent; appears high-dome but somewhat obscured by overarching papillae; stomata too infrequent to form a regular distributional pattern (Plate 4*a,b,c*).

INTERSTOMATAL CELLS.—Rectangular; ends straight to convex; markedly sinuous, interlocking, raised. *Papillae*: Few toward the ends and overarching the stomata, globose, variable; usually many long cells separating the sporadically distributed stomata (Plate 4*a,c*).

LONG CELLS.—Long, narrow, width uniform; markedly sinuous, interlocking, raised. *Papillae*: None seen. It is difficult to distinguish between costal and intercostal regions; a distinctive feature in the intercostal (?) is a wide band of long cells, the ends of which are not discernible (Plate 4*a,d*).

PRICKLES.—None seen.

SHORT CELLS.—Costal and intercostal paired. *Silica Cells*: Costal and intercostal abundant. *Cork Cells*: Costal and intercostal abundant (Plate 4*e,f*).

SILICA BODIES.—Costal and intercostal intermediate between saddle-shaped and figure-eight (Plate 4*e,f*).

MICROHAIRS.—None seen.

MACROHAIRS.—None seen.

Oxytenanthera abyssinica (A. Richard) Munro

PLATES 5-6

ABAXIAL

STOMATA.—Abundant; triangular; 1 stomatal band/intercostal zone, 5-8 rows/band; stomata somewhat obscured by overarching papillae (Plate 5*a,b*).

INTERSTOMATAL CELLS.—Rectangular or some-

times square; nature of ends indeterminable because of papillae; outline of cells indeterminable. *Papillae*: Many, irregular, globose, variable (Plate 5c).

LONG CELLS.—Rectangular; outline of cells indeterminable. *Papillae*: Many, irregular, globose, variable (Plate 5a,d).

PRICKLES.—Common; intercostal prickles; prickles on either side of vein as well as in middle of intercostal zone (Plate 5d).

SHORT CELLS.—Costal single, paired or >5/row (often a single silica cell or a pair of short cells alternates with a single papillate long cell); intercostal not seen. *Silica Cells*: Costal abundant; intercostal not seen. *Cork Cells*: Costal abundant; intercostal not seen; each cork cell generally has a single small papilla (Plate 5c,d,e).

SILICA BODIES.—Costal saddle-shaped; intercostal not seen (Plate 5d,e).

MICROHAIRS.—Common; two-celled; basal longer, apical shorter; apex rounded (Plate 5f).

MACROHAIRS.—None seen.

ADAXIAL

STOMATA.—Infrequent; shape of subsidiary cell indeterminable because of overarching papillae; stomata occur too infrequently to form a definite distributional pattern (Plate 6a,b).

INTERSTOMATAL CELLS.—Not applicable.

LONG CELLS.—Long, narrow, width uniform; markedly sinuous, interlocking, raised. *Papillae*: Many, single row or sometimes irregular, globose, variable; sometimes concealed by wax (Plate 6d).

PRICKLES.—Infrequent; intercostal prickles (Plate 6a).

SHORT CELLS.—Costal solitary (or paired?); intercostal solitary; short cells indistinct because of wax. *Silica Cells*: Costal common; intercostal abundant. *Cork Cells*: None seen (?) (this may be because of wax) (Plate 6c,e).

SILICA BODIES.—Costal saddle-shaped; intercostal saddle-shaped or sometimes approaching figure-eight (Plate 6c,e,f).

MICROHAIRS.—None seen.

MACROHAIRS.—None seen.

Puelia olyriformis (Franchet) Clayton

PLATES 7-8

ABAXIAL

STOMATA.—Abundant; triangular; 2 stomatal bands/intercostal zone, 3 or 4 rows/band; stomatal bands adjacent to veins and separated by wide area of long cells lacking stomata (Plate 7a,b).

INTERSTOMATAL CELLS.—Rectangular; ends straight to convex; markedly sinuous, interlocking, slightly raised. *Papillae*: None seen (Plate 7c).

LONG CELLS.—Rectangular to long, narrow, width uniform; markedly sinuous, interlocking, slightly raised. *Papillae*: None seen (Plate 7d).

PRICKLES.—None seen.

SHORT CELLS.—Costal >5/row; intercostal paired. *Silica Cells*: Costal and intercostal abundant. *Cork Cells*: Costal and intercostal abundant (Plate 7d,e).

SILICA BODIES.—Costal and intercostal saddle-shaped (Plate 7e,f).

MICROHAIRS.—None seen.

MACROHAIRS.—None seen.

ADAXIAL

STOMATA.—Infrequent; triangular; distribution indeterminable because stomata too infrequent (Plate 8b).

INTERSTOMATAL CELLS.—Not applicable.

LONG CELLS.—Rectangular to long, narrow, width uniform; markedly sinuous, interlocking, slightly raised. *Papillae*: None seen (Plate 8a).

PRICKLES.—Infrequent; on margins only (Plate 8c).

SHORT CELLS.—Costal paired or >5/row; intercostal paired. *Silica Cells*: Costal and intercostal abundant. *Cork Cells*: Costal and intercostal abundant (Plate 8d,e,f).

SILICA BODIES.—Costal saddle-shaped; intercostal saddle-shaped, figure-eight, or intermediate between these two shapes (Plate 8d,e,f).

MICROHAIRS.—None seen.

MACROHAIRS.—None seen.

SPECIAL FEATURES.—On the costal regions there are large irregularly distributed structures (perhaps silicified papillae) (Plate 8a).

Tribe OLYREAE

Olyra latifolia Linnaeus

PLATES 9-10

ABAXIAL

STOMATA.—Abundant; triangular; 2 or sometimes 3 stomatal bands/intercostal zone, 5 or sometimes 3 or 6 rows/band; bands adjacent to veins (Plate 9a,b).

INTERSTOMATAL CELLS.—Rectangular to long, narrow, width uniform; ends slightly concave; markedly sinuous, interlocking, flat to slightly raised; often walls appear slightly sinuous because of collapsed cells. *Papillae*: Many, irregular, globose, uniform; other cells lack papillae or papillae so deflated as to be inconspicuous (Plate 9b).

LONG CELLS.—Rectangular to long, narrow, width uniform; markedly sinuous, interlocking, flat to slightly raised; often walls appear slightly sinuous because of collapsed cells. *Papillae*: Many, long cells near the stomatal bands often with a single row of small globose uniform papillae; sometimes irregular; other long cells usually lacking papillae; a band of long cells in center of intercostal zone (between stomatal bands) often has longitudinal folds due to collapsed cells (Plate 9a,c,e).

PRICKLES.—None seen.

SHORT CELLS.—Costal >5/row; intercostal paired or sometimes solitary. *Silica Cells*: Costal and intercostal abundant. *Cork Cells*: Costal and intercostal abundant (Plate 9d,e).

SILICA BODIES.—Costal cross-shaped to figure-eight; intercostal crenate-vertical or sometimes figure-eight (Plate 9c,d,e).

MICROHAIRS.—Abundant; two-celled; basal slightly longer, apical shorter; apex rounded (Plate 9b,f).

MACROHAIRS.—None seen.

ADAXIAL

STOMATA.—Common; triangular; 2 or sometimes 3 stomatal bands/intercostal zone, 2 or sometimes 1 or 3 rows/band; occasional scattered solitary stomata (Plate 10b).

INTERSTOMATAL CELLS.—Rectangular to long, narrow, width uniform; ends markedly concave; markedly sinuous, interlocking, flat to slightly raised. *Papillae*: None seen.

LONG CELLS.—Rectangular to long, narrow, width uniform; markedly sinuous, interlocking, flat to slightly raised. *Papillae*: None seen (Plate 10a,c).

PRICKLES.—None seen.

SHORT CELLS.—Costal solitary, paired, or >5/row; intercostal solitary or paired. *Silica Cells*: Costal common; intercostal abundant. *Cork Cells*: Costal common; intercostal abundant (Plate 10c,d,e,f).

SILICA BODIES.—Costal cross-shaped to intermediate between cross-shaped and figure-eight; intercostal crenate-vertical (Plate 10d,e).

MICROHAIRS.—None seen.

MACROHAIRS.—None seen.

Tribe PHAREAE

Leptaspis cochleata Thwaites

PLATES 11-12

ABAXIAL

STOMATA.—Infrequent; high-or sometimes low-dome; stomata too infrequent to form a distributional pattern (Plate 11c,d).

INTERSTOMATAL CELLS.—Long, narrow, width uniform; ends straight to convex; markedly sinuous, interlocking, raised. *Papillae*: None seen (Plate 11d).

LONG CELLS.—Long, narrow, width uniform, sometimes tapered at end; intercostal zone of large veins with narrow band of markedly sinuous, interlocking, raised long cells, alternating with narrow bands (small veins?) of slightly sinuous long cells. A single row of short cells occurs

within the latter band. *Papillae*: None seen (Plate 11*b*).

PRICKLES.—None seen.

SHORT CELLS.—Costal >5 /row; intercostal not seen. *Silica Cells*: Costal common; intercostal not seen. *Cork Cells*: Costal common; intercostal not seen. Throughout the intercostal zone of large veins single rows of short cells (small veins?) occur (Plate 11*e*).

SILICA BODIES.—Costal dumbbell, ends rounded, middle wide or sometimes narrow, short (Plate 11*e,f*).

MICROHAIRS.—None seen.

MACROHAIRS.—None seen.

ADAXIAL

STOMATA.—Common; high- or sometimes low-dome; 2 stomatal bands/intercostal zone, 2 rows/band, bands adjacent to veins. Each cell adjacent to stoma obscured by large deflated papilla (Plate 12*a,b,e*).

INTERSTOMATAL CELLS.—Each obscured by a single large deflated papilla (Plate 12*b*).

LONG CELLS.—Long, narrow, width uniform, ends often tapered; slightly sinuous. *Papillae*: None seen, except cells adjacent to stomata as indicated above. Intercostal zone of large veins with narrow band of slightly sinuous long cells alternating with narrow bands (small veins?) of nonsinuous long cells. A single row of short cells occurs within the latter band. Longitudinal striations often present (Plate 12*c,f*).

PRICKLES.—Infrequent, costal prickles (Plate 12*e*).

SHORT CELLS.—Costal >5 /row; intercostal not seen. *Silica Cells*: Costal common; intercostal not seen. *Cork Cells*: Costal common; intercostal not seen. In the intercostal zone between major veins, single rows of short cells (small veins?) occur (Plate 12*c,e*).

SILICA BODIES.—Costal dumbbell, ends rounded, middle narrow or sometimes wide, short; intercostal not seen (Plate 12*d*).

MICROHAIRS.—None seen.

MACROHAIRS.—None seen.

Tribe STREPTOGYNEAE

Streptogyna crinita P. Beauvois

PLATES 13-14

ABAXIAL

STOMATA.—Abundant; triangular or sometimes high-dome; 1 stomatal band/intercostal zone, 3 or sometimes 2-5 rows/band; a small protrusion resembling an underdeveloped papilla present on each end of subsidiary cell (Plate 13*a,b*).

INTERSTOMATAL CELLS.—Square to rectangular; ends slightly to markedly concave; markedly sinuous, interlocking, slightly raised. *Papillae*: None seen (Plate 13*c*).

LONG CELLS.—Long, narrow, width uniform or sometimes rectangular; markedly sinuous, interlocking, slightly raised. *Papillae*: None seen (Plate 13*a*).

PRICKLES.—Infrequent to abundant (varies from one specimen to another); costal prickles (Plate 13*e*).

SHORT CELLS.—Costal solitary, paired or sometimes 3-5/row or >5 /row; intercostal paired. *Silica Cells*: Costal and intercostal abundant. *Cork Cells*: Costal and intercostal abundant (Plate 13*c,d,f*).

SILICA BODIES.—Costal and intercostal saddle-shaped (Plate 13*c,d,f*).

MICROHAIRS.—None seen.

MACROHAIRS.—None seen.

SPECIAL FEATURES.—Transverse veins present.

ADAXIAL

STOMATA.—Common to abundant; triangular; 1 stomatal band/intercostal zone, 1 or 2 rows/band (Plate 14*a,b*).

INTERSTOMATAL CELLS.—Rectangular; ends slightly concave; slightly sinuous, interlocking, slightly raised. *Papillae*: None seen (Plate 14*c*).

LONG CELLS.—Long, narrow, width uniform; markedly sinuous, interlocking, slightly raised. *Papillae*: None seen (Plate 14*a*).

PRICKLES.—None seen.

SHORT CELLS.—Costal >5 /row; intercostal paired. *Silica Cells*: Costal and intercostal abundant. *Cork Cells*: Costal and intercostal abundant (Plate 14*d,e*).

SILICA BODIES.—Costal and intercostal saddle-shaped (Plate 14*d,e*).

MICROHAIRS.—None seen.

MACROHAIRS.—Infrequent; costal and intercostal; basal cells slightly raised (Plate 14*f*).

SPECIAL FEATURES.—Large protrusions occurring in a row in the midintercostal region (may be silicified papillae) (Plate 14*a*).

Tribe ORYZEAE

Leersia hexandra Swartz

PLATES 15–16

ABAXIAL

STOMATA.—Common; triangular; 2 stomatal bands/intercostal zone, 1 row/band; each subsidiary cell has a pair of papillae (Plate 15*a,b*).

INTERSTOMATAL CELLS.—Rectangular; ends markedly or sometimes slightly concave; outline of walls obscured by wax. *Papillae*: Many, irregular, globose, variable (Plate 15*b*).

LONG CELLS.—Long, narrow, width uniform; outline of walls obscured by wax. *Papillae*: Many, irregular to occurring in 1 or 2 rows, globose, variable. In the midregion of the intercostal zone, on either side of a groove, there are several rows of long cells with very large papillae (Plate 15*a,c*).

PRICKLES.—Common; costal prickles. Prickles are very large and robust; often the pointed tip is broken off, prickle then resembles a large papilla (Plate 15*d*).

SHORT CELLS.—Costal >5 /row; intercostal not seen. *Silica Cells*: Costal abundant; intercostal not seen. *Cork Cells*: Costal abundant; intercostal not seen (Plate 15*e*).

SILICA BODIES.—Costal figure-eight or sometimes cross-shaped; intercostal not seen (Plate 15*e*).

MICROHAIRS.—Common; two-celled; basal and apical equal in length, medium or sometimes

apical slightly longer; apex rounded (usually deflated) (Plate 15*f*).

MACROHAIRS.—None seen.

ADAXIAL

STOMATA.—Abundant; triangular; 2 stomatal bands/intercostal zone, 1 row/band; each subsidiary cell has a pair of papillae (Plate 16*a,b*).

INTERSTOMATAL CELLS.—Square to rectangular; ends markedly concave; wax obscures outline of cell walls. *Papillae*: Many, irregular, globose, uniform (Plate 16*b*).

LONG CELLS.—Long, narrow, width uniform; wax obscures outline of cell walls. *Papillae*: Many, irregular, globose, uniform (Plate 16*c*).

PRICKLES.—Common; costal prickles; intercostal hooks; hooks usually with a ring of papillae around base (Plate 16*c,d*).

SHORT CELLS.—Costal >5 /row; intercostal not seen. *Silica Cells*: Costal abundant; intercostal infrequent. *Cork Cells*: Costal abundant; intercostal not seen (Plate 16*e*).

SILICA BODIES.—Costal figure-eight or sometimes cross-shaped; intercostal cross-shaped (Plate 16*e*).

MICROHAIRS.—Common; two-celled; basal cell slightly shorter than the apical; nature of apex indeterminable because of deflated apical cell (Plate 16*f*).

MACROHAIRS.—None seen.

Maltebrunia leersoides Kunth

PLATES 17–18

ABAXIAL

STOMATA.—Abundant; high-dome; 1 stomatal band/intercostal zone, 1 or sometimes 2 rows/band; each subsidiary cell has a pair of papillae, one at each end of cell (Plate 17*a,b*).

INTERSTOMATAL CELLS.—Square; ends slightly concave although sometimes obscured by papillae; outline of walls indeterminable. *Papillae*: Many, irregular, globose, variable; some papillae appear compound or doubled (the forked type of Terrell and Wergin, 1979) (Plate 17*b*).

LONG CELLS.—Long, narrow, width uniform or sometimes rectangular; outline of walls indeterminate. *Papillae*: Many, irregular, globose, variable; some papillae appear compound or doubled (the forked type of Terrell and Wergin, 1979) (Plate 17f).

PRICKLES.—Abundant; costal and intercostal prickles; intercostal hooks (Plate 17e).

SHORT CELLS.—Costal >5/row; intercostal solitary. *Silica Cells*: Costal and intercostal abundant. *Cork Cells*: Costal abundant; intercostal not seen (Plate 17c,d).

SILICA BODIES.—Costal and intercostal figure-eight (Plate 17c,d).

MICROHAIRS.—Abundant; two-celled; basal and apical equal in length, long; apex indeterminate because of deflated cells (Plate 17f).

MACROHAIRS.—None seen.

ADAXIAL

STOMATA.—Abundant; high-dome; 1 stomatal band/intercostal zone, 1 or sometimes 2 rows/band; each subsidiary cell has a pair of papillae, one on each end of cell (Plate 18a,b).

INTERSTOMATAL CELLS.—Square; ends slightly concave; outline of walls indeterminate. *Papillae*: Many, irregular, globose, variable; there seem to be fewer papillae than on abaxial, and the papillae are the simple type (Plate 18b).

LONG CELLS.—Long, narrow, width uniform; outline of walls indeterminate. *Papillae*: Many, irregular, globose, variable; some long cells fairly smooth without papillae. Papillae of the simple type (Plate 18a,e).

PRICKLES.—Common; costal prickles and an occasional intercostal prickle (Plate 18e).

SHORT CELLS.—Costal >5/row; intercostal solitary. *Silica Cells*: Costal abundant; intercostal common. *Cork Cells*: Costal abundant; intercostal not seen (Plate 18c,d).

SILICA BODIES.—Costal figure-eight; intercostal figure-eight or sometimes elongated cross-shaped (Plate 18c,d).

MICROHAIRS.—Common; two-celled; basal and apical cells equal in length, long, or sometimes

apical slightly longer; nature of apex indeterminate because of deflated cells (Plate 18f).

MACROHAIRS.—None seen.

Oryza punctata Steudel

PLATES 19–20

ABAXIAL

STOMATA.—Abundant; triangular; 2 stomatal bands/intercostal zone, 2 or sometimes 1 row/band; pair of papillae on each subsidiary cell (Plate 19a,b,d).

INTERSTOMATAL CELLS.—Square to rectangular or sometimes long, narrow, width uniform; ends slightly to markedly concave; outline of walls obscured by wax. *Papillae*: Many, irregular or sometimes in rows, globose to elongate, variable (Plate 19b,d).

LONG CELLS.—Long, narrow, width uniform; outline of walls obscured by wax. *Papillae*: Many, irregular to sometimes in one or two rows, globose to elongate, variable (Plate 19b,c,d).

PRICKLES.—Abundant; costal prickles (Plate 19c).

SHORT CELLS.—Costal >5/row; intercostal solitary. *Silica Cells*: Costal abundant; intercostal common. *Cork Cells*: Costal abundant; intercostal not seen (Plate 19d,e).

SILICA BODIES.—Costal figure-eight; intercostal figure-eight or sometimes crenate-verticil or cross-shaped (Plate 19d,e).

MICROHAIRS.—Common; two-celled; basal longer, apical shorter, apex rounded (apical cell usually deflated) (Plate 19f).

MACROHAIRS.—None seen.

ADAXIAL

STOMATA.—Abundant; triangular; 2 stomatal bands/intercostal zone, 1 or sometimes 2 rows/band; pair of papillae on each subsidiary cell (Plate 20a,b).

INTERSTOMATAL CELLS.—Rectangular or sometimes square or long, narrow, width uniform; ends slightly to markedly concave; outline of

walls obscured by wax. *Papillae*: Many, irregular or sometimes in rows, globose to elongate, variable (Plate 20*b*).

LONG CELLS.—Long, narrow, width uniform; outline of walls obscured by wax. *Papillae*: Many, irregular or sometimes in rows, globose to elongate, variable (Plate 20*b,c*).

PRICKLES.—Abundant; costal prickles (Plate 20*c*).

SHORT CELLS.—Costal >5/row; intercostal solitary. *Silica Cells*: Costal abundant; intercostal common. *Cork Cells*: Costal abundant; intercostal not seen (Plate 20*d,e*).

SILICA BODIES.—Costal figure-eight; intercostal figure-eight or sometimes cross-shaped (Plate 20*d,e*).

MICROHAIRS.—Common; two-celled; basal longer, apical shorter; apex indeterminable because of deflated apical cells (Plate 20*f*).

MACROHAIRS.—None seen.

Tribe PHYLLORHACHIDEAE

Humbertochloa greenwayi C. E. Hubbard

PLATES 21–22

ABAXIAL

STOMATA.—Abundant; triangular; 2 stomatal bands/intercostal zone, 3 or sometimes 2 rows/band; bands near veins, wide space between bands (Plate 21*a,b*).

INTERSTOMATAL CELLS.—Square to rectangular; ends markedly concave; markedly sinuous, interlocking, flat or sometimes slightly raised. *Papillae*: None seen (Plate 21*b*).

LONG CELLS.—Long, narrow, width uniform; markedly sinuous, interlocking, flat or sometimes slightly raised. *Papillae*: None seen (Plate 21*a*).

PRICKLES.—Infrequent; margins only, prickles (Plate 21*e*).

SHORT CELLS.—Costal solitary, paired, 3–5/row, or >5/row; intercostal paired. *Silica Cells*:

Costal and intercostal abundant. *Cork Cells*: Costal and intercostal abundant (Plate 21*c,d*).

SILICA BODIES.—Costal saddle-shaped or sometimes figure-eight; intercostal figure-eight (Plate 21*c,d*).

MICROHAIRS.—Abundant; two-celled; basal shorter, apical slightly longer; apex rounded (Plate 21*f*).

MACROHAIRS.—Infrequent; basal cells slightly raised; margins only (Plate 21*e*).

ADAXIAL

STOMATA.—Infrequent; triangular; stomata too infrequent to form a distributional pattern (Plate 22*b*).

INTERSTOMATAL CELLS.—Not applicable.

LONG CELLS.—Rectangular to long, narrow, width uniform; markedly sinuous, interlocking, flat or sometimes slightly raised. *Papillae*: None seen (Plate 22*a,d*).

PRICKLES.—None seen.

SHORT CELLS.—Costal solitary, paired, or >5/row; intercostal paired. *Silica Cells*: Costal and intercostal abundant. *Cork Cells*: Costal and intercostal abundant (Plate 22*c,d,e*).

SILICA BODIES.—Costal and intercostal saddle-shaped and figure-eight (Plate 22*c,d,e*).

MICROHAIRS.—None seen.

MACROHAIRS.—Infrequent; marginal only, basal cells absent (Plate 22*f*).

Phyllorhachis sagittata Trimen

PLATES 23–24

ABAXIAL

STOMATA.—Abundant; triangular; 1 stomatal band/intercostal zone, 2 or sometimes 1 row/band (Plate 23*a,b,c*).

INTERSTOMATAL CELLS.—Rectangular to long, narrow, width uniform; ends slightly or sometimes markedly concave; markedly sinuous, inter-

locking, flat or sometimes slightly raised. *Papillae*: None seen (Plate 23*b*).

LONG CELLS.—Rectangular to long, narrow, width uniform; markedly sinuous, interlocking, flat or sometimes slightly raised. *Papillae*: None seen (Plate 23*b*).

PRICKLES.—None seen.

SHORT CELLS.—Costal solitary or paired; intercostal solitary. *Silica Cells*: Costal and intercostal abundant. *Cork Cells*: Costal abundant; intercostal not seen (Plate 23*d,e*).

SILICA BODIES.—Costal cross-shaped; intercostal crescent-shaped or sometimes tall and narrow or figure-eight (Plate 23*d,e*).

MICROHAIRS.—Abundant; two-celled; basal shorter, apical longer; apex rounded (often deflated) (Plate 23*f*).

MACROHAIRS.—None seen.

ADAXIAL

STOMATA.—Common; triangular; 1 or sometimes 2 stomatal bands/intercostal zone, 1 row/band (Plate 24*a*).

INTERSTOMATAL CELLS.—Rectangular to long, narrow, width uniform; ends slightly concave; markedly sinuous, interlocking, flat or sometimes slightly raised. *Papillae*: None seen (Plate 24*a*).

LONG CELLS.—Rectangular to long, narrow, width uniform; markedly sinuous, interlocking, flat or sometimes slightly raised. *Papillae*: None seen.

PRICKLES.—Infrequent, marginal prickles (Plate 24*e*).

SHORT CELLS.—Costal solitary, 3–5/row, or >5/row; intercostal solitary. *Silica Cells*: Costal and intercostal common. *Cork Cells*: Costal common; intercostal not seen (Plate 24*b,c,d*).

SILICA BODIES.—Costal cross-shaped or sometimes saddle-shaped; intercostal tall and narrow, saddle-shaped, or crescent-shaped (Plate 24*b,c,d*).

MICROHAIRS.—Common; two-celled; basal shorter, apical longer; apex rounded (Plate 24*f*).

MACROHAIRS.—None seen.

Tribe EHRHARTEAE

Ehrharta erecta (Lamarck) var. *abyssinica* (Hochstetter) Pilger

PLATES 25–26

ABAXIAL

STOMATA.—Common or sometimes infrequent; low-dome (often collapsed); 2 stomatal bands/intercostal zone, 1 row/band (Plate 25*a,b*).

INTERSTOMATAL CELLS.—Rectangular to long, narrow, width uniform (often collapsed); ends straight to convex or slightly concave, nonsinuous. *Papillae*: None seen (Plate 25*b*).

LONG CELLS.—Long, narrow, width nonuniform (may be an artifact due to collapse of cell) or sometimes uniform near margin; nonsinuous or sometimes slightly sinuous near margin. *Papillae*: None seen (Plate 25*a,f*).

PRICKLES.—Common; costal prickles (Plate 25*c,e,f*).

SHORT CELLS.—Costal 3–5 or >5/row; intercostal not seen. *Silica Cells*: Costal abundant; intercostal not seen. *Cork Cells*: Costal and intercostal not seen (silica cells appear to be in rows without alternating cork cells) (Plate 25*c,d*).

SILICA BODIES.—Costal dumbbell, ends concave, middle narrow, short (often appearing saddle-shaped because of indistinct middle portion); intercostal not seen (Plate 25*c,d*).

MICROHAIRS.—Infrequent; two-celled; basal shorter, apical longer; apex rounded to tapered (usually collapsed) (Plate 25*e*, arrow).

MACROHAIRS.—Infrequent; costal, near margin only; basal cells slightly raised or absent (Plate 25*f*).

ADAXIAL

STOMATA.—Common; low-dome (often collapsed); 2 or 3 stomatal bands/intercostal zone, 1–3 rows/band (Plate 26*a*).

INTERSTOMATAL CELLS.—Square to rectangular, sometimes long, narrow, width uniform; ends

straight to convex; nonsinuous (often collapsed). *Papillae*: None seen (Plate 26a).

LONG CELLS.—Rectangular to long, narrow, width uniform to nonuniform; nonsinuous (often collapsed). *Papillae*: None seen (Plate 26a,c).

PRICKLES.—Common; costal prickles, or costal prickles and intercostal prickle-type structures ranging from prickles to short macrohairs (see "Macrohairs" below) (Plate 26e,f).

SHORT CELLS.—Costal >5/row; intercostal not seen. *Silica Cells*: Costal abundant; intercostal not seen. *Cork Cells*: Costal and intercostal not seen (Plate 26c).

SILICA BODIES.—Costal dumbbell, ends concave, middle narrow, short (often appearing saddle-shaped because of indistinct middle portion); intercostal not seen (Plate 26c).

MICROHAIRS.—Infrequent to common; two-celled; basal shorter, apical longer; apex tapered (Plate 26d).

MACROHAIRS.—Infrequent; restricted to margin or restricted to costal and marginal areas; basal cells slightly raised (occasional "macro-prickles," somewhat intermediate between prickle and macrohair, in intercostal zone) (Plate 26e,f).

Tribe ARUNDINEAE

Phragmites mauritianus Kunth

PLATES 27–28

ABAXIAL

STOMATA.—Abundant; shape indeterminable because of curly wax deposits; 2 bands/intercostal zone, 3–6 rows/band (Plate 27a,b).

INTERSTOMATAL CELLS.—Square to rectangular; ends and outline of walls obscured by wax. *Papillae*: None seen (Plate 27b).

LONG CELLS.—Square, rectangular to long, narrow, width uniform; outline of walls obscured by wax. *Papillae*: None seen. A double row of square to rectangular long cells in middle of intercostal zone; long cells adjacent to veins long, narrow, width uniform, alternating with silica cells (Plate 27a,d).

PRICKLES.—Infrequent; intercostal hooks, marginal prickles (Plate 27e).

SHORT CELLS.—Costal >5/row, paired; intercostal solitary. *Silica Cells*: Costal abundant; intercostal infrequent to common. *Cork Cells*: Costal abundant; intercostal not seen (Plate 27c,d).

SILICA BODIES.—Costal and intercostal saddle-shaped (Plate 27c,d).

MICROHAIRS.—Infrequent to common; two-celled; basal longer, apical shorter; apex rounded; basal 5 to 6 times as long as apical (Plate 27f).

MACROHAIRS.—None seen.

ADAXIAL

STOMATA.—Abundant; shape indeterminable because of wax; 1 band/intercostal zone, 16–18 rows/band; stomatal band covers entire intercostal zone (Plate 28a,b).

INTERSTOMATAL CELLS.—Square to rectangular; ends and outline of walls obscured by wax. *Papillae*: None seen (Plate 28c).

LONG CELLS.—Rectangular to long, narrow, width uniform; outline of walls obscured by wax. *Papillae*: None seen. Long cells seem to occur in 1 or 2 rows (alternating with silica cells) adjacent to veins (Plate 28a).

PRICKLES.—Common; costal prickles; intercostal hooks infrequent along sides of veins (Plate 28d).

SHORT CELLS.—Costal and intercostal paired (?). *Silica Cells*: Costal and intercostal infrequent to common. *Cork Cells*: Costal and intercostal infrequent to common (Plate 28e).

SILICA BODIES.—Costal and intercostal saddle-shaped (Plate 28e).

MICROHAIRS.—Infrequent; two-celled; basal longer, apical shorter; apex rounded; basal 4 to 5 times as long as apical (Plate 28f).

MACROHAIRS.—None seen.

Tribe DANTHONIEAE

Asthenatherum glaucum (Nees) Nevski

PLATES 29–30

ABAXIAL

STOMATA.—Common; low-dome to triangular; 1 stomatal band/intercostal zone, 2 or 3 rows/

band; often in grooves and somewhat obscured by overarching prickles (Plate 29a,b).

INTERSTOMATAL CELLS.—Rectangular to long, narrow, width uniform; ends slightly concave; markedly sinuous, interlocking, slightly raised. *Papillae*: None seen (Plate 29a,b).

LONG CELLS.—Long, narrow, width uniform; markedly sinuous, interlocking, slightly raised. *Papillae*: None seen (Plate 29a,f).

PRICKLES.—Abundant; costal prickles, short, stiff, macrohair-like prickles; sometimes intercostal, short, stiff, macrohair-like prickles; prickles often overarching the intercostal zone and obscuring features there (Plate 29c,e).

SHORT CELLS.—Costal paired or 3–5/row; intercostal not seen. *Silica Cells*: Costal common; intercostal not seen. *Cork Cells*: Costal common; intercostal not seen (Plate 29d).

SILICA BODIES.—Costal cross-shaped, square, or sometimes elliptical or dumbbell, ends rounded, middle wide and short; intercostal not seen (Plate 29d).

MICROHAIRS.—Infrequent; two-celled; basal longer, apical shorter; apex rounded (?), usually deflated (Plate 29f).

MACROHAIRS.—None seen.

ADAXIAL

STOMATA.—Common; low-dome to triangular; 2 stomatal bands/intercostal zone, 1 row/band; often in grooves, overarched by prickles (Plate 30a,b).

INTERSTOMATAL CELLS.—Rectangular to long, narrow, width uniform; ends slightly concave; outline of walls indeterminable. *Papillae*: None seen (Plate 30c).

LONG CELLS.—Long, narrow, width uniform; outline of walls indeterminable. *Papillae*: None seen (Plate 30c).

PRICKLES.—Abundant; costal prickles, hooks, and short, straight, stiff, macrohair-like prickles; sometimes intercostal hooks and macrohair-like prickles (Plate 30c,d).

SHORT CELLS.—Costal paired, 3–5/row, or >5/row; intercostal not seen. *Silica Cells*: Costal

common, intercostal not seen. *Cork Cells*: Costal common, intercostal not seen (Plate 30e).

SILICA BODIES.—Costal cross-shaped, square, or dumbbell, ends rounded, middle wide and short; intercostal not seen (Plate 30e).

MICROHAIRS.—Infrequent; two-celled; basal longer, apical shorter; apex rounded (Plate 30f).

MACROHAIRS.—None seen.

Crinipes abyssinicus Hochstetter

PLATES 31–32

ABAXIAL

STOMATA.—Infrequent; low-dome (?), subsidiary cell collapsed and shape difficult to determine; stomata too infrequent to determine distributional pattern (Plate 31a).

INTERSTOMATAL CELLS.—Not applicable.

LONG CELLS.—Long, narrow, width uniform; markedly sinuous, interlocking, raised. *Papillae*: None seen. Surface striated; end walls raised forming a transverse ridge, central portion raised forming a longitudinal ridge (Plate 31d).

PRICKLES.—None seen.

SHORT CELLS.—Costal >5/row; intercostal solitary. *Silica Cells*: Costal abundant; intercostal not seen. *Cork Cells*: Costal and intercostal abundant (Plate 31c,d).

SILICA BODIES.—Costal nodular with 3 or 4 nodes; intercostal not seen (Plate 31c).

MICROHAIRS.—Infrequent; two-celled; basal longer, apical shorter; apex rounded (Plate 31f).

MACROHAIRS.—None seen.

ADAXIAL

STOMATA.—Abundant; high-dome; 2 stomatal bands/intercostal zone, 2 or 3 rows/band; bands adjacent to veins with broad intercostal area without stomata (Plate 32a,b).

INTERSTOMATAL CELLS.—Rectangular or sometimes square; ends slightly concave; outline of walls indeterminable. *Papillae*: None seen, surface striated (Plate 32a,b).

LONG CELLS.—Long, narrow, width uniform,

or rectangular, pentagonal, or sometimes square or hexagonal; outline of walls indeterminable. *Papillae*: None seen. Surface striated; edges of cells raised to form prominent ridges (Plate 32c,e).

PRICKLES.—Common; costal prickles (Plate 32c).

SHORT CELLS.—Costal >5/row; intercostal not seen. *Silica Cells*: Costal abundant; intercostal not seen. *Cork Cells*: Costal abundant; intercostal not seen (Plate 32c).

SILICA BODIES.—Costal nodular, nodes 4 or sometimes 3; intercostal not seen (Plate 32c).

MICROHAIRS.—Infrequent; two-celled; basal shorter, apical longer; apex rounded (Plate 32f).

MACROHAIRS.—Infrequent; intercostal; basal cells markedly raised (Plate 32d).

Elytrophorus globularis Hackel

PLATES 33-34

ABAXIAL

STOMATA.—Abundant; low-dome; 1-2 stomatal bands/intercostal zone, 1-4 rows/band; stomata often difficult to see because of collapsed cells (Plate 33a).

INTERSTOMATAL CELLS.—Long, narrow, width uniform; ends markedly concave; nonsinuous. *Papillae*: Many tiny papillae giving the surface a warty appearance (Plate 33a-c).

LONG CELLS.—Long, narrow, width uniform; nonsinuous. *Papillae*: Many tiny papillae giving surface a warty appearance (Plate 33d).

PRICKLES.—Infrequent; primarily marginal (Plate 33b).

SHORT CELLS.—Costal >5/row; intercostal not seen. *Silica Cells*: Costal abundant; intercostal not seen. *Cork Cells*: Costal abundant; intercostal not seen (Plate 33c,e).

SILICA BODIES.—Costal nodular; intercostal not seen (Plate 33c,e).

MICROHAIRS.—Common; two-celled; basal shorter, apical much longer; apex tapered (Plate 33e,f).

MACROHAIRS.—None seen.

ADAXIAL

STOMATA.—Common; low-dome; 2 stomatal bands/intercostal zone, 3-4 rows/band; bands adjacent to veins with broad region of long cells in between (Plate 34a).

INTERSTOMATAL CELLS.—Long, narrow, width appearing nonuniform (may be an artifact caused by collapsed cells); ends slightly concave; nonsinuous. *Papillae*: Many tiny papillae giving surface a warty texture; warty texture often obscured by wax (Plate 34b,c).

LONG CELLS.—Rectangular to long, narrow, width nonuniform (perhaps due to collapsed cells); nonsinuous. *Papillae*: Many tiny papillae giving surface a warty texture (Plate 34c,d).

PRICKLES.—Common; costal prickles; intercostal not seen (Plate 34b,c).

SHORT CELLS.—Costal >5/row; intercostal not seen. *Silica Cells*: Costal abundant; intercostal not seen. *Cork Cells*: Costal abundant; intercostal not seen (Plate 34e).

SILICA BODIES.—Costal nodular; intercostal not seen (Plate 34e).

MICROHAIRS.—Infrequent; two-celled; basal shorter, apical much longer; apex tapered (Plate 34f).

MACROHAIRS.—None seen.

Elytrophorus spicatus (Willdenow) A. Camus shows remarkable similarity to this species, the major difference being the apparent absence of the tiny papillae giving the surface a smooth rather than warty texture. The specimen observed was very waxy, and the wax may obscure the papillae.

Habrochloa bullockii Hubbard

PLATES 35-36

ABAXIAL

STOMATA.—None seen.

LONG CELLS.—Long, narrow, width uniform; slightly sinuous. *Papillae*: None seen (Plate 35a,b).

PRICKLES.—Infrequent to common; costal prickles (Plate 35*a,c*).

SHORT CELLS.—Costal >5/row; intercostal not seen. *Silica Cells*: Costal abundant; intercostal not seen. *Cork Cells*: Costal abundant; intercostal not seen (Plate 35*d,e*).

SILICA BODIES.—Costal dumbbell, ends rounded, middle narrow, long or sometimes nodular with three lobes; intercostal not seen (Plate 35*d,e*).

MICROHAIRS.—Infrequent; two-celled; basal and apical equal in length, medium (Plate 35*f*).

MACROHAIRS.—None seen.

ADAXIAL

STOMATA.—Infrequent; high-dome; 3 stomatal bands/intercostal zone, 1 row/band (Plate 36*b,c*).

INTERSTOMATAL CELLS.—Rectangular to long, narrow, width uniform to nonuniform (cells often collapsed and difficult to ascertain width); ends straight to convex; nonsinuuous. *Papillae*: None seen (Plate 36*b,c*).

LONG CELLS.—Long, narrow, width uniform to nonuniform (cells often collapsed); nonsinuuous. *Papillae*: None seen (Plate 36*c*).

PRICKLES.—Common; costal prickles; infrequent, intercostal bicellular prickles (Plate 36*d,e*).

SHORT CELLS.—Costal >5/row; intercostal not seen. *Silica Cells*: Costal abundant; intercostal not seen. *Cork Cells*: Costal abundant; intercostal not seen (Plate 36*d*).

SILICA BODIES.—Costal dumbbell, ends concave, middle wide, long and short; intercostal not seen (Plate 36*e*).

MICROHAIRS.—Common; two-celled; basal and apical equal in length, medium, or basal shorter, apical longer (apical often collapsed); apex indeterminate, apical cell collapsed (Plate 36*f*).

MACROHAIRS.—None seen.

Neyraudia arundinacea (Linnaeus) Henrard

PLATES 37–38

ABAXIAL

STOMATA.—Abundant; low-dome; 2 stomatal bands/intercostal zone, 1 or sometimes 2 rows/band (Plate 37*a,b*).

INTERSTOMATAL CELLS.—Rectangular to long, narrow, width uniform; ends slightly concave; outline of walls obscured by wax. *Papillae*: None seen (Plate 37*c*).

LONG CELLS.—Long, narrow, width uniform; outline of walls obscured by wax. *Papillae*: None seen (Plate 37*d*).

PRICKLES.—Common; costal prickles (Plate 37*c*).

SHORT CELLS.—Costal >5/row; intercostal paired. *Silica Cells*: Costal common; intercostal infrequent. *Cork Cells*: Costal common; intercostal infrequent (Plate 37*d,e*).

SILICA BODIES.—Costal saddle-shaped or sometimes cross-shaped; intercostal saddle-shaped (Plate 37*d,e*).

MICROHAIRS.—Common; two-celled; basal longer, apical shorter; apex rounded (Plate 37*f*).

MACROHAIRS.—None seen.

ADAXIAL

STOMATA.—Common; low-dome, 2 stomatal bands/intercostal zone, 1–2 rows/band (Plate 38*a,b*).

INTERSTOMATAL CELLS.—Square to rectangular; ends straight to convex or slightly concave; outline of walls obscured by wax. *Papillae*: None seen (Plate 38*a,b*).

LONG CELLS.—Rectangular to long, narrow, width uniform; nature of walls obscured by wax. *Papillae*: None seen (Plate 38*a,f*).

PRICKLES.—Common; costal prickles (Plate 38*c*).

SHORT CELLS.—Costal >5/row; intercostal not seen. *Silica Cells*: Costal abundant; intercostal not seen. *Cork Cells*: Costal common; intercostal not seen (Plate 38*d*).

SILICA BODIES.—Costal dumbbell, ends rounded or straight, middle wide, short; intercostal not seen (Plate 38*d*).

MICROHAIRS.—Common; two-celled; basal longer, apical shorter; apex rounded (often collapsed) (Plate 38*e*).

MACROHAIRS.—Infrequent; intercostal (Plate 38*f*).

***Pentasthictis borussica* (K. Schumann) Pilger**

PLATES 39-40

ABAXIAL

STOMATA.—None seen.

LONG CELLS.—Long, narrow, width uniform; markedly sinuous, interlocking, slightly raised. *Papillae*: None seen (Plates 39a,e).

PRICKLES.—None seen.

SHORT CELLS.—Costal >5 /row, paired; intercostal solitary or paired. *Silica Cells*: Costal abundant; intercostal infrequent. *Cork Cells*: Costal abundant; intercostal infrequent (Plate 39a,b).

SILICA BODIES.—Costal dumbbell, ends rounded, middle wide and short, or sometimes square or elliptical (Plate 39a-c).

MICROHAIRS.—Common; two-celled; basal longer, apical shorter (basal 7 or more times as long); apex tapered (Plate 39e).

MACROHAIRS.—Abundant; basal cells markedly raised (Plate 39f).

Pentasthictis minor (Ballard and Hubbard) Ballard and Hubbard was also observed, and the features are remarkably similar to *P. borussica*. The obvious difference is the common occurrence of paired or solitary short cells in the intercostal zone (Plate 39d). The cells at the base of the macrohairs in *P. minor* are only slightly raised in contrast to the markedly raised cells described above.

ADAXIAL

STOMATA.—Common; low-dome; 1 stomatal band/intercostal zone, 1 or 2 rows/band (Plate 40a,b).

INTERSTOMATAL CELLS.—Square to rectangular; ends slightly concave; outline of walls indistinguishable because of wax. *Papillae*: None seen (Plate 40a).

LONG CELLS.—Long, narrow, width uniform or sometimes rectangular to pentagonal; markedly sinuous, interlocking, slightly raised. *Papillae*: None seen (Plate 40b,f).

PRICKLES.—Infrequent; costal prickles (Plate 40c).

SHORT CELLS.—Costal 3-5/row or >5 /row; intercostal paired. *Silica Cells*: Costal abundant; intercostal infrequent (near margins only). *Cork Cells*: Costal abundant; intercostal infrequent (near margins only) (Plate 40d,e).

SILICA BODIES.—Costal nodular or dumbbell, ends rounded, middle wide and short; intercostal (margins only) dumbbell, ends rounded, middle wide and short (Plate 40d,e).

MICROHAIRS.—Abundant; two-celled; basal longer, apical shorter (basal 7 or more times as long); apex tapered (Plate 40f).

MACROHAIRS.—None seen.

The adaxial of *P. minor* is very similar to *P. borussica* except that no intercostal short cells were seen. The intercostal zone of *P. minor* has a few large, straight, stiff prickles that resemble short macrohairs.

***Triraphis schinzii* Hackel**

PLATES 41-42

ABAXIAL

STOMATA.—Common; triangular; 1 stomatal band/intercostal zone, 3-4 rows/band; intercostal zone very narrow (Plate 41a-c).

INTERSTOMATAL CELLS.—Long, narrow, width uniform; ends slightly to markedly concave; markedly sinuous, interlocking, raised. *Papillae*: None seen (Plate 41c).

LONG CELLS.—Long, narrow, width uniform; markedly sinuous, interlocking, raised. *Papillae*: None seen (Plate 41a).

PRICKLES.—None seen.

SHORT CELLS.—Costal >5 /row; intercostal not seen. *Silica Cells*: Costal common; intercostal not seen. *Cork Cells*: Costal common; intercostal not seen (Plate 41d).

SILICA BODIES.—Costal dumbbell, ends concave or sometimes straight, middle wide, short; intercostal not seen (Plate 41d,e).

MICROHAIRS.—Common; two-celled; basal

longer, apical shorter; apex tapered; occur in rows on each side of veins (Plate 41f).

MACROHAIRS.—None seen.

ADAXIAL

STOMATA.—Common; triangular (shape sometimes indistinct because of wax); 2 stomatal bands/intercostal zone, 2 or sometimes 1 row/band (Plate 42a,b).

INTERSTOMATAL CELLS.—Rectangular to long, narrow, width uniform; ends slightly concave; slightly to markedly sinuous; outline of walls indistinct because of wax. *Papillae*: None seen (Plate 42a,c).

LONG CELLS.—Long, narrow, width uniform; slightly to markedly sinuous; outline of walls indistinct because of wax. *Papillae*: None seen (Plate 42a).

PRICKLES.—Infrequent; costal prickles; common near margins (Plate 42d,f).

SHORT CELLS.—Costal >5/row; intercostal not seen. *Silica Cells*: Costal abundant; intercostal not seen. *Cork Cells*: Costal abundant; intercostal not seen (Plate 42a,c,d).

SILICA BODIES.—Costal dumbbell, ends concave or sometimes straight, middle wide, short or sometimes long; intercostal not seen (Plate 42c,d).

MICROHAIRS.—Abundant; two-celled; basal longer, apical slightly shorter to basal and apical equal in length; apex tapered (Plate 42e).

MACROHAIRS.—None seen.

Tribe CENTOSTECEAE

Bromuniola gossweileri Stapf and C. E. Hubbard

PLATES 43-44

ABAXIAL

STOMATA.—Common; triangular; 2 stomatal bands/intercostal zone, 2 rows/band; bands adjacent to veins, fairly wide region of long cells between bands (Plate 43b).

INTERSTOMATAL CELLS.—Rectangular to long,

narrow, width uniform; ends slightly concave; markedly sinuous, interlocking, raised. *Papillae*: Many, irregular, globose, variable, extremely small giving surface a warty texture (Plate 43b).

LONG CELLS.—Long, narrow, width uniform; markedly sinuous, interlocking, raised. *Papillae*: Many, irregular, globose, variable, extremely small giving surface a warty texture (Plate 43a).

PRICKLES.—Common; intercostal prickles (Plate 43a).

SHORT CELLS.—Costal >5/row; intercostal infrequent (?). *Silica Cells*: Costal common; intercostal not seen. *Cork Cells*: Costal common; intercostal infrequent (?) (Plate 43c).

SILICA BODIES.—Costal dumbbell, ends rounded or sometimes straight, middle narrow, short; intercostal not seen (Plate 43c).

MICROHAIRS.—Infrequent; two-celled; basal shorter, apical longer; apex rounded; demarcation between basal and apical cells usually indistinct (Plate 43d).

MACROHAIRS.—Infrequent; intercostal; basal cells markedly raised (Plate 43e).

SPECIAL FEATURES.—Transverse veins present (Plate 43f).

ADAXIAL

STOMATA.—Infrequent; triangular; 1-2 stomatal bands/intercostal zone, 1 row/band (Plate 44a).

INTERSTOMATAL CELLS.—Rectangular to long, narrow, width uniform; ends straight to convex or slightly concave; markedly sinuous, interlocking, raised. *Papillae*: Some irregular, globose, variable, extremely small (surface features less distinct than on abaxial because of wax) (Plate 44a).

LONG CELLS.—Long, narrow, width uniform or sometimes rectangular; markedly sinuous, interlocking, raised. *Papillae*: Some irregular, globose, variable, extremely small (surface features less distinct than on abaxial because of wax) (Plate 44b,c).

PRICKLES.—Common; intercostal prickles and hooks (Plate 44a,c).

SHORT CELLS.—Costal >5 /row; intercostal not seen. *Silica Cells*: Costal common; intercostal not seen. *Cork Cells*: Costal common; intercostal not seen (Plate 44*d*).

SILICA BODIES.—Costal dumbbell, ends straight to concave, middle wide, short (Plate 44*d*).

MICROHAIRS.—Infrequent; two-celled; basal shorter, apical longer; apex rounded; demarcation between basal and apical cells usually indistinct (Plate 44*e*).

MACROHAIRS.—Common; intercostal; basal cells markedly raised (Plate 44*f*).

Megastachya mucronata (Poiret) P. Beauvois

PLATES 45-46

ABAXIAL

STOMATA.—Abundant; triangular; 6 or sometimes 5 stomatal bands/intercostal zone, 2 or sometimes 1 row/band (Plate 45*a,b*).

INTERSTOMATAL CELLS.—Rectangular or sometimes long, narrow, width uniform; ends markedly or sometimes slightly concave; markedly to slightly sinuous, interlocking, flat. *Papillae*: Many, irregular, globose, variable, extremely small giving surface a warty texture (Plate 45*c*).

LONG CELLS.—Long, narrow, width uniform; markedly sinuous, interlocking, flat. *Papillae*: Many, irregular, globose, variable, extremely small giving surface a warty texture (Plate 45*c*).

PRICKLES.—Infrequent; on or near margin only.

SHORT CELLS.—Costal >5 /row; intercostal not seen. *Silica Cells*: Costal abundant; intercostal not seen. *Cork Cells*: Costal abundant; intercostal not seen (Plate 45*d*).

SILICA BODIES.—Costal dumbbell, ends straight or sometimes concave, middle wide and short; intercostal not seen (Plate 45*d*).

MICROHAIRS.—Common; two-celled; basal shorter, apical longer; apex rounded (Plate 45*e*).

MACROHAIRS.—None seen.

SPECIAL FEATURES.—Transverse veins present (Plate 45*f*).

ADAXIAL

STOMATA.—Abundant; triangular; 2 or 3 stomatal bands/intercostal zone, 1 or 2 rows/band; bands adjacent to veins (Plate 46*a*).

INTERSTOMATAL CELLS.—Rectangular to long, narrow, width uniform; ends markedly concave; markedly sinuous, interlocking, raised. *Papillae*: Many, irregular, globose, variable, extremely small giving surface a warty texture (Plate 46*b*).

LONG CELLS.—Rectangular to long, narrow, width uniform; markedly sinuous, interlocking, raised or sometimes flat. *Papillae*: Many, irregular, globose, variable, extremely small giving surface a warty texture (Plate 46*c*).

PRICKLES.—Common; intercostal, appearing bicellular (Plate 46*d*).

SHORT CELLS.—Costal >5 /row; intercostal solitary (?). *Silica Cells*: Costal abundant; intercostal not seen. *Cork Cells*: Costal abundant; intercostal common (?) (Plate 46*a,e*).

SILICA BODIES.—Costal dumbbell, ends straight, middle wide and short; intercostal not seen (Plate 46*e*).

MICROHAIRS.—Infrequent; two-celled; basal shorter, apical longer; apex rounded (?); basal cell appears to be sunken; apical cell tip often broken (Plate 46*f*).

MACROHAIRS.—None seen.

Orthoclada africana Hubbard

PLATES 47-48

ABAXIAL

STOMATA.—Common; triangular; 2 stomatal bands/intercostal zone, 2 or sometimes 1 or 3 rows/band, an occasional stoma outside rows; bands adjacent to veins, wide space between bands (Plate 47*a,b*).

INTERSTOMATAL CELLS.—Square to rectangular; ends slightly concave; slightly sinuous, interlocking, flat. *Papillae*: Many, irregular, globose, variable, extremely small giving surface a warty texture (Plate 47*a,b*).

LONG CELLS.—Rectangular; slightly sinuous,

interlocking, flat. *Papillae*: Many, irregular, globose, variable, extremely small giving surface a warty texture (Plate 47*d,e*).

PRICKLES.—None seen.

SHORT CELLS.—Costal >5/row; intercostal solitary. *Silica Cells*: Costal common; intercostal infrequent. *Cork Cells*: Costal common; intercostal not seen (?) (Plate 47*c,d*).

SILICA BODIES.—Costal dumbbell, ends straight to concave, middle wide and short; intercostal crenate-vertical, sometimes cross-shaped, figure-eight, or irregular (Plate 47*c,d*).

MICROHAIRS.—Abundant; two-celled; basal and apical equal in length, medium, or sometimes basal slightly longer than apical, long; apex tapered (Plate 47*d*).

MACROHAIRS.—Infrequent; intercostal; basal cells slightly raised; macrohairs short; ends curved like a fish-hook (Plate 47*e*).

SPECIAL FEATURES.—Transverse veins present (Plate 47*f*).

ADAXIAL

STOMATA.—Infrequent; triangular; too few stomata to form a distributional pattern; those few observed adjacent to veins (Plate 48*a*).

INTERSTOMATAL CELLS.—Rectangular; ends straight to slightly concave; slightly sinuous, interlocking, flat. *Papillae*: Many, irregular, globose, variable, extremely small giving surface a warty texture (Plate 48*a*).

LONG CELLS.—Square to rectangular; slightly sinuous, interlocking, flat. *Papillae*: Many, irregular, globose, variable, extremely small giving surface a warty texture (Plate 48*b*).

PRICKLES.—None seen.

SHORT CELLS.—Costal >5/row; intercostal not seen. *Silica Cells*: Costal common; intercostal not seen. *Cork Cells*: Costal common; intercostal not seen (Plate 48*c*).

SILICA BODIES.—Costal dumbbell, ends straight to concave, middle wide and short; intercostal not seen (Plate 48*c*).

MICROHAIRS.—Infrequent; two-celled; basal and apical equal in length, medium; apex tapered (Plate 48*d*).

MACROHAIRS.—Infrequent; intercostal; basal cells slightly raised; macrohairs short; ends curved like a fish-hook (Plate 48*e*).

SPECIAL FEATURES.—Transverse veins present (Plate 48*f*).

Appendix

Material Studied

(Asterisk indicates taxa treated in this study)

<i>Species</i>	<i>Collection</i>	<i>Origin</i>	<i>Herbarium</i>
<i>Andropogon stolzii</i>	Wiehe N/293	Malawi	K
* <i>Arundinaria alpina</i>	Dummer 3508	Uganda	US
	Meyer 7750	Uganda	US
<i>Asthenatherum forskalii</i>	Mandaville 388	Saudi Arabia	US
* <i>Asthenatherum glaucum</i>	Rains & Yalala 22	Botswana	K
<i>Avena abyssinica</i>	Pappi 4901	Ethiopia	US
<i>Brachiaria brizantha</i>	Hitchcock 24884	Uganda	US
* <i>Bromuniola gossweileri</i>	Jackson 47	Rhodesia	MO
<i>Chlorocalymma crytocantha</i>	Greenway & Kanuri 13980	Tanganyika	MO
<i>Chrysochloa hindsii</i>	Lewalle 4841	Burundi	MO
<i>Cleistachne sorghoides</i>	Thomas 1325	Uganda	US
<i>Coelachne africana</i>	Schlieben 4161	Tanganyika	US
<i>Colpodium chionogeiton</i>	Wood 923	Tanzania	K
<i>Commelinidium mayumbense</i>	Chandler 1859	Uganda	US
* <i>Crinipes abyssinicus</i> ¹	Gay <i>s.n.</i>	Ethiopia	US
<i>Cynodon dactylon</i>	Hitchcock 24507	Tanganyika	US
<i>Dactylis glomerata</i>	Gillett 15753	E. Jordan	US
<i>Dactyloctenium giganteum</i>	Bullock 305	Tanganyika	US
<i>Daknopholis boivinii</i>	Croat 30897	Madagascar	MO
<i>Danthoniopsis viridis</i>	Verhoon 1373	Rhodesia	US
<i>Dichanthium aristatum</i>	Eyles 2210	Rhodesia	MO
<i>Echinochloa colona</i>	de Wet 5416	Cultivated	CEL
<i>Echinochloa pyramidalis</i>	Ortaggeup 372	Soudan	US
* <i>Ehrharta erecta</i> var. <i>abyssinica</i>	Renvoize 2099	Tanzania	US
	Renvoize 2454	Tanzania	US
<i>Eleusine coracana</i>	de Wet 3833	Cultivated	CEL
* <i>Elytrophorus globularis</i>	Schweickerdt 2158	Southwest Africa	US
<i>Elytrophorus spicatus</i>	Rensburg 1905	N. Rhodesia	US
* <i>Habrochloa bullockii</i>	Webster T234	Tanganyika	MO
<i>Harpachne schimperi</i>	Milne-Redhead & Taylor 8828	Tanganyika	US
<i>Helictotrichon elongatum</i>	Liebenberg 12	Uganda	US
<i>Heteroanthoecia guineensis</i>	Simon & Williamson 1925	Zambia	MO
* <i>Humbertochloa greenwayi</i>	Wingfield 1680	Tanzania	MO
<i>Isachne buettneri</i>	Baldwin 6718	Liberia	MO
* <i>Leersia hexandra</i>	Milne-Redhead & Taylor 8664	Tanganyika	US

¹ Very similar to the East African species *C. longifolius* Hubbard, which is poorly collected and for which no material was available.

* <i>Leptaspis cochleata</i>	Shandler 2890	Uganda	US
	Brenan 8504	Nigeria	US
<i>Lepturus repens</i>	Bogdan 3642	Kenya	US
* <i>Maltebrunia leersiooides</i>	Humbert 5783	Madagascar	US
* <i>Megastachya mucronata</i>	Faden 74/345	Tanzania	MO
* <i>Neyraudia arundinacea</i>	Humbert 13042	Madagascar	US
* <i>Olyra latifolia</i>	Baldwin 10059	Liberia	US
	Clayton 623	Nigeria	US
	Faulkner 1201	Tanganyika	US
	Hitchcock 24555	Tanganyika	US
	Palmer 901	Ghana	DUKE
* <i>Oreobambos buchwaldii</i>	Thomas 3775	Uganda	K
<i>Oropetium thomaeum</i>	Olufsen 393	French Sudan	US
* <i>Orthoclada africana</i>	Paterson <i>s.n.</i>	Mwinilunga Luakera Falls, Zambia, Oct. 1937-Feb. 1938	US
<i>Oryza barthii</i>	de Wet 626	Cultivated	CEL
	de Wet 633	Cultivated	CEL
* <i>Oryza punctata</i>	Greenway 15151	Tanganyika	MO
* <i>Oxytenanthera abyssinica</i>	Snowden 1051	Uganda	US
* <i>Pentaschistis borussica</i>	Hitchcock 24629	Tanganyika	US
<i>Pentaschistis minor</i>	Hitchcock 24641	Tanganyika	US
<i>Phacelurus huillensis</i>	Webster T238	Tanzania	K
* <i>Phragmites mauritianus</i>	Hitchcock 24910	Uganda	US
	Mearns 1211	British E. Africa	US
* <i>Phyllorhachis sagittata</i>	Guy 1636	Rhodesia	MO
* <i>Puelia olyrififormis</i>	Callens 2678	French Congo	K
<i>Sacciolepis africana</i>	Thomas 4544	Uganda	US
<i>Schmidtia bulbosa</i>	Brass 17909	Malawi	US
<i>Sehima nervosum</i>	Hudson 271	Uganda	US
<i>Sorghum arundinaceum</i>	Myre 26	Mozambique	US
<i>Stipa drageana</i>	Schweickerdt 1818	S. Africa	US
* <i>Streptogyna crinita</i>	Jones, Reag, & Ono- chie 14564	Nigeria	MO
	Louis 12181	Zaire	K
<i>Trichoneura mollis</i>	Napper 550	Kenya	US
<i>Triraphis fleckii</i>	Schweickerdt 2115	S.W. Africa	US
* <i>Triraphis schinzii</i>	Schweickerdt 1859	North Transvaal	US
<i>Triticum aestivum</i>	Harshberger 1139	Algeria	US
<i>Vossia cuspidata</i>	Meyer 7503	Ethiopia	US

Literature Cited

- Clark, C. A., and F. W. Gould
1975. Some Epidermal Characteristics of Paleas of *Dichanthelium*, *Panicum*, and *Echinochloa*. *American Journal of Botany*, 62(7):743-748.
- Clayton, W. D.
1970. Gramineae, Part 1. In E. Milne-Redhead and R. M. Polhill, editors, *Flora of Tropical East Africa*, pages 1-176. London: Crown Agents for Oversea Governments and Administrations.
1974. Gramineae, Part 2. In E. Milne-Redhead and R. M. Polhill, editors, *Flora of Tropical East Africa*, pages 177-449. London: Crown Agents for Oversea Governments and Administrations.
In prep. Gramineae, Part 3. In E. Milne-Redhead and R. M. Polhill, editors, *Flora of Tropical East Africa*. London: Crown Agents for Oversea Governments and Administrations.
- Jacques-Félix, H.
1962. Les Graminées d'Afrique tropicale, I: Generalités, classification, description des genres. *Bulletin Scientifique D'Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières*, 8: xi + 345 pages.
- Livingstone, D. A., and W. D. Clayton
1980. An Altitudinal Cline in Tropical African Grass Floras and Its Paleocological Significance. *Quaternary Research*, 13:392-402.
- Metcalf, C. R.
1960. *Anatomy of the Monocotyledons, I: Gramineae*. lxi + 731 pages. London: Oxford University Press.
- Palmer, P. G.
1976. Grass Cuticles: A New Paleocological Tool for East African Lake Sediments. *Canadian Journal of Botany*, 54(15):1725-1734.
- Prat, H.
1932. L'Épiderme des graminées: Etude anatomique et systématique. *Annales des Sciences Naturelles, Botanique*, series 10, 14:117-324.
1936. La Systématique des Graminées. *Annales des Sciences Naturelles, Botanique*, series 10, 18:165-258.
- Soderstrom, T. R., and H. F. Decker
1973. *Calderonella*, a New Genus of Grasses and Its Relationships to the Centostecoid Genera. *Annals of the Missouri Botanical Garden*, 60(2):427-441.
- Stewart, D.R.M.
1965a. The Epidermal Characters of Grasses, with Special Reference to East African Plains Species, Part 1. *Botanische Jahrbücher*, 84(1):63-116.
1965b. The Epidermal Characters of Grasses, with Special Reference to East African Plains Species, Part 2. *Botanische Jahrbücher*, 84(2):117-173.
- Tateoka, T., S. Inoue, and S. Kawano
1959. Notes on Some Grasses, IX: Systematic Significance of Bicellular Microhairs of Leaf Epidermis. *Botanical Gazette*, 121(2):80-91.
- Terrell, E. E., and W. P. Wergin
1979. Scanning Electron Microscopy and Energy Dispersive X-Ray Analysis of Leaf Epidermis in *Zizania* (Gramineae). *Scanning Electron Microscopy*, 3: 81-88.

Plates

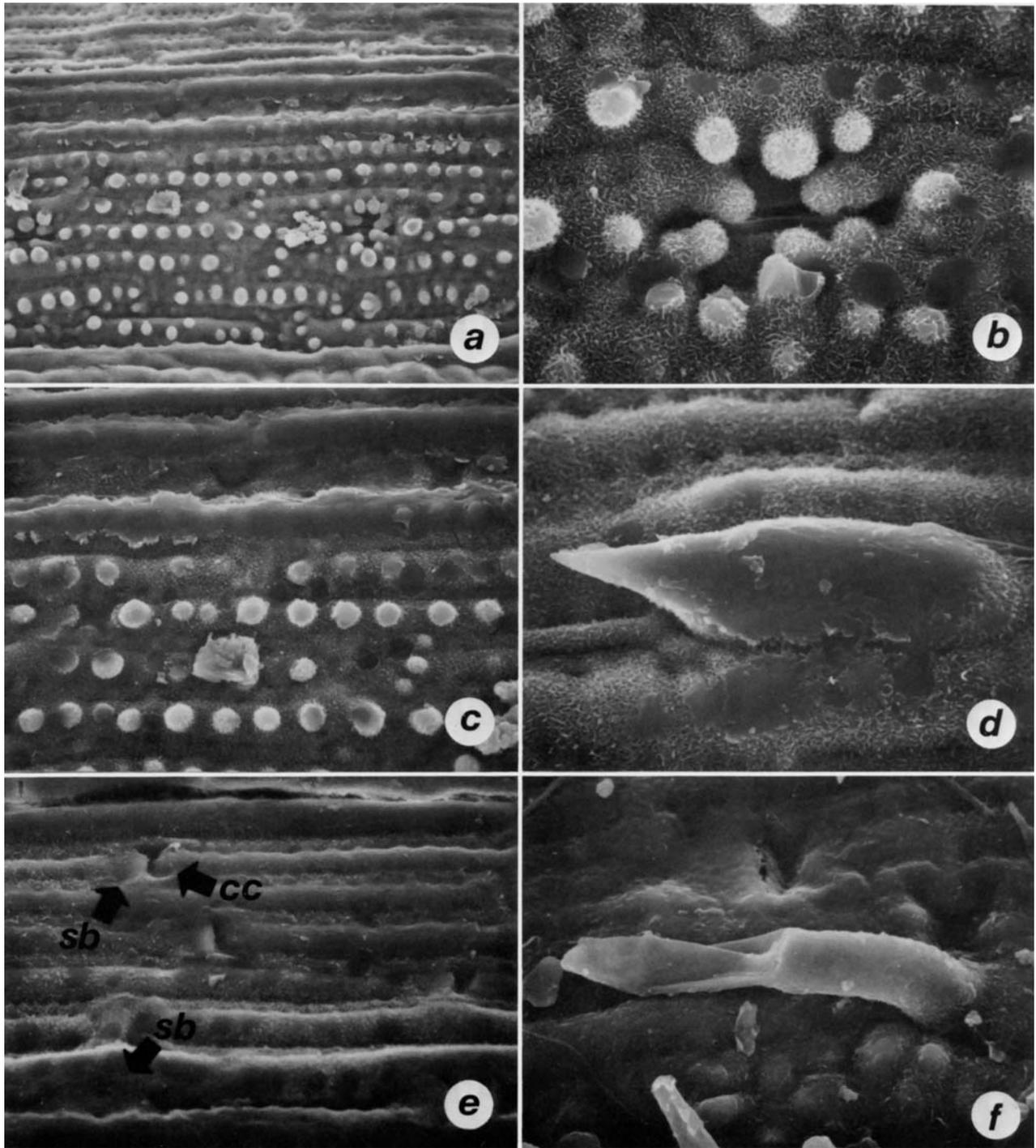


PLATE 1.—Abaxial epidermis *Arundinaria alpina*, Dummer 3508: *a*, overview, $\times 416$; *b*, stoma with overarching papillae, $\times 1696$; *c*, papillate long cells, $\times 867$; *d*, prickle, $\times 1696$; *e*, intercostal silica bodies (sb), cork cells (cc) and costal silica body (sb), $\times 867$; *f*, microhair, $\times 1696$.

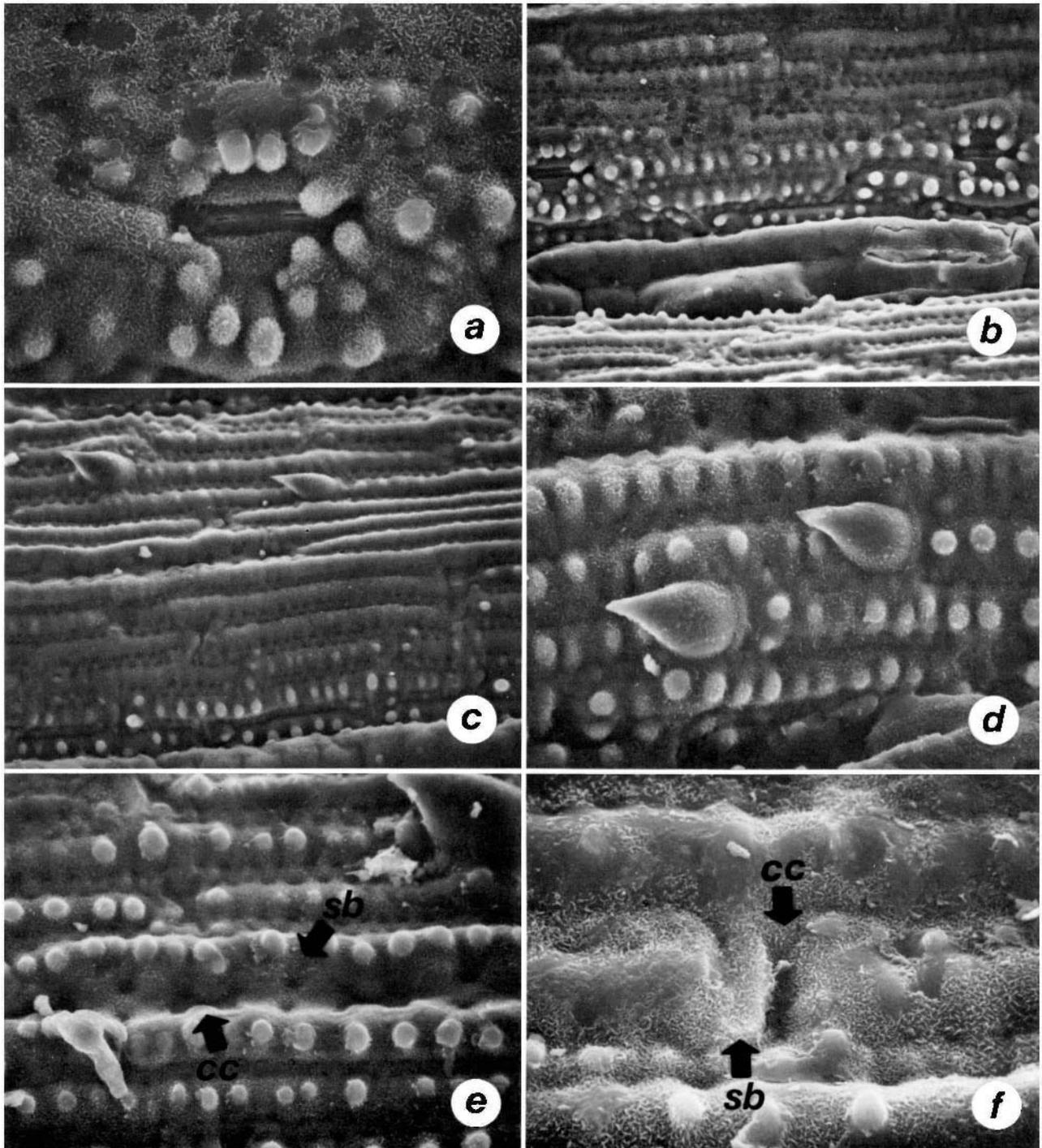


PLATE 2.—Adaxial epidermis *Arundinaria alpina*, Dummer 3508: *a*, stoma, $\times 1285$; *b*, overview, interstomatal cell, $\times 416$; *c*, long cells, $\times 416$; *d*, intercostal prickles, $\times 867$; *e*, costal silica bodies (sb) and cork cells (cc), $\times 867$; *f*, intercostal cork cell (cc) and silica body (sb), $\times 1696$.

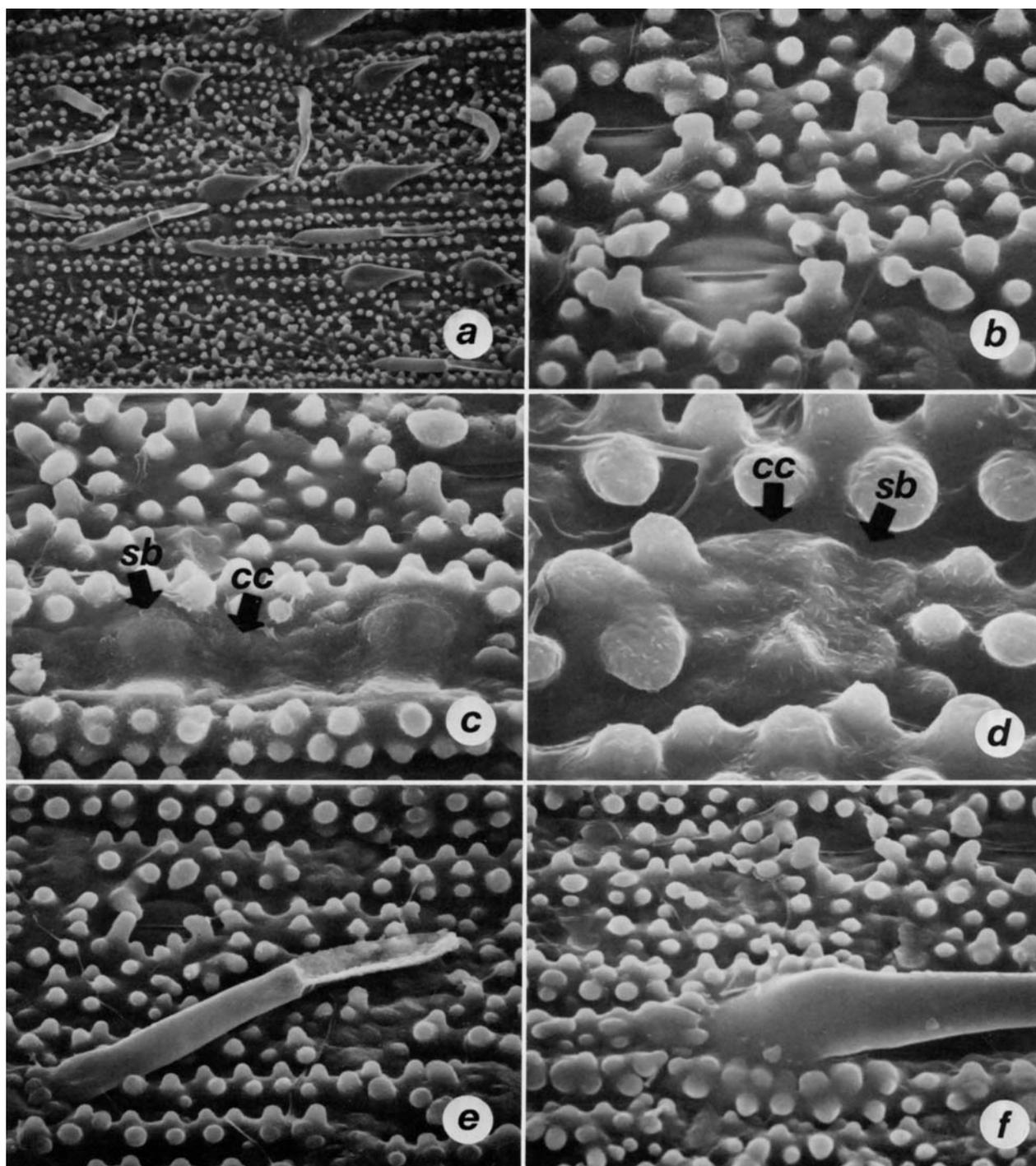


PLATE 3.—Abaxial epidermis *Oreobambos buchwaldii*, Thomas 3775: *a*, overview, $\times 295$; *b*, stomata, interstomatal cell, $\times 1285$; *c*, costal silica bodies (sb) and cork cells (cc), $\times 1285$; *d*, intercostal cork cell (cc) and silica body (sb), $\times 2970$; *e*, microhair, $\times 867$; *f*, base of macrohair, $\times 867$.

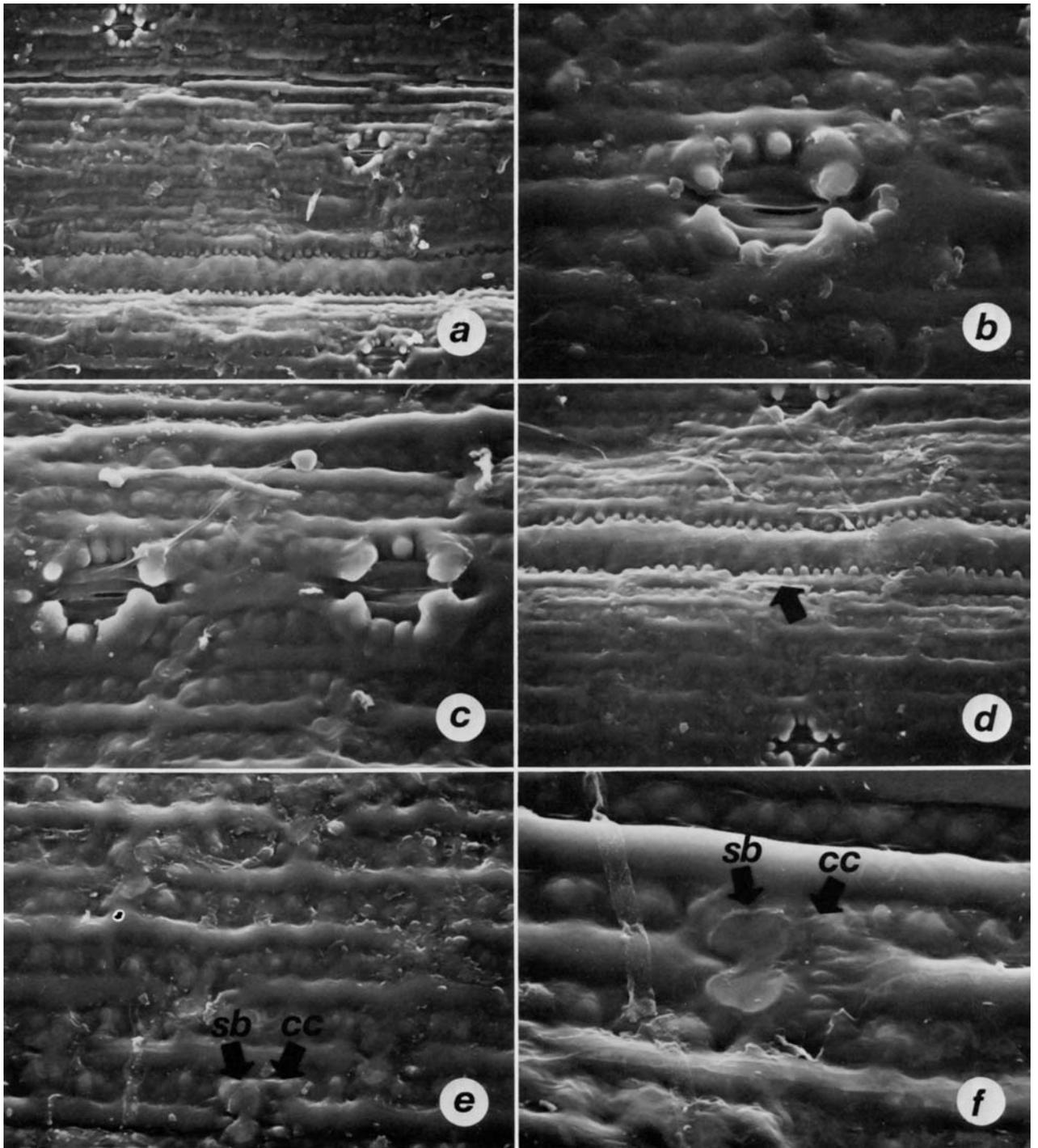


PLATE 4.—Adaxial epidermis *Oreobambos buchwaldii*, Thomas 3775: *a*, overview, $\times 295$; *b*, stoma, $\times 867$; *c*, interstomatal cell, $\times 867$; *d*, long cells (note wide band at arrow), $\times 416$; *e*, intercostal silica bodies (sb) and cork cells (cc), $\times 867$; *f*, cork cell (cc) and silica body (sb), $\times 1696$.

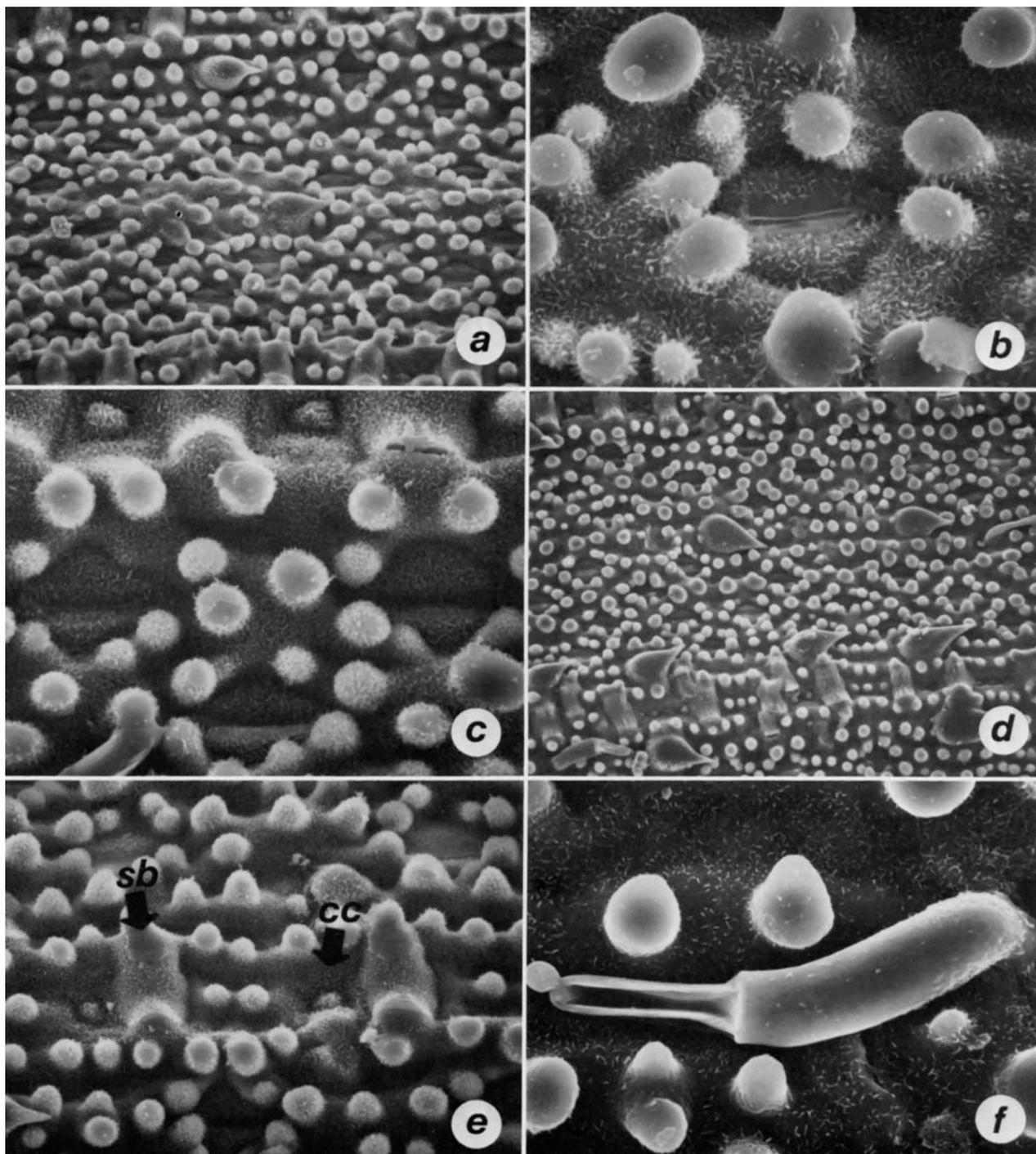


PLATE 5.—Abaxial epidermis *Oxytenanthera abyssinica*, Snowden 1051: *a*, overview, $\times 416$; *b*, stoma, $\times 1696$; *c*, interstomatal cell, $\times 1285$; *d*, prickles, $\times 295$; *e*, costal silica bodies (sb) and cork cells (cc), $\times 867$; *f*, microhair, $\times 1696$.

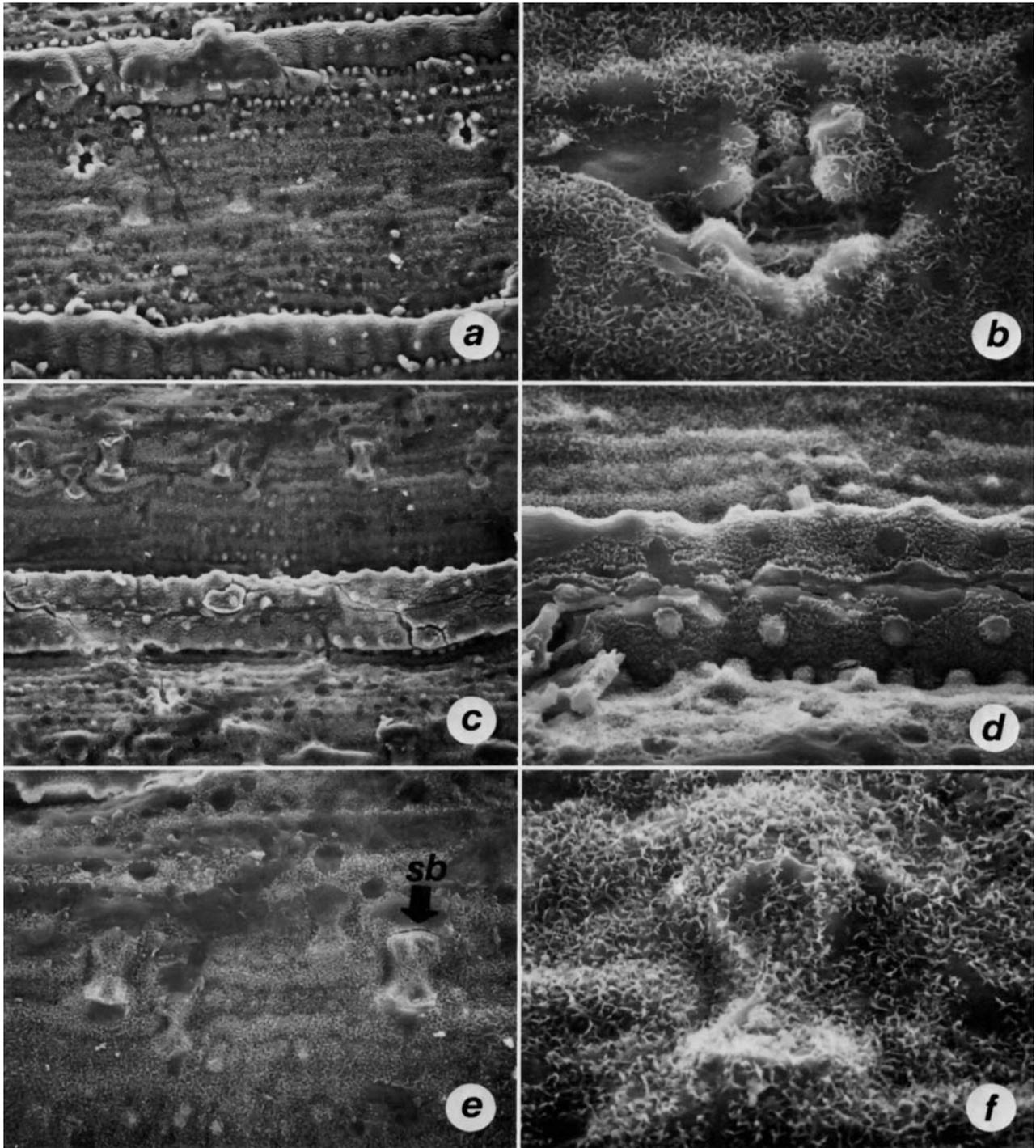


PLATE 6.—Adaxial epidermis *Oxytenanthera abyssinica*, Snowden 1051: *a*, overview, $\times 295$; *b*, stoma, $\times 1696$; *c*, long and short cells, $\times 295$; *d*, long cells, $\times 867$; *e*, silica bodies (sb), $\times 625$; *f*, intercostal silica body, $\times 1696$.

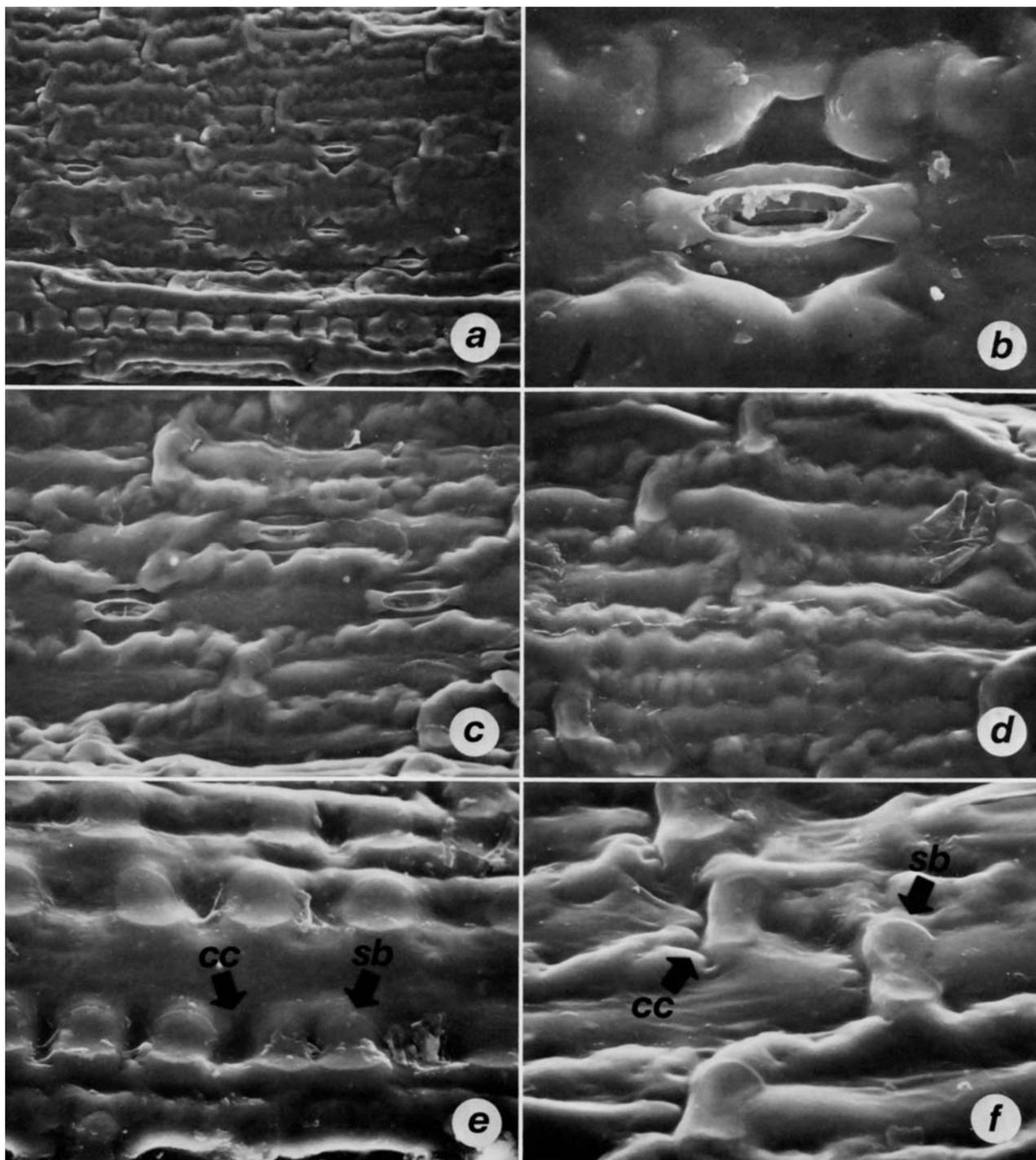


PLATE 7.— Abaxial epidermis *Puelia olyrififormis*, Callens 2678: *a*, overview, $\times 295$; *b*, stoma, $\times 1696$; *c*, interstomatal cells, $\times 625$; *d*, long cells, $\times 625$; *e*, costal silica bodies (sb) and cork cells (cc), $\times 867$; *f*, intercostal cork cells (cc) and silica bodies (sb), $\times 1285$.

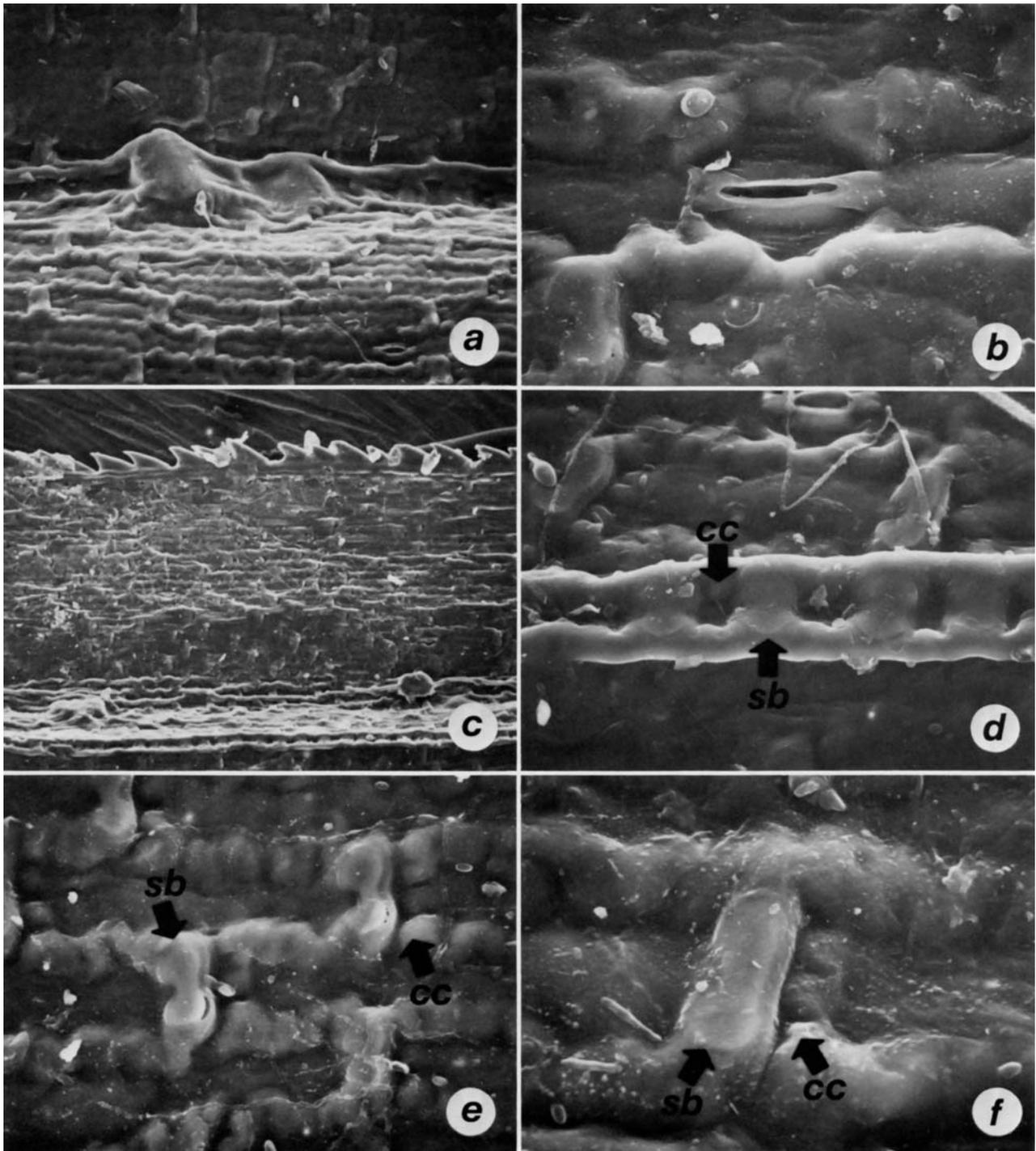


PLATE 8.—Adaxial epidermis *Puelia olyniformis*, Callens 2678: *a*, overview, $\times 295$; *b*, stoma, $\times 1285$; *c*, marginal prickles, $\times 121$; *d*, costal silica bodies (sb) and cork cells (cc), $\times 867$; *e*, intercostal silica bodies (sb) and cork cells (cc), $\times 867$; *f*, intercostal cork cell (cc) and silica body (sb), $\times 1696$.

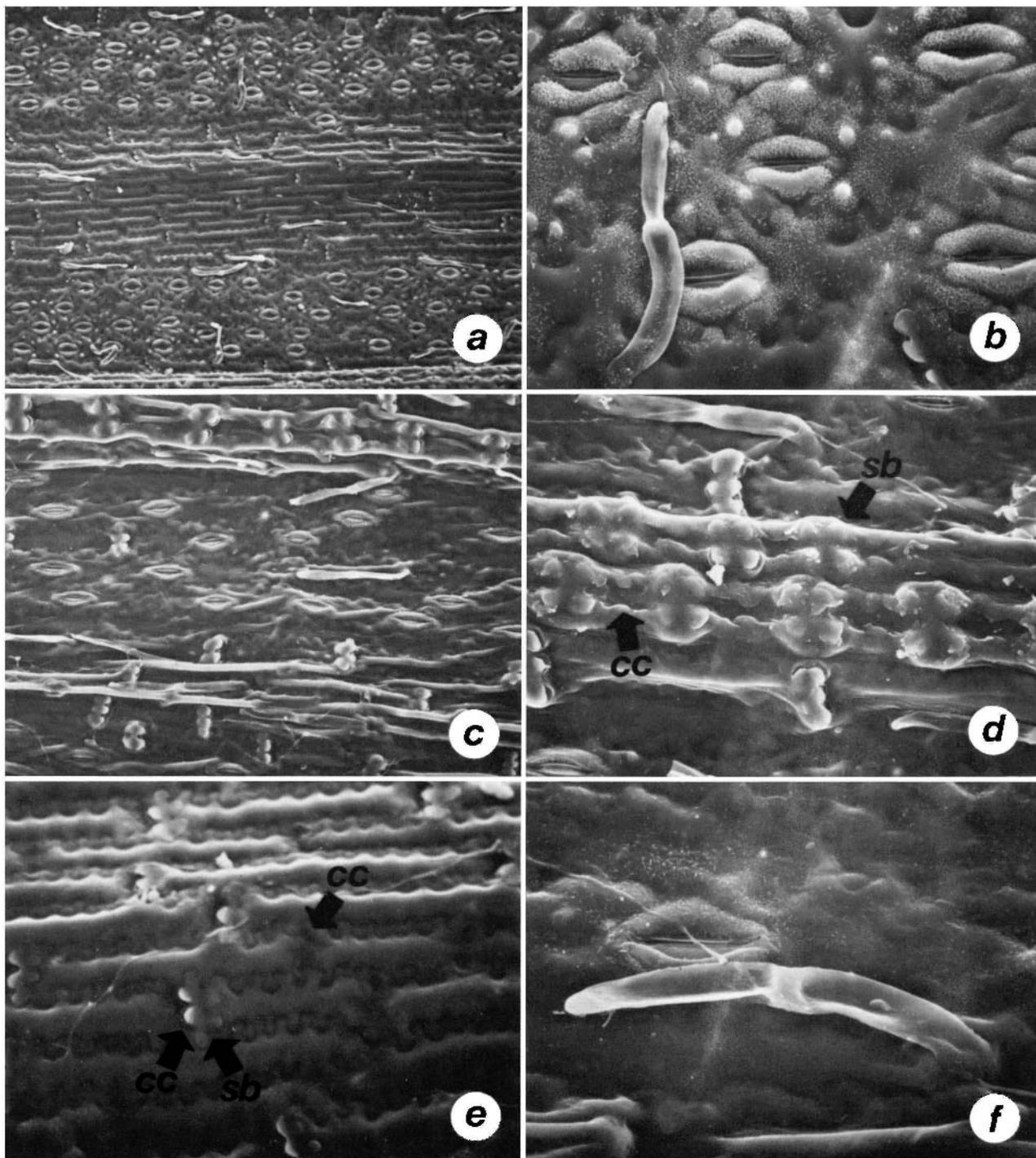


PLATE 9.—Abaxial epidermis *Olyra latifolia*, Hitchcock 24555 (*a,b,e*), Faulkner 1201 (*c,d,f*): *a*, overview, $\times 161$; *b*, stomata, $\times 867$; *c*, stomatal band, $\times 295$; *d*, costal silica bodies (sb) and cork cells (cc), $\times 625$; *e*, intercostal silica bodies (sb) and cork cells (cc), $\times 625$; *f*, microhair, $\times 1285$.

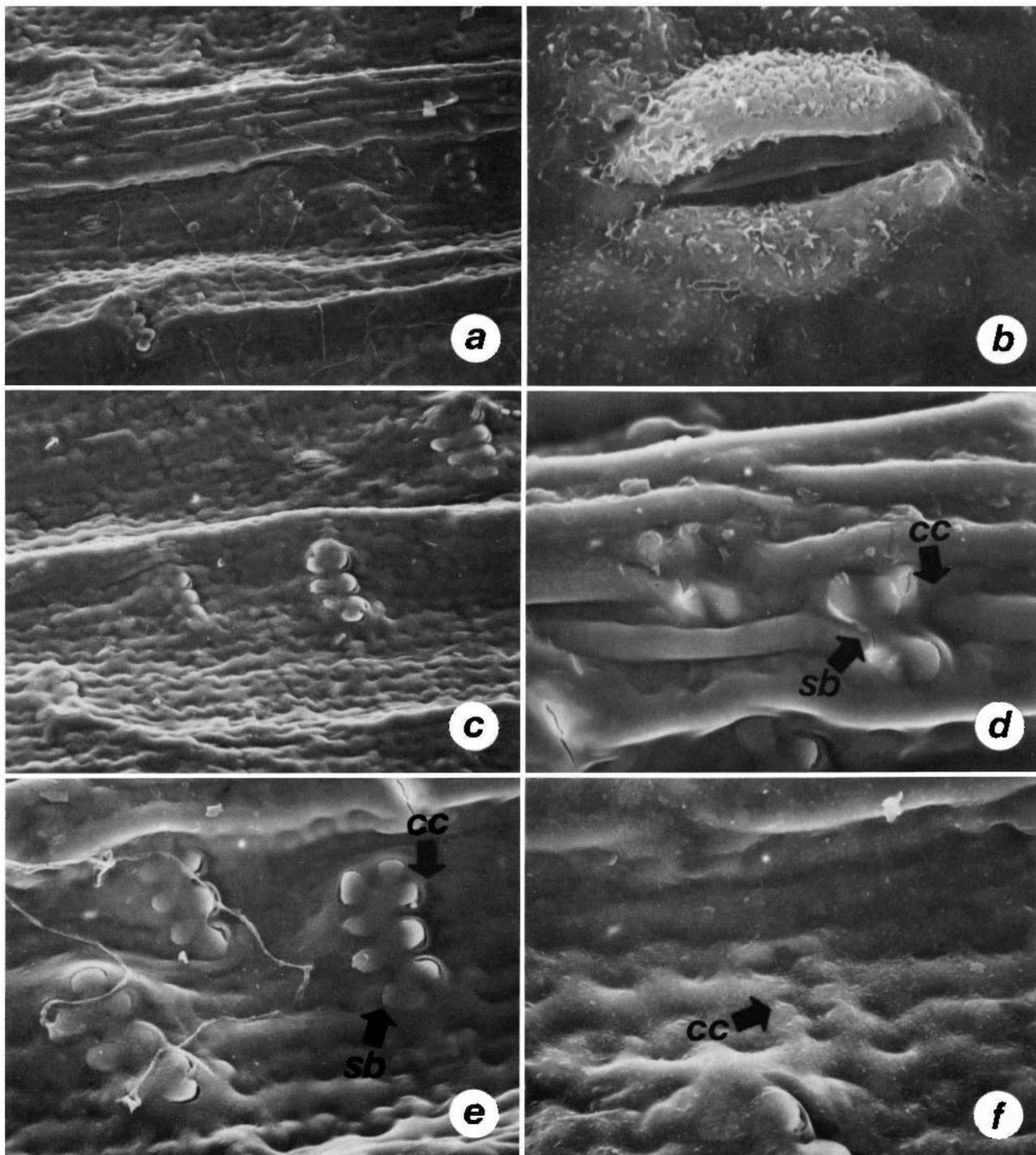


PLATE 10.—Adaxial epidermis *Olyra latifolia*, Faulkner 1201: *a*, overview, $\times 295$; *b*, stoma, $\times 2970$; *c*, intercostal long and short cells, $\times 416$; *d*, costal silica bodies (sb) and cork cells (cc), $\times 1285$; *e*, intercostal silica bodies (sb) and cork cells (cc), $\times 867$; *f*, intercostal cork cell, $\times 1285$.

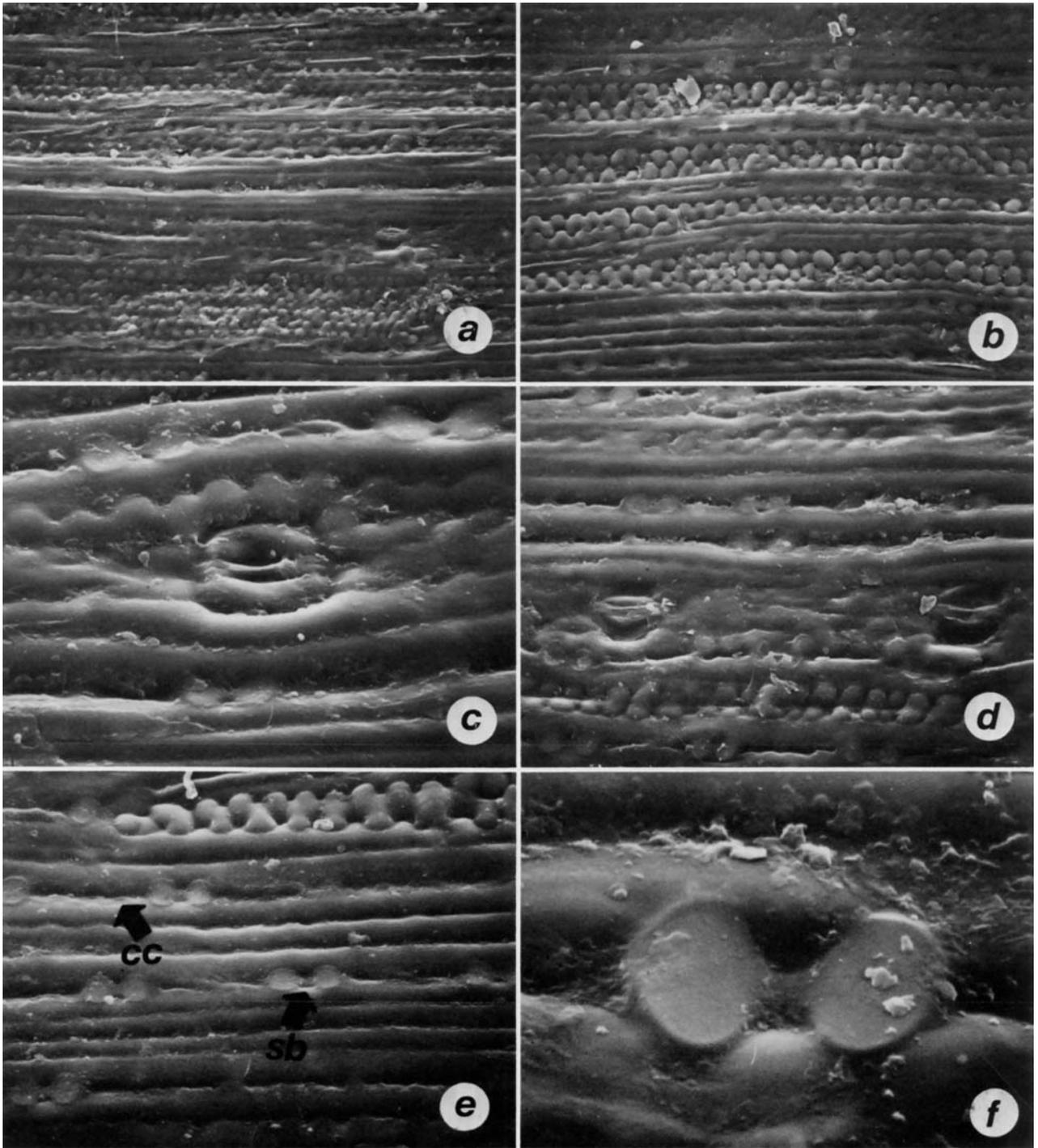


PLATE 11.—Abaxial epidermis *Leptaspis cochleata*, Shandler 2890: *a*, overview, $\times 295$; *b*, banded intercostal zone between large veins, $\times 416$; *c*, stoma, $\times 1285$; *d*, interstomatal cell, $\times 625$; *e*, costal silica bodies (sb) and cork cells (cc), $\times 867$; *f*, costal silica body, $\times 4290$.

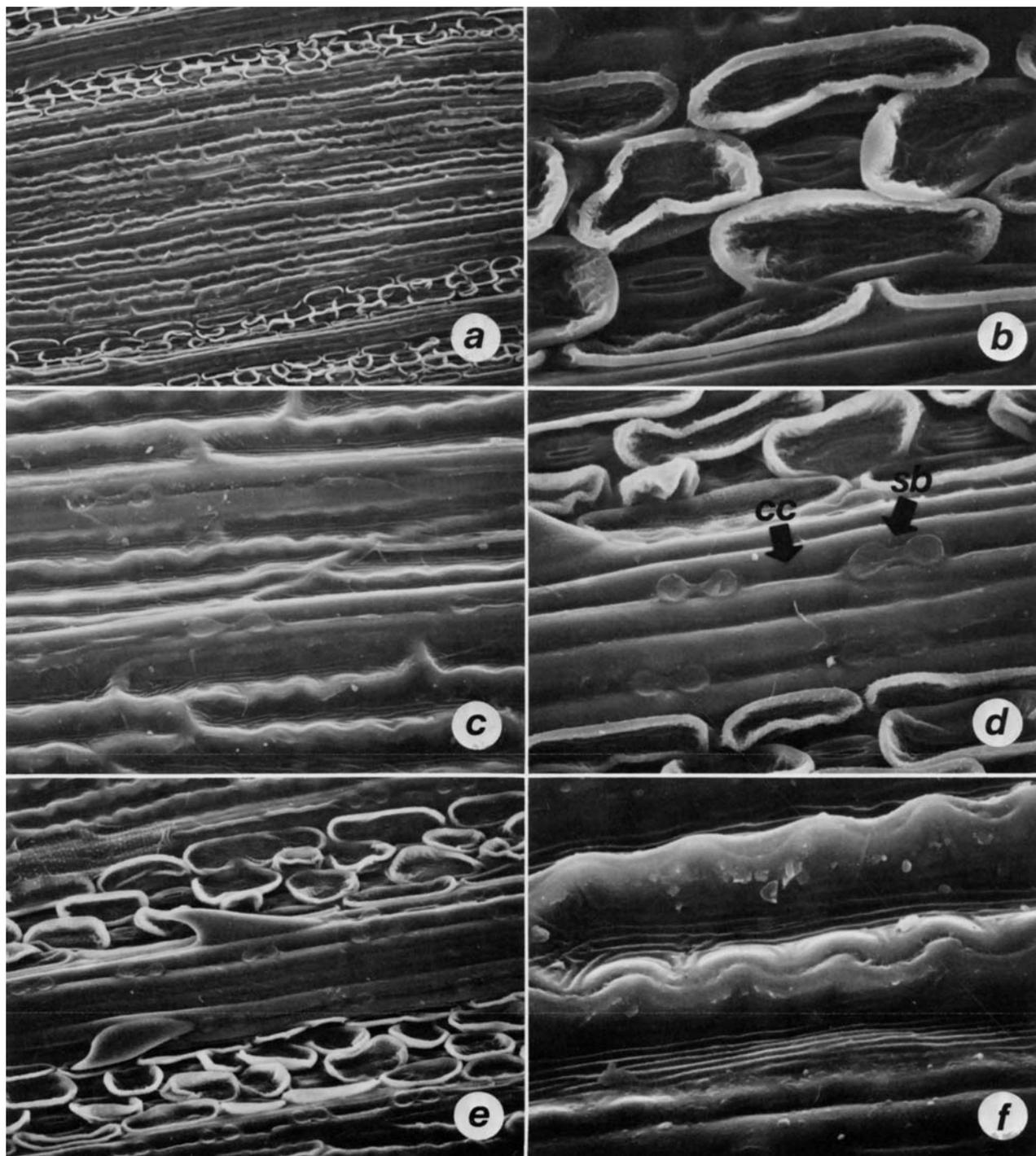


PLATE 12.—Adaxial epidermis *Leptaspis cochleata*, Shandler 2890: *a*, overview, $\times 161$; *b*, stomata with large deflated papillae on adjacent cells, $\times 1285$; *c*, portion of a banded intercostal zone between large veins, $\times 625$; *d*, costal silica bodies (sb) and cork cells (cc), $\times 867$; *e*, costal prickles, $\times 416$; *f*, slightly sinuous long cells with longitudinal striations, $\times 1696$.

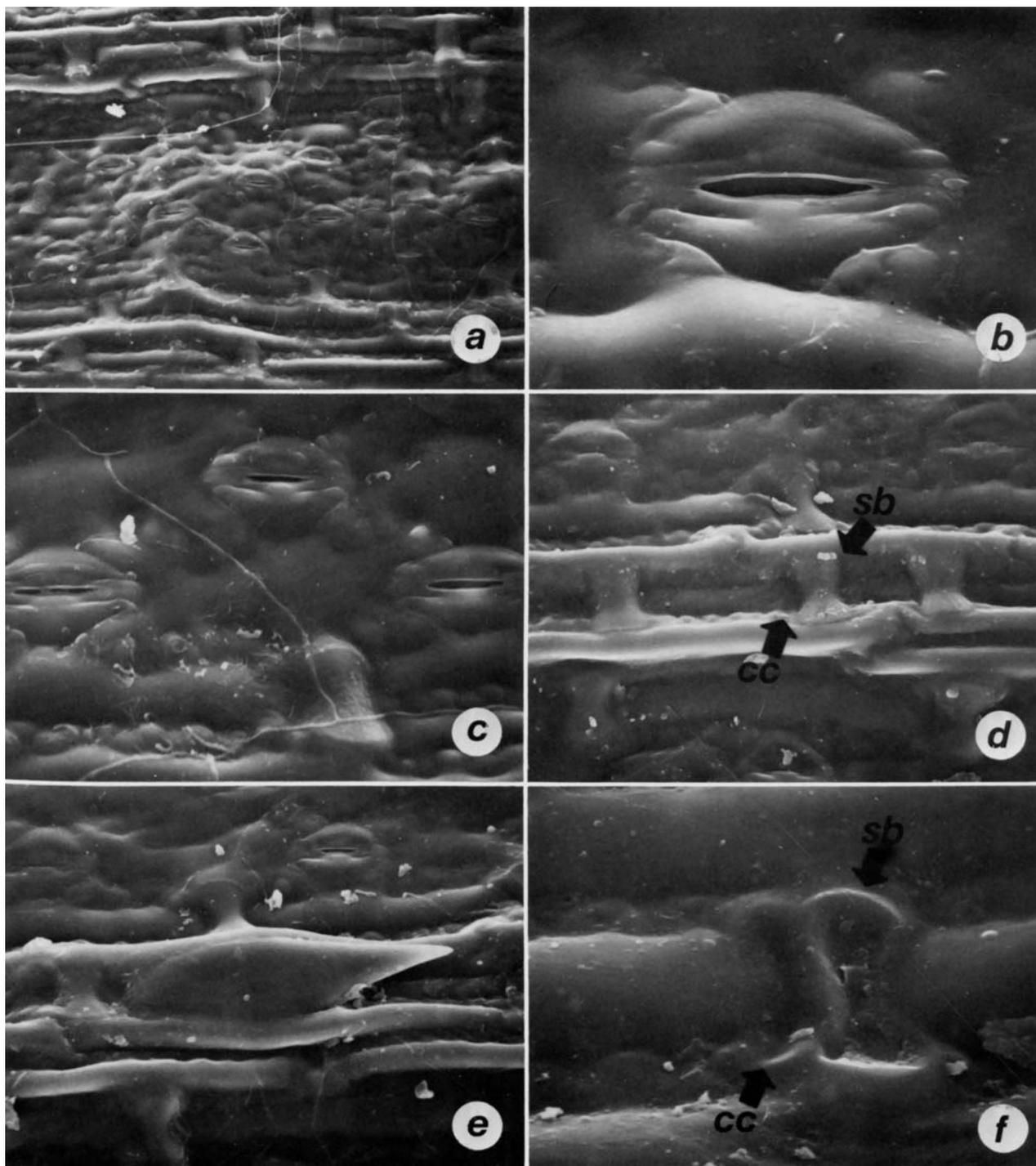


PLATE 13.—Abaxial epidermis *Streptogyna crinita* Jones, Reag, and Onochie 14564 (a-c), Louis 12181 (d-f): a, overview, $\times 416$; b, stoma, $\times 2970$; c, interstomatal cell, $\times 1285$; d, costal silica bodies (sb) and cork cells (cc), $\times 867$; e, costal prickle, $\times 867$; f, intercostal cork cell (cc) and silica body (sb), $\times 2970$.

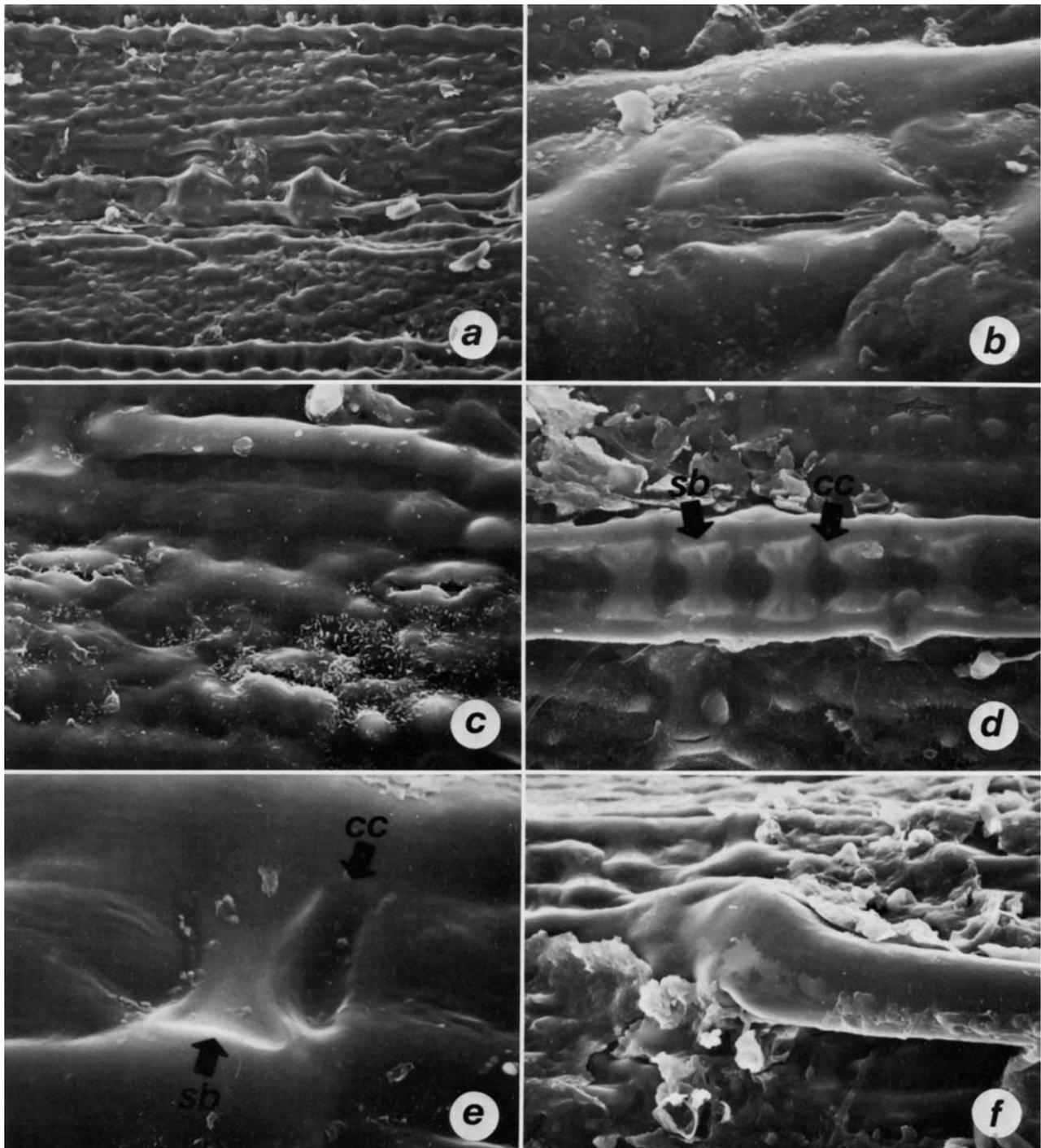


PLATE 14.—Adaxial epidermis *Streptogyna crinita*, Louis 12181: *a*, overview, $\times 295$; *b*, stoma, $\times 2970$; *c*, interstomatal cell, $\times 1285$; *d*, costal silica bodies (sb) and cork cells (cc), $\times 867$; *e*, intercostal silica body (sb) and cork cell (cc), $\times 2970$; *f*, base of macrohair, $\times 625$.

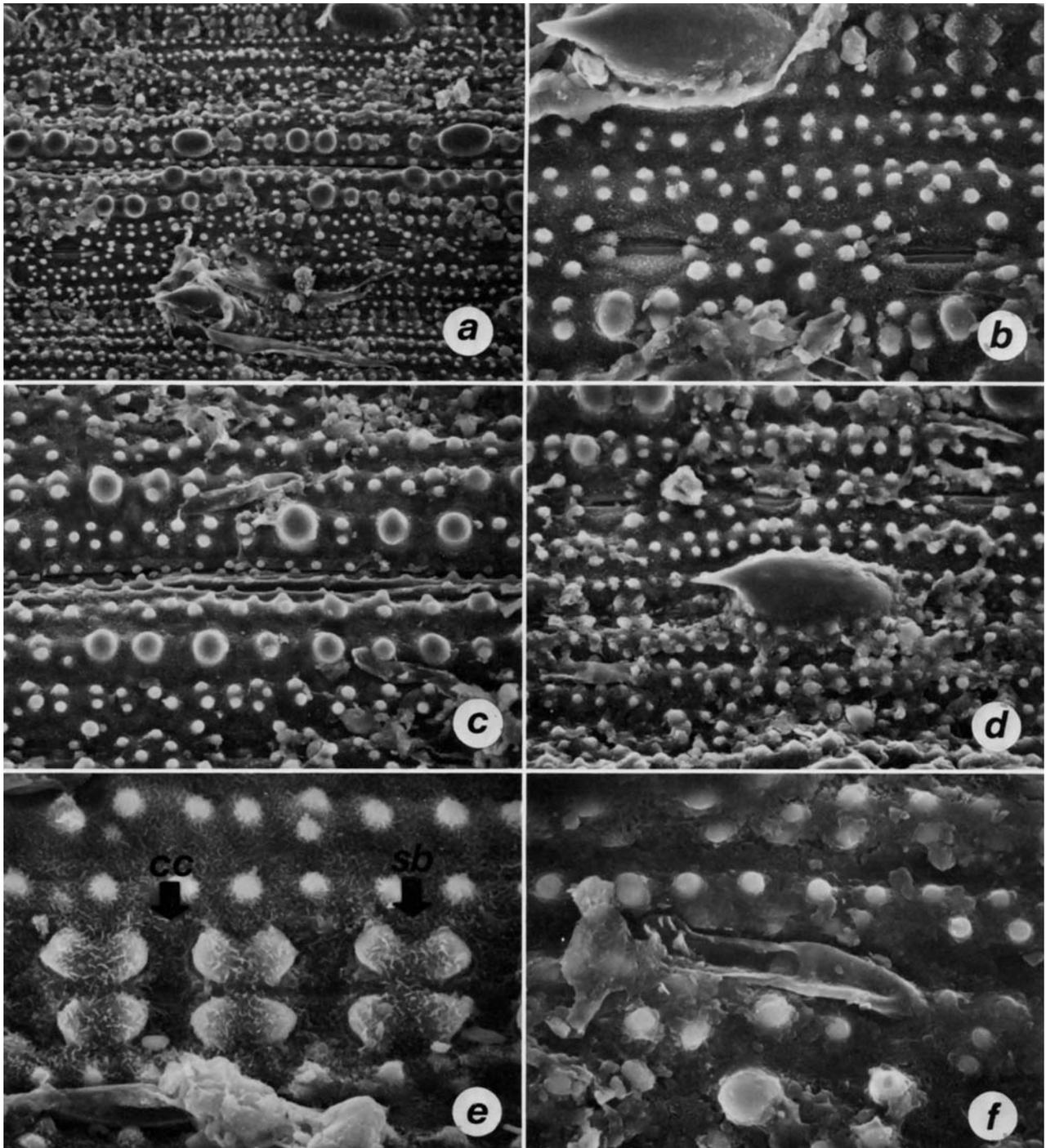


PLATE 15.—Abaxial epidermis *Leersia hexandra*, Milne-Redhead and Taylor 8664: *a*, overview, $\times 295$; *b*, stomata and interstomatal cell, $\times 867$; *c*, long cells, $\times 625$; *d*, costal prickle, $\times 625$; *e*, costal silica bodies (sb) and cork cells (cc), $\times 1696$; *f*, microhair, $\times 1696$.

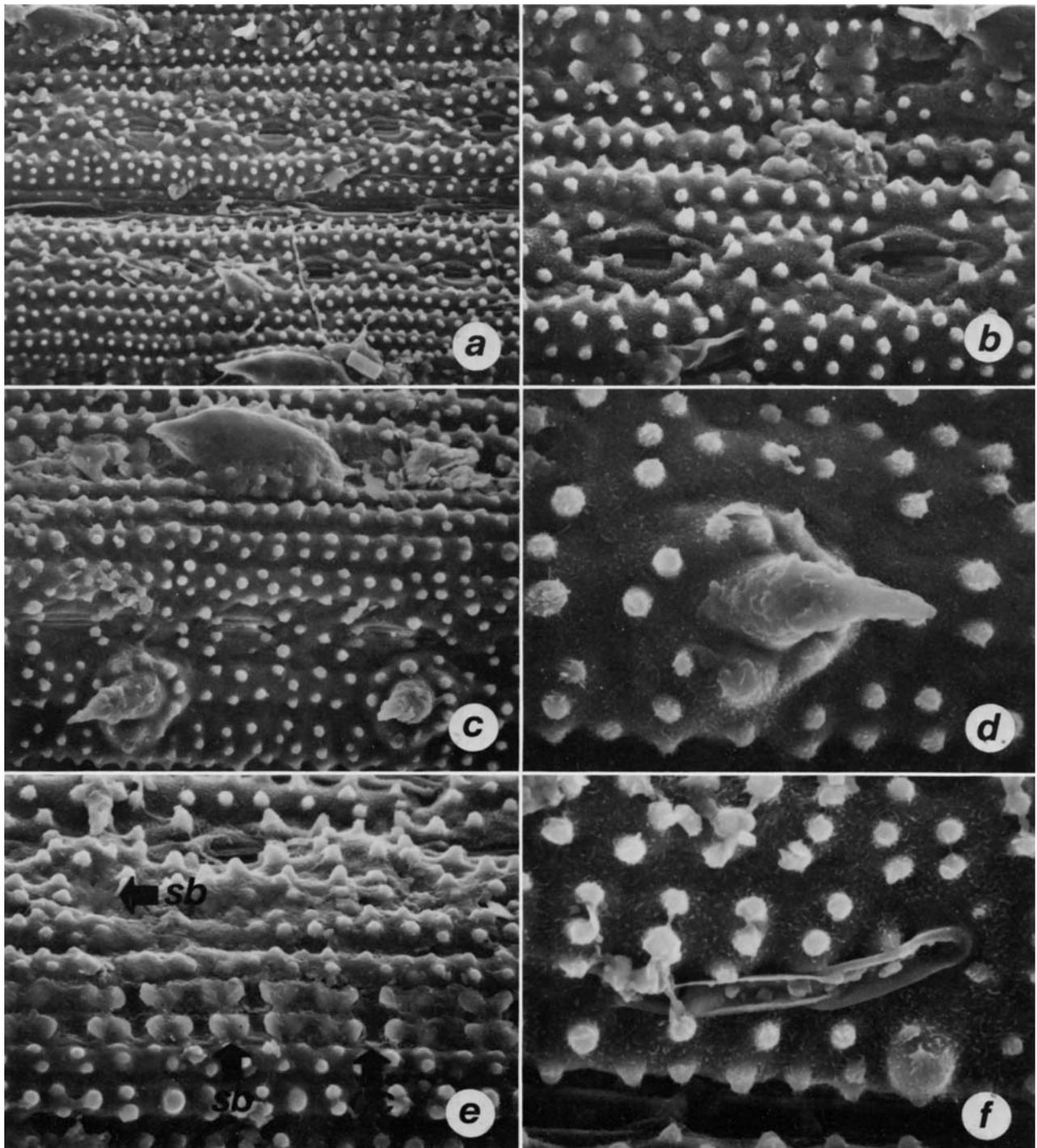


PLATE 16.—Adaxial epidermis *Leersia hexandra*, Milne-Redhead and Taylor 8664: *a*, overview, $\times 416$; *b*, stomata and interstomatal cell, $\times 867$; *c*, costal prickle, long cells, intercostal hooks, $\times 625$; *d*, intercostal hook with papillate base, $\times 1696$; *e*, costal silica bodies (sb) and cork cells (cc) and intercostal silica body (sb), $\times 867$; *f*, microhair, $\times 1696$.

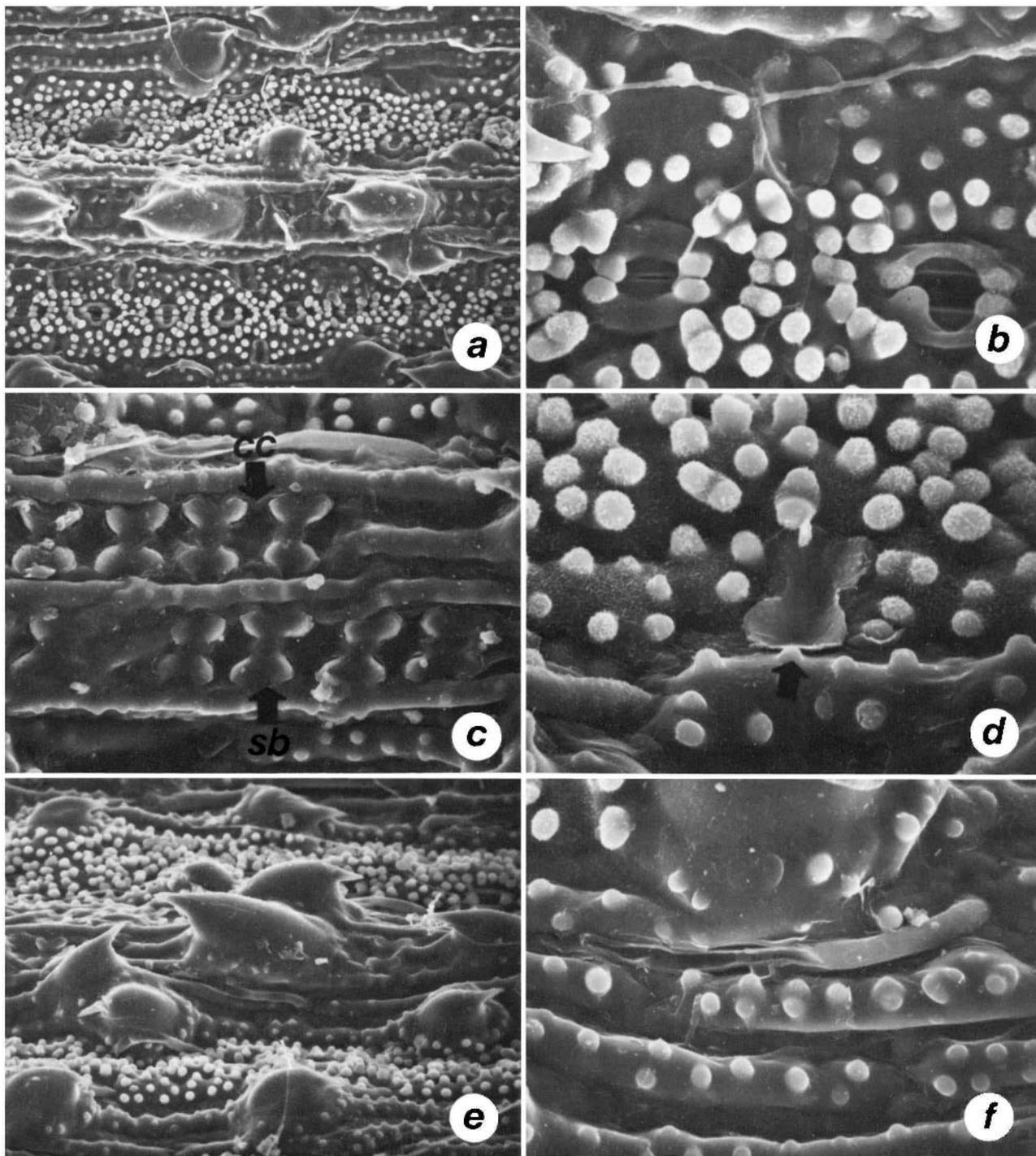


PLATE 17.—Abaxial epidermis *Maltebrunia leersioides*, Humbert 5783: *a*, overview, $\times 295$; *b*, stoma with papillate subsidiary cells and interstomatal cell, $\times 1696$; *c*, costal silica bodies (sb) and cork cells (cc), $\times 1696$; *d*, intercostal silica body, $\times 2970$; *e*, costal prickles, $\times 416$; *f*, microhair, $\times 1285$.

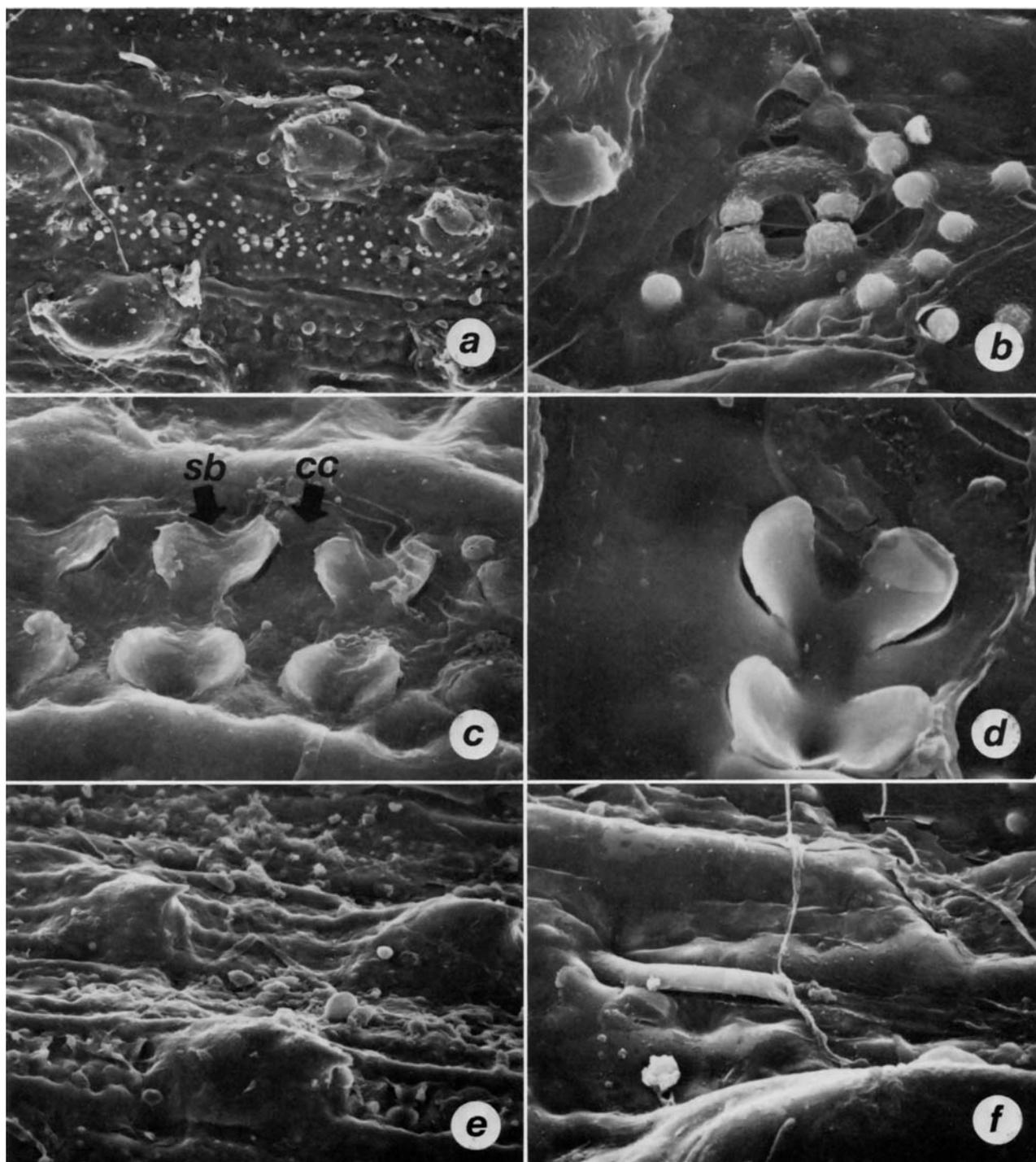


PLATE 18.—Adaxial epidermis *Mallebrunia leersioides*, Humbert 5783: *a*, overview, $\times 295$; *b*, stoma with papillate subsidiary cells, $\times 1696$; *c*, costal silica bodies (sb) and cork cells (cc), $\times 1696$; *d*, intercostal silica body, $\times 2970$; *e*, costal prickles, $\times 416$; *f*, microhair, $\times 1285$.

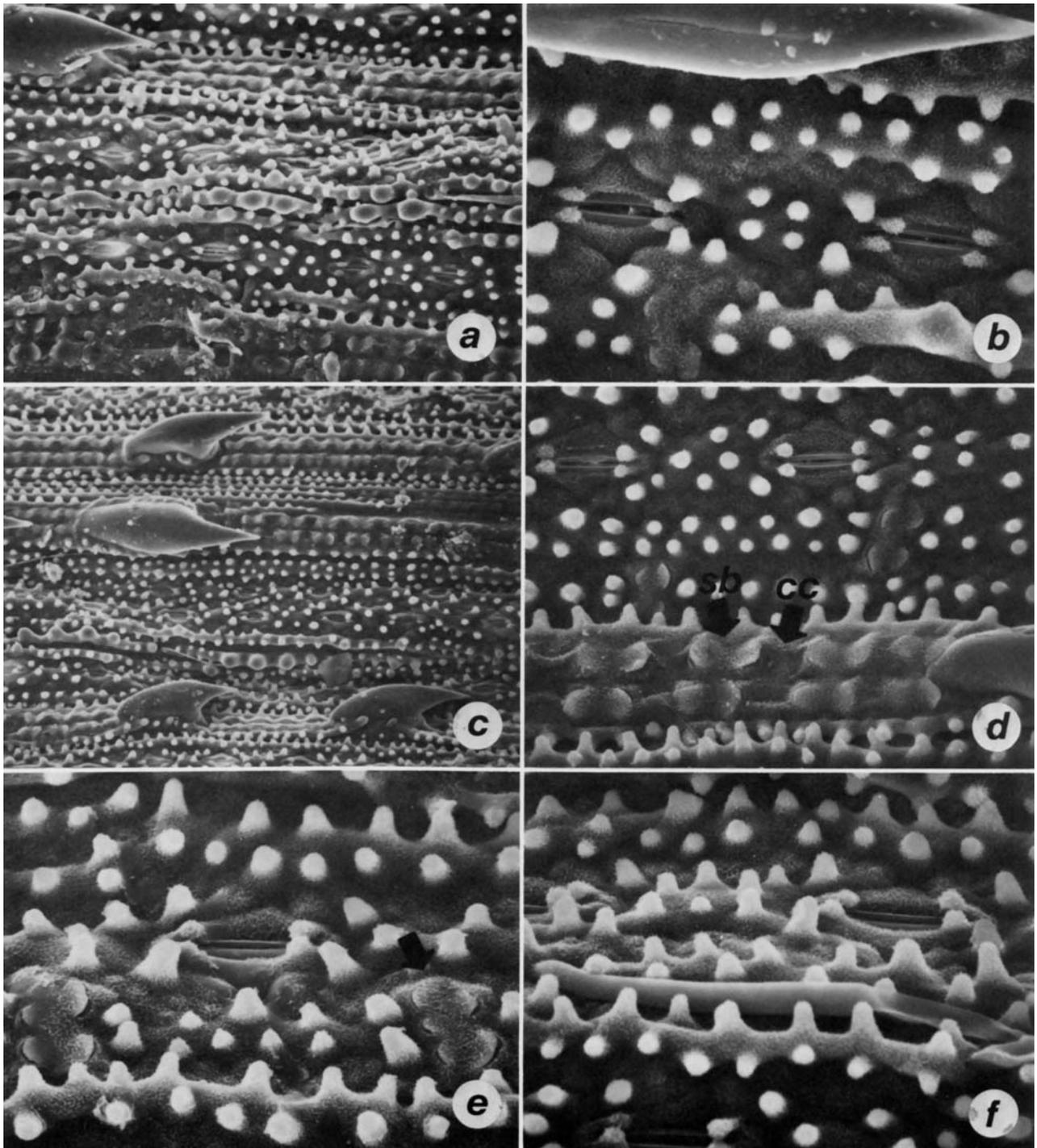


PLATE 19.—Abaxial epidermis *Oryza punctata*, Greenway 15151: *a*, overview, $\times 295$; *b*, stomata and interstomatal cell, $\times 1285$; *c*, costal prickles, $\times 625$; *d*, costal silica bodies (sb) and cork cells (cc), $\times 1285$; *e*, intercostal silica bodies, $\times 4290$; *f*, microhair, $\times 1285$.

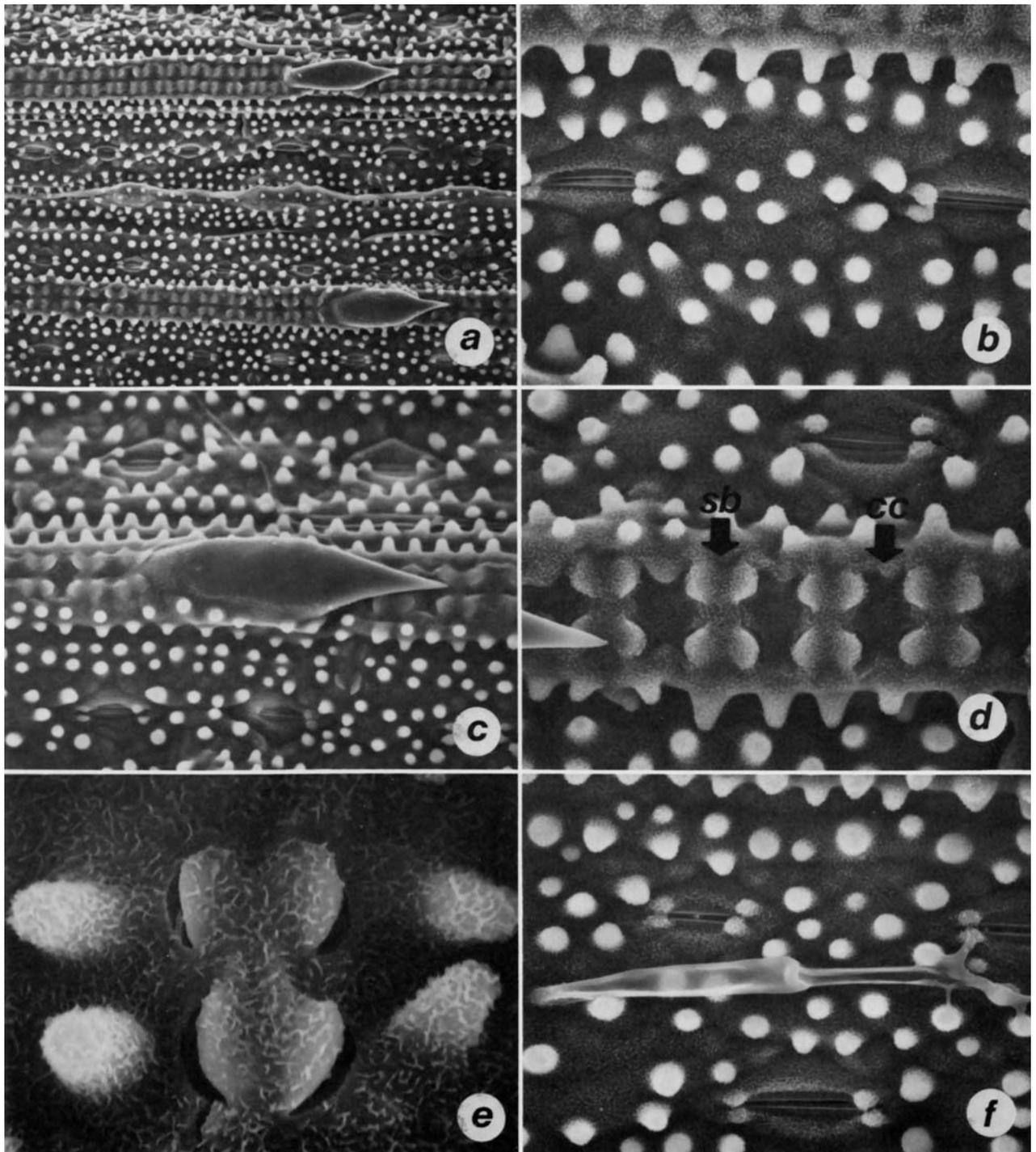


PLATE 20.—Adaxial epidermis *Oryza punctata*, Greenway 15151: *a*, overview, $\times 295$; *b*, stomata and interstomatal cell, $\times 1285$; *c*, costal prickle, $\times 625$; *d*, costal silica bodies (sb) and cork cells (cc), $\times 1285$; *e*, intercostal silica body, $\times 4290$; *f*, microhair, $\times 1285$.

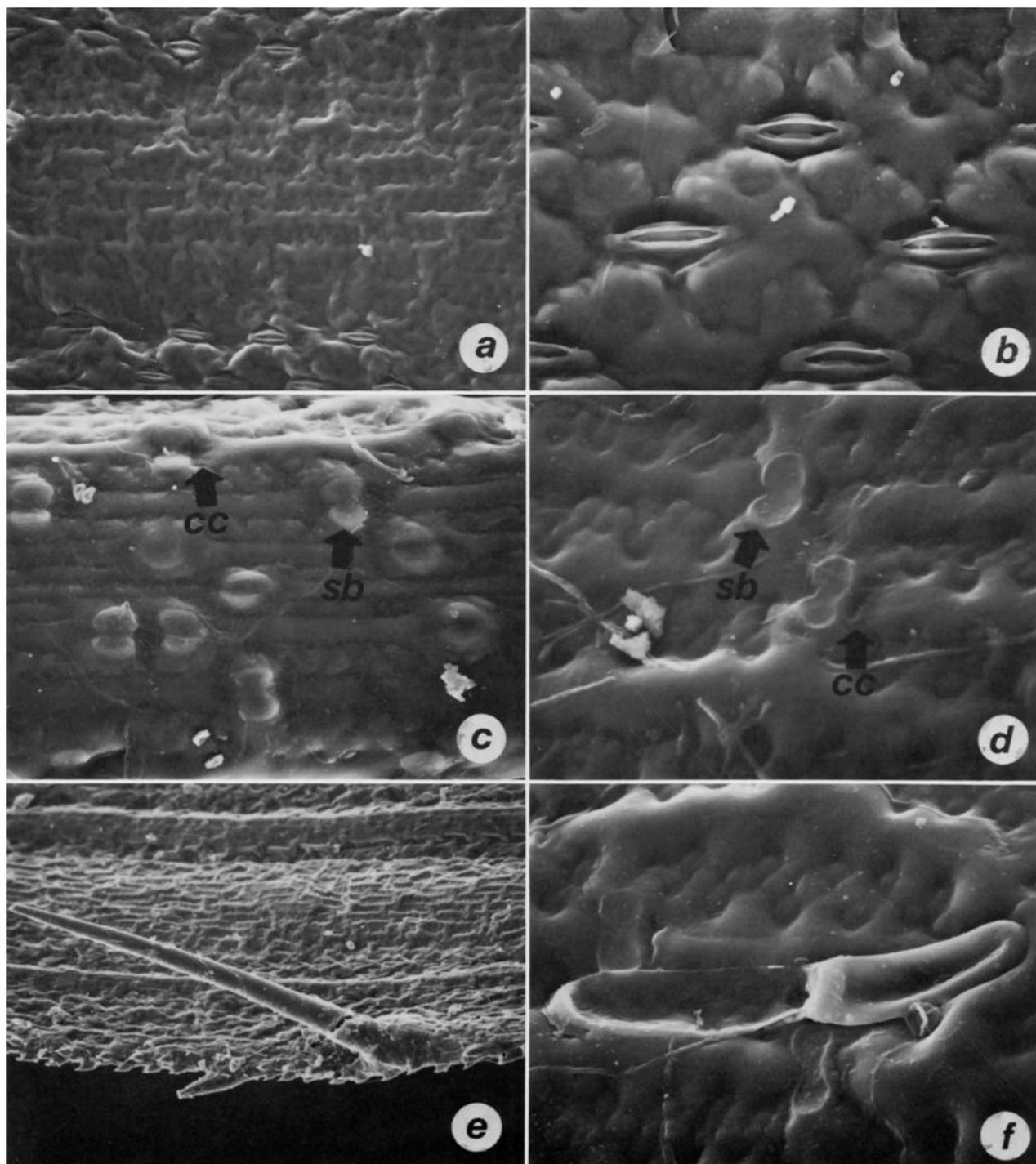


PLATE 21.—Abaxial epidermis *Humbertochloa greenwayi*, Wingfield 1680: *a*, overview, $\times 295$; *b*, stomata and interstomatal cells, $\times 867$; *c*, costal silica bodies (sb) and cork cells (cc), $\times 867$; *d*, intercostal cork cells (cc) and silica bodies (sb), $\times 1285$; *e*, marginal macrohair and prickles, $\times 121$; *f*, microhair, $\times 1285$.

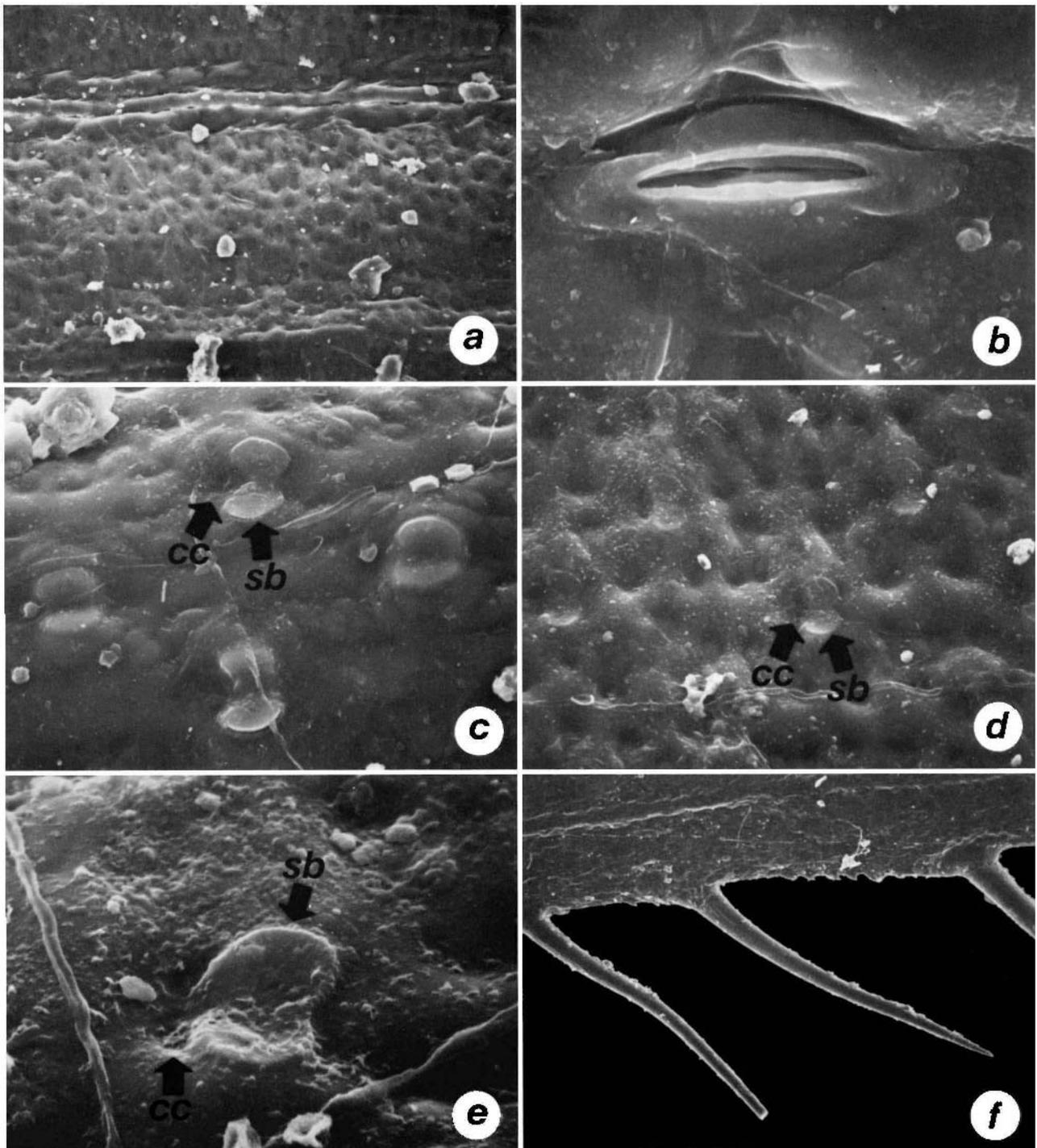


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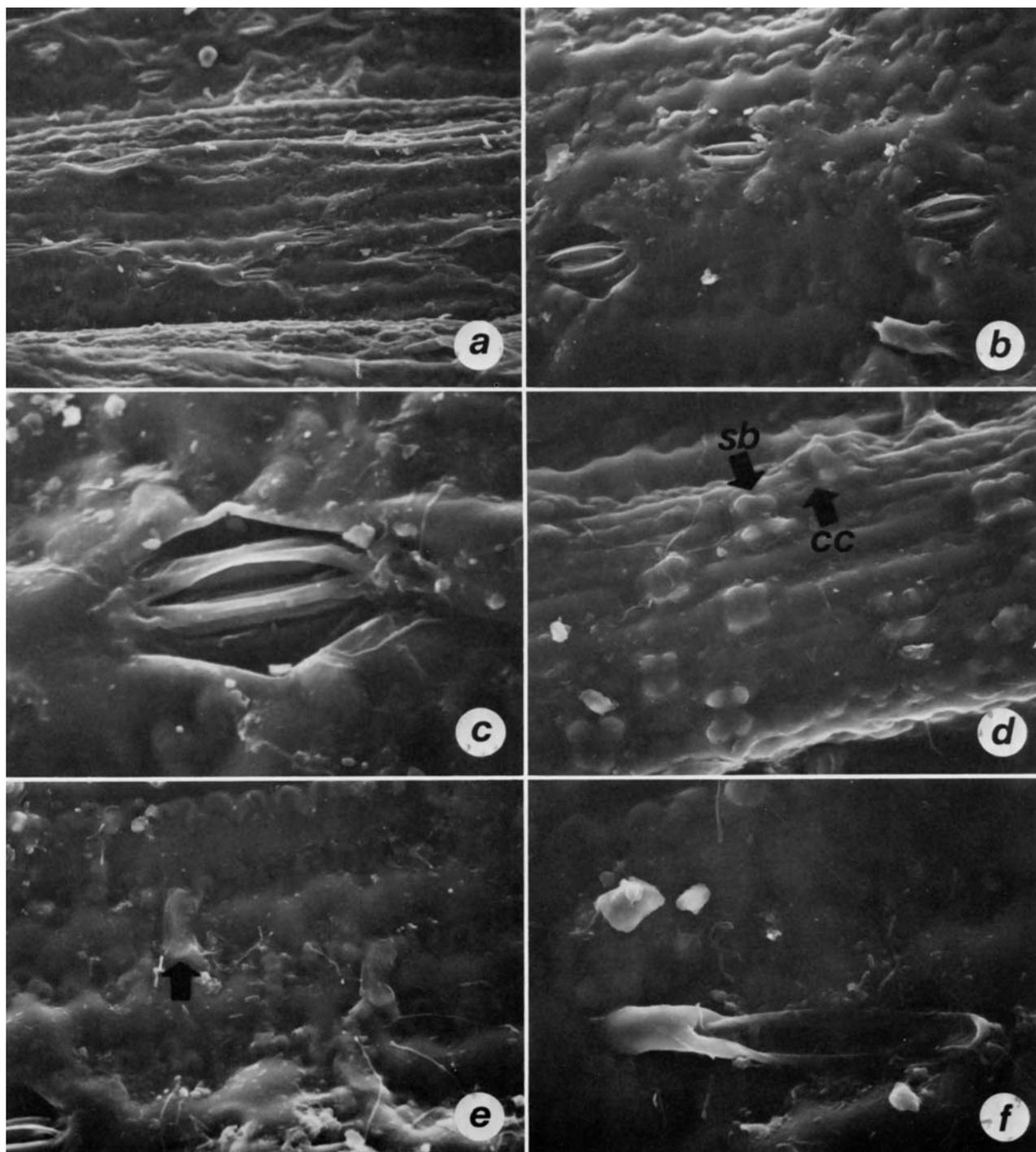


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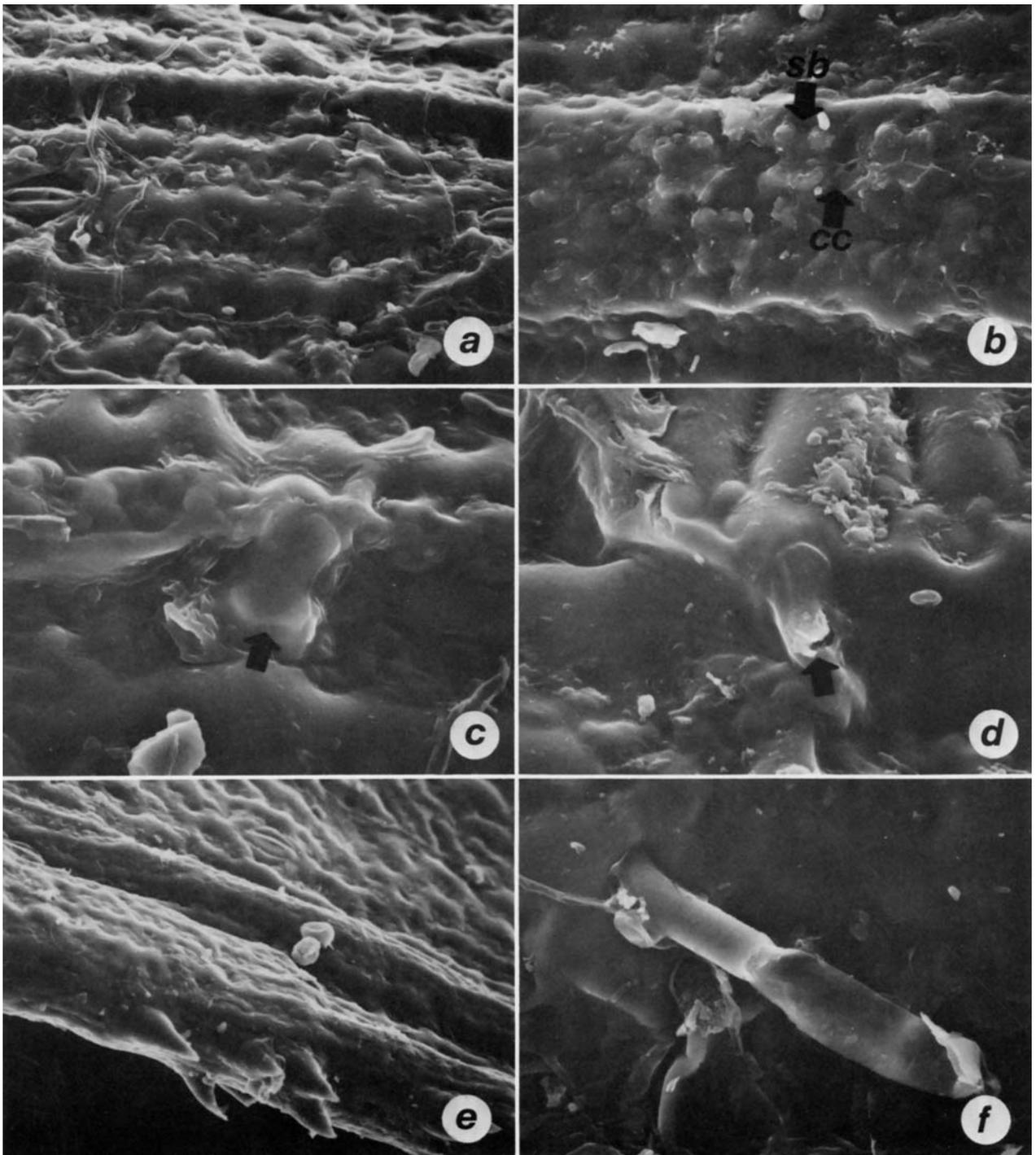


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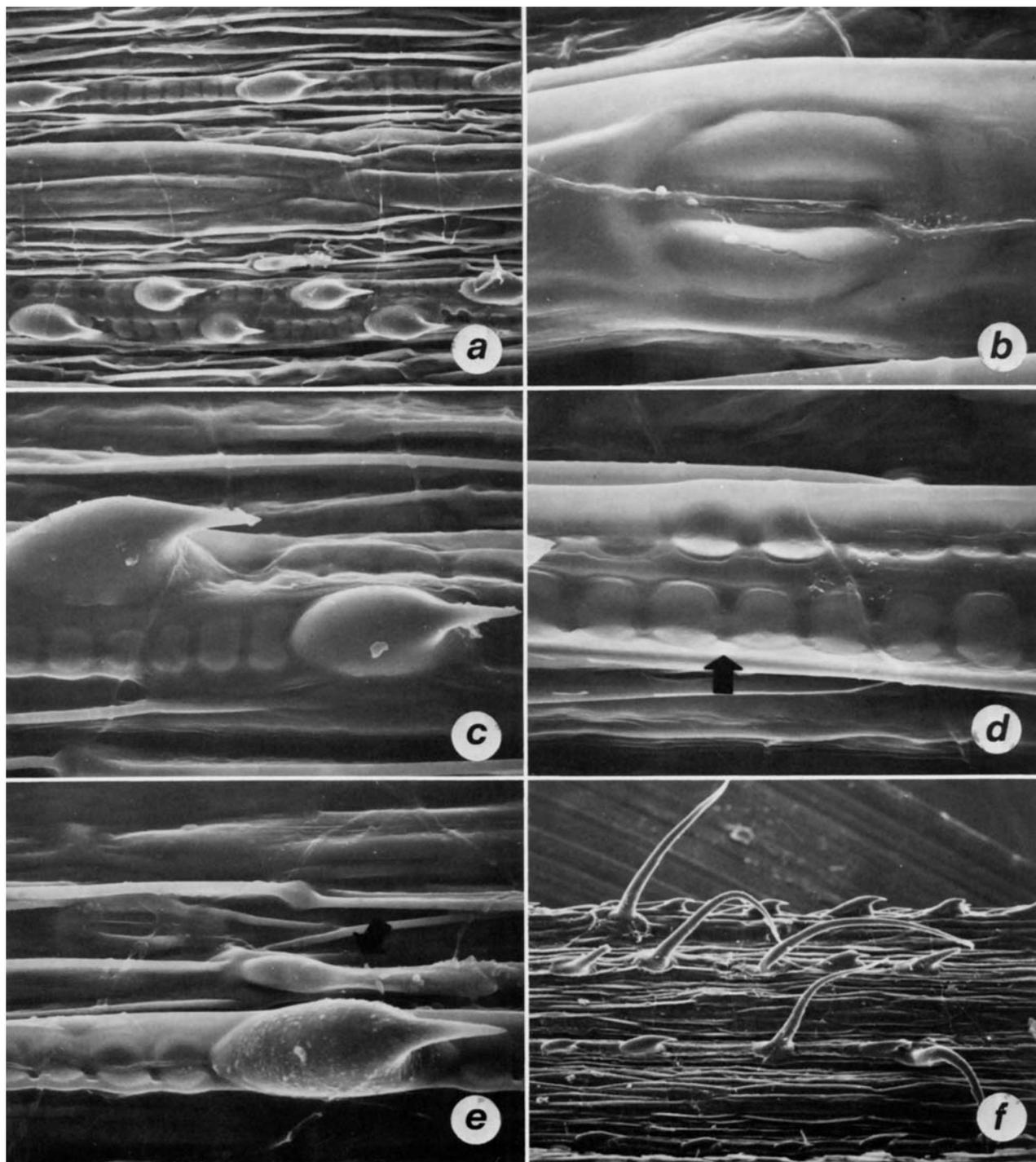


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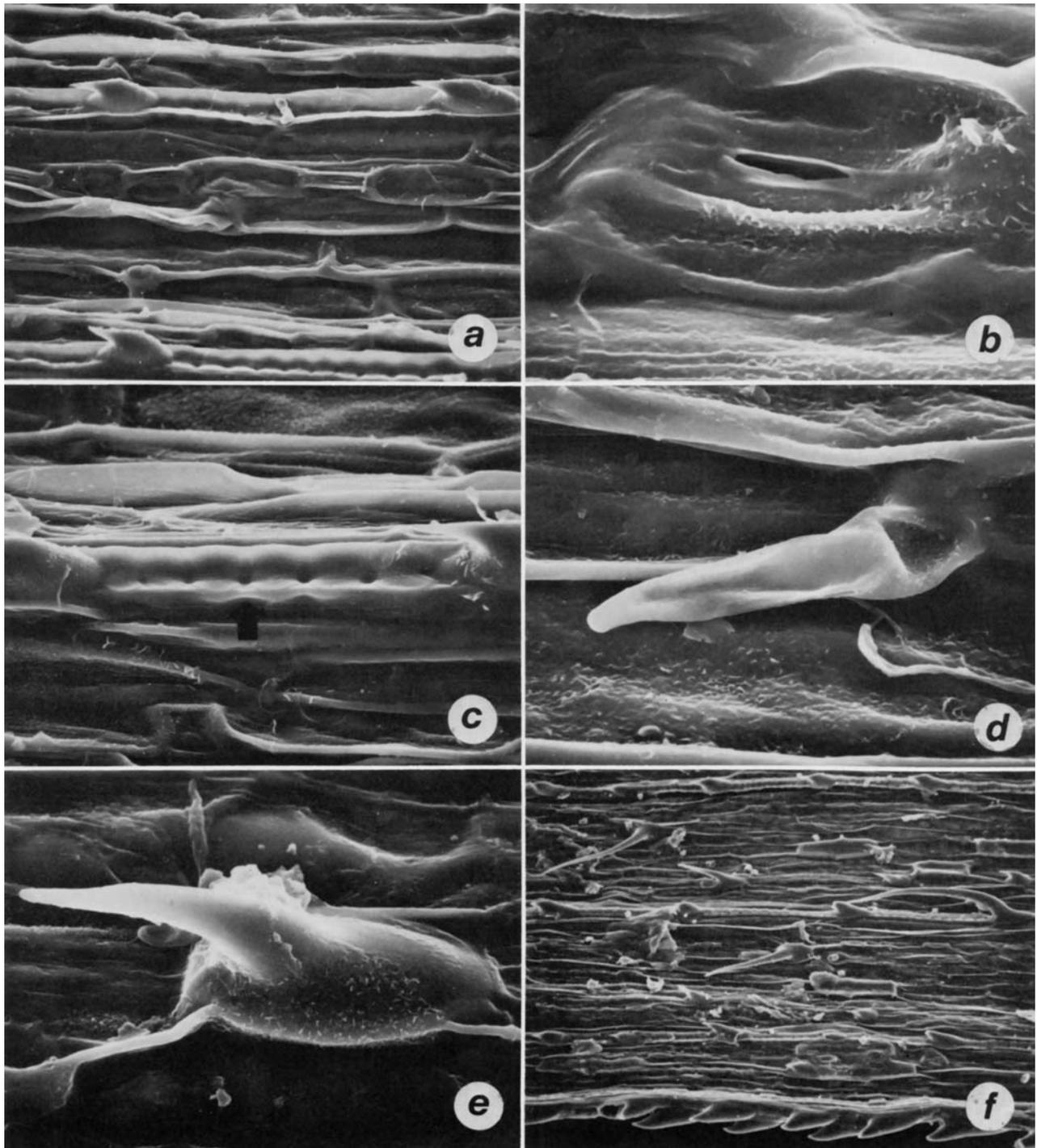


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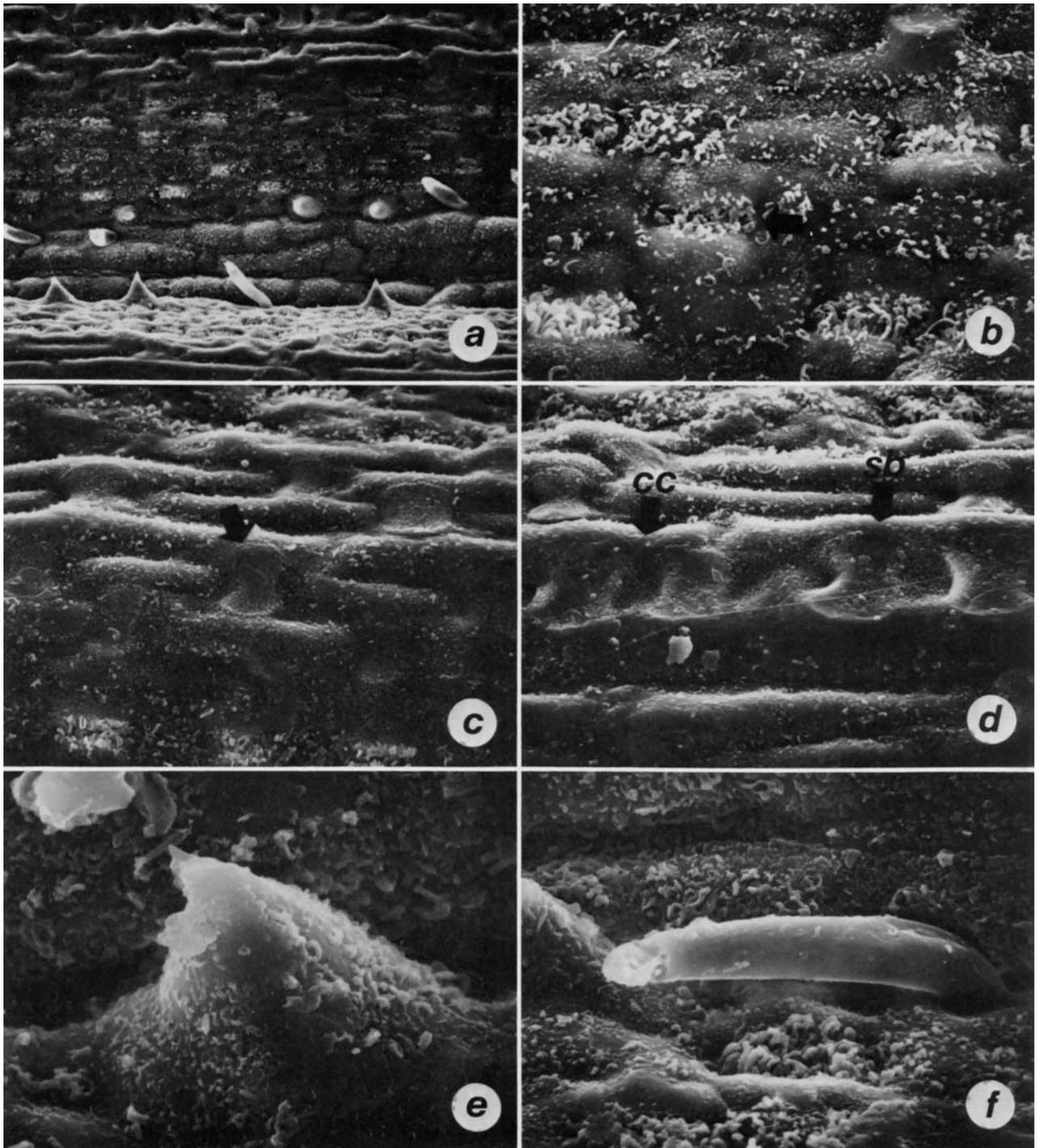


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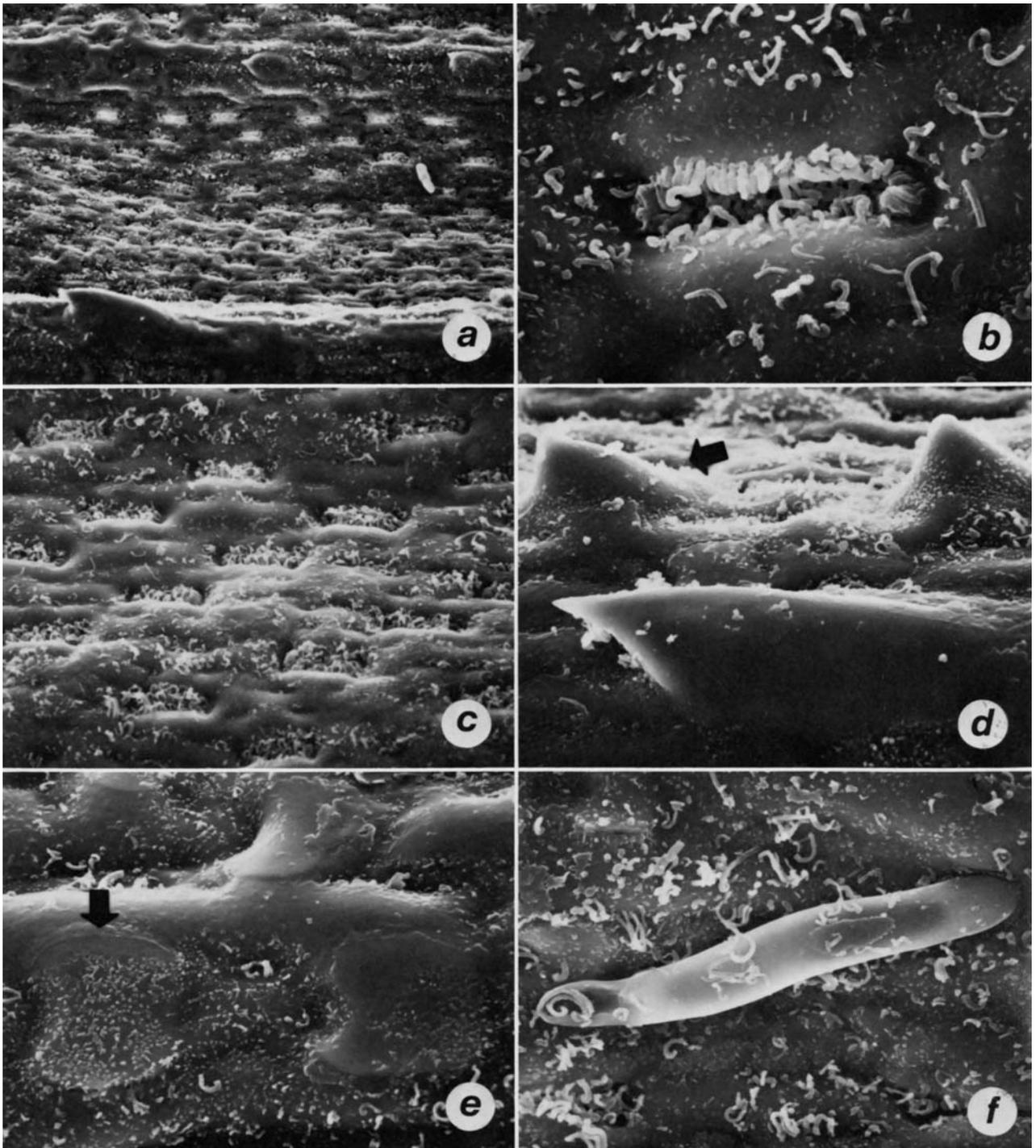


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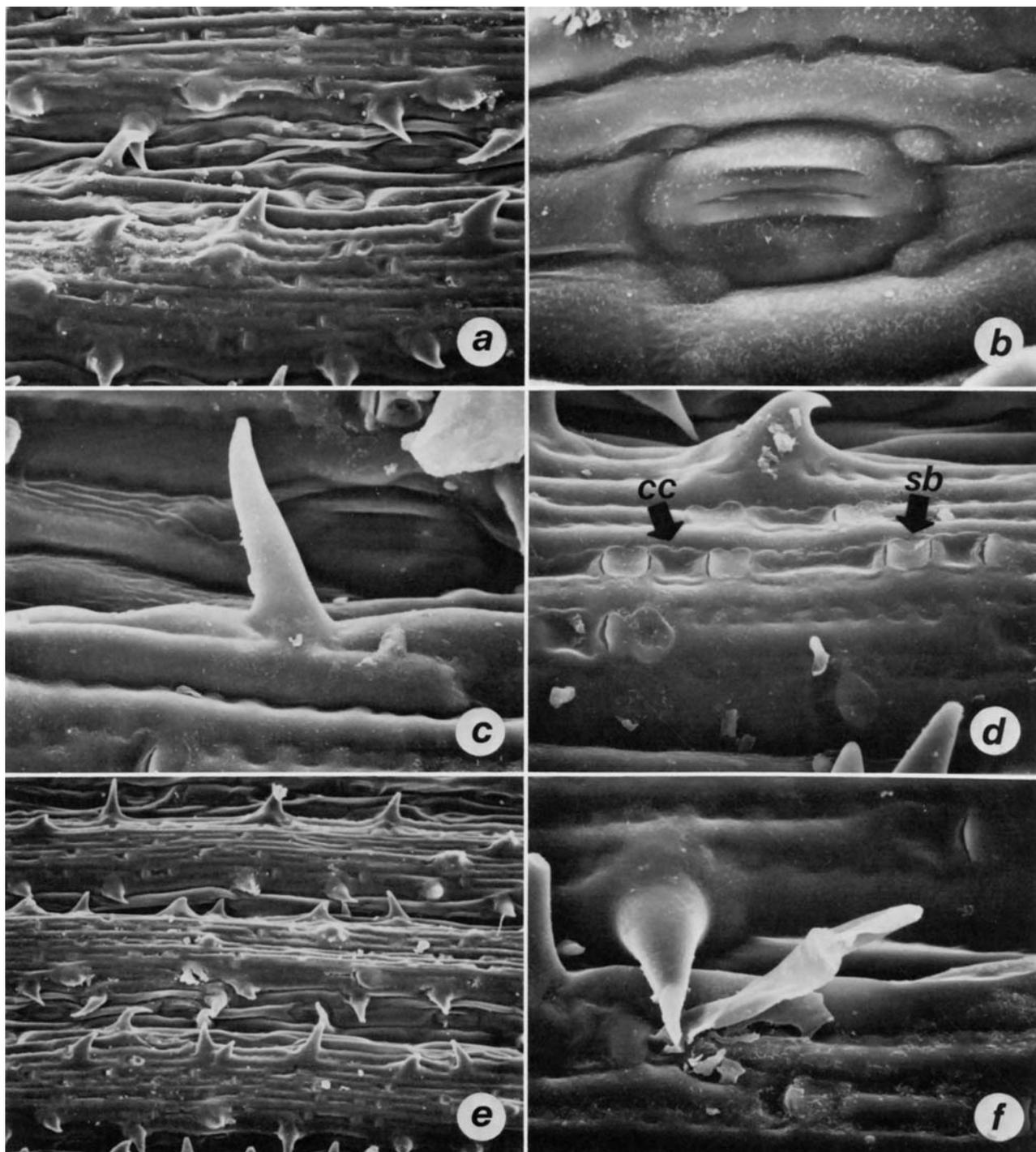


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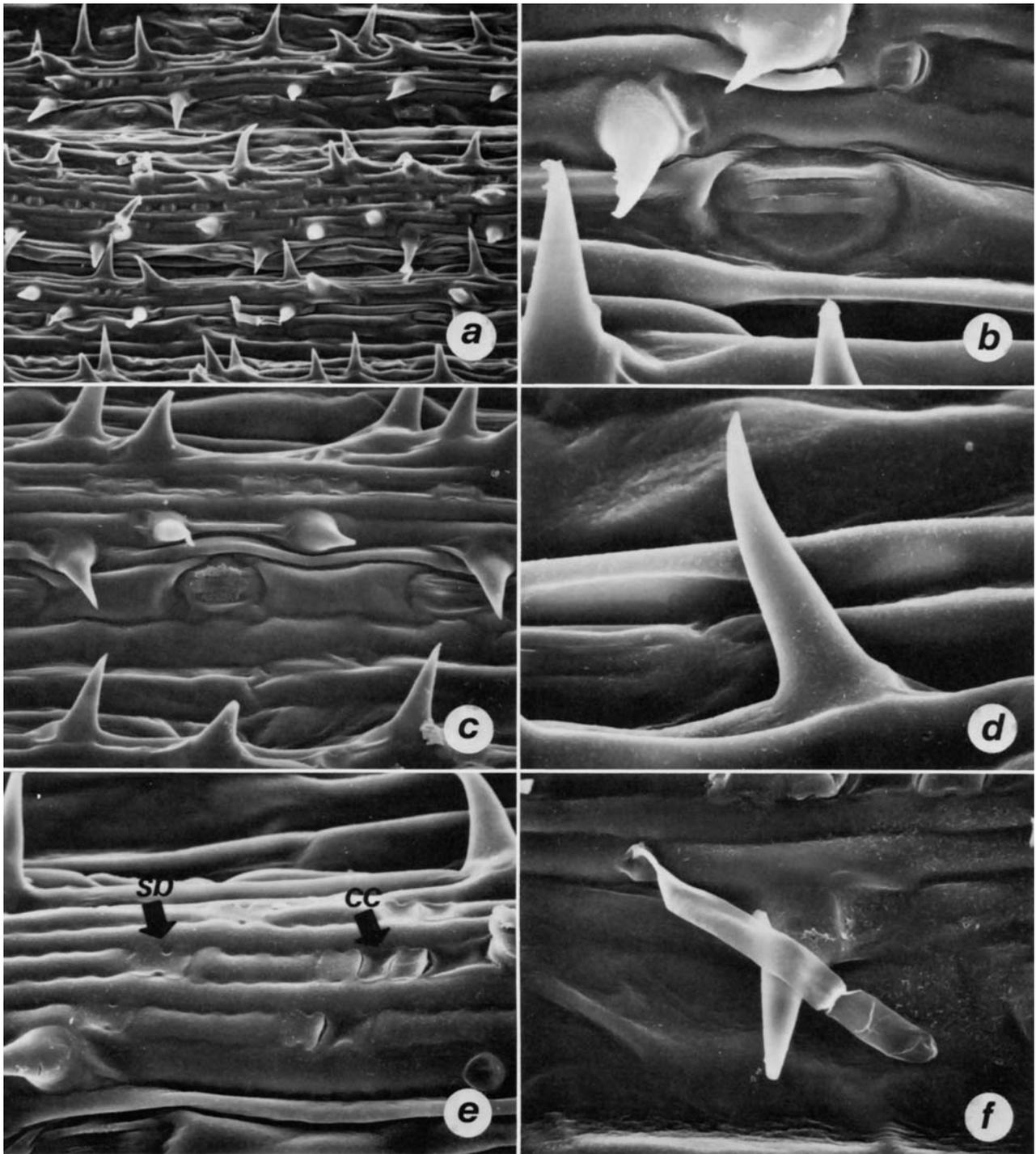


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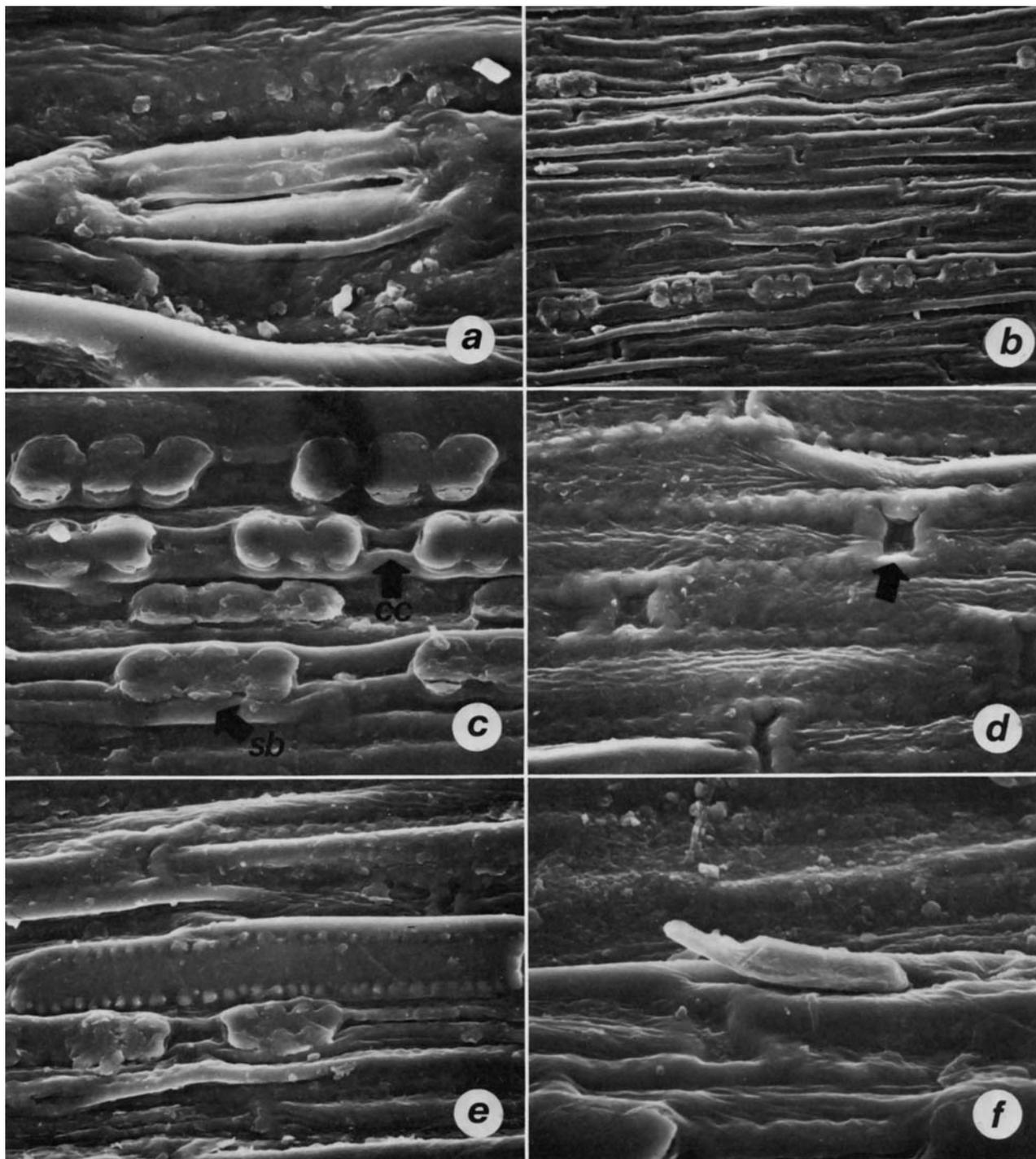


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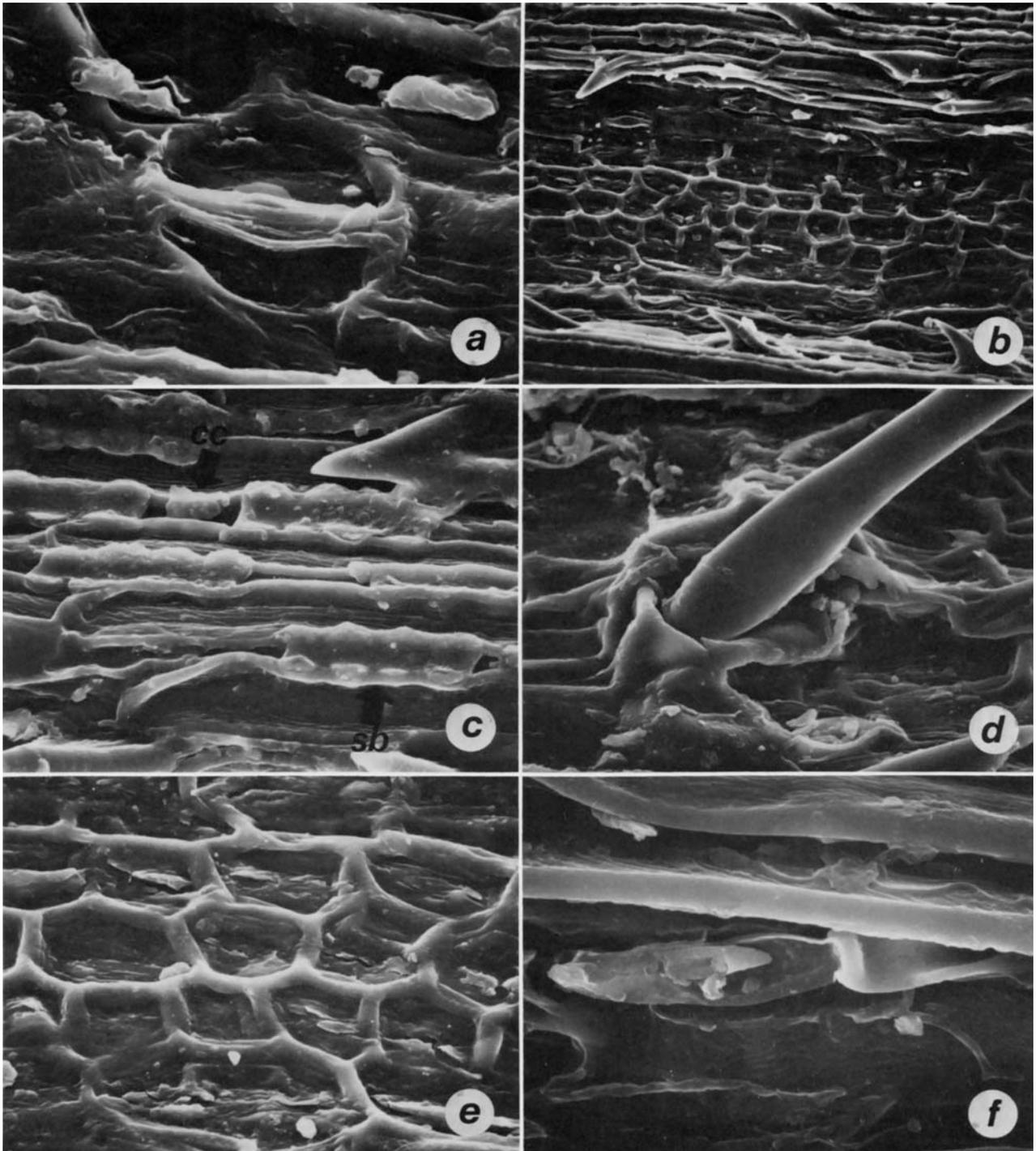


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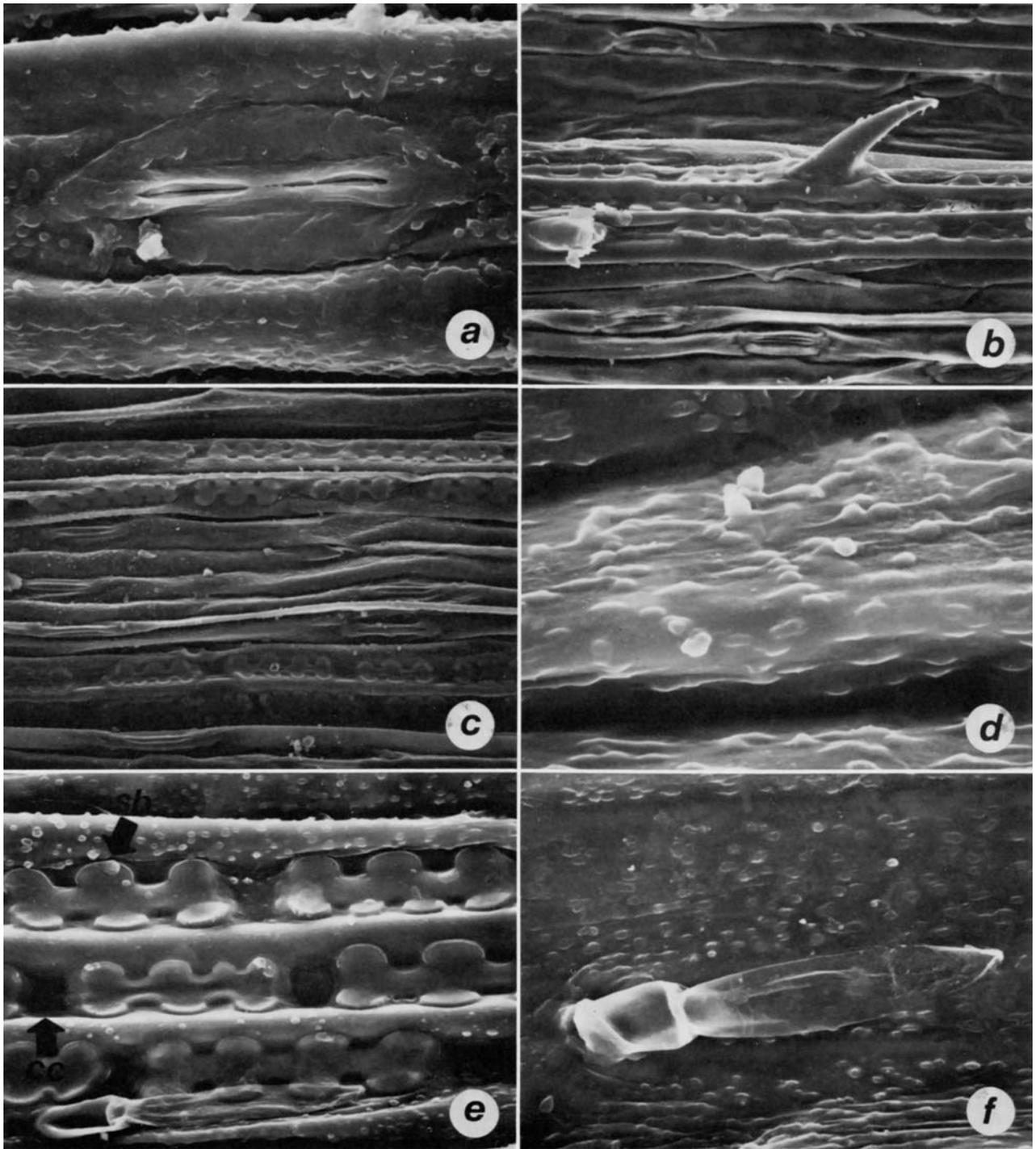


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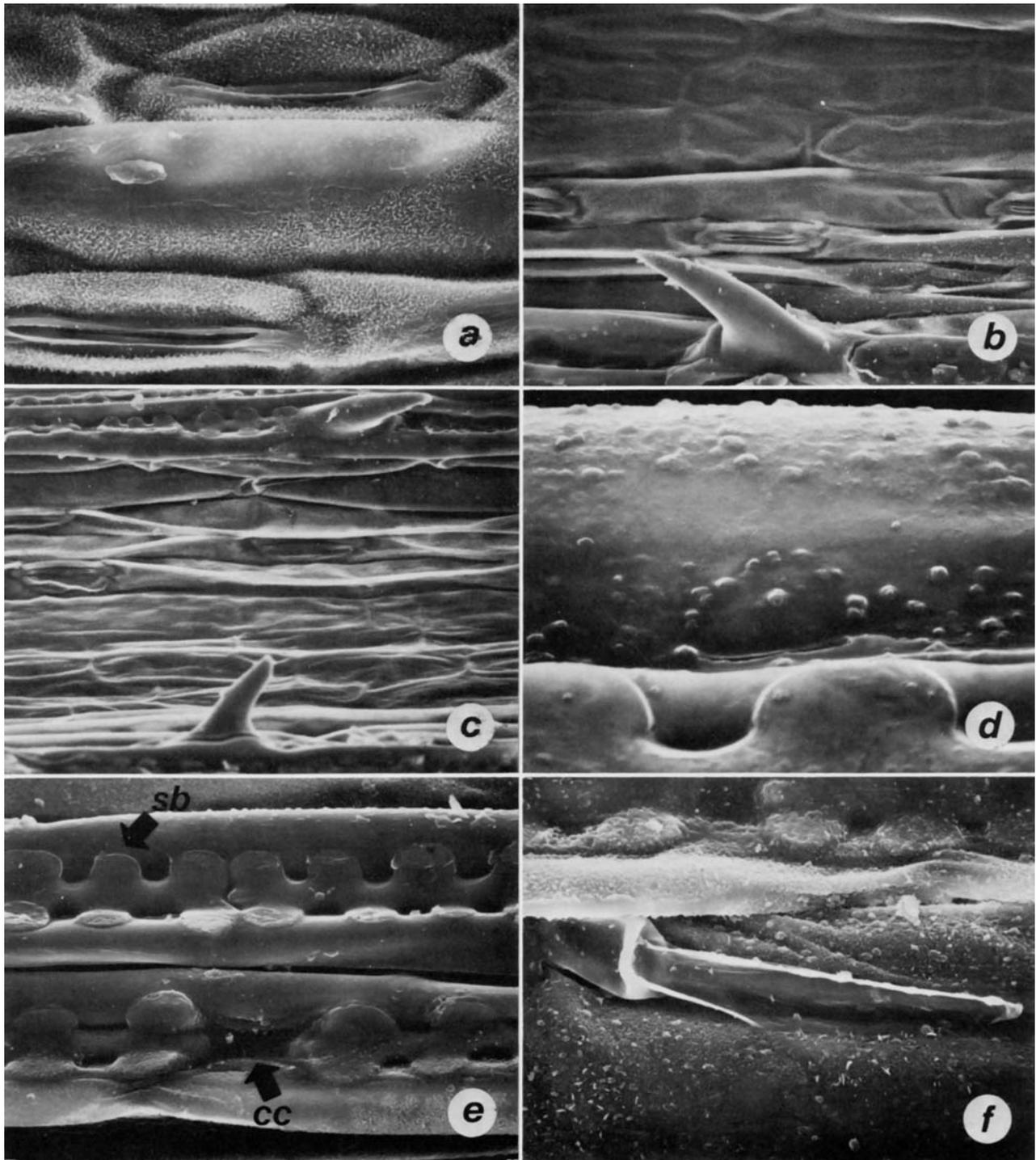


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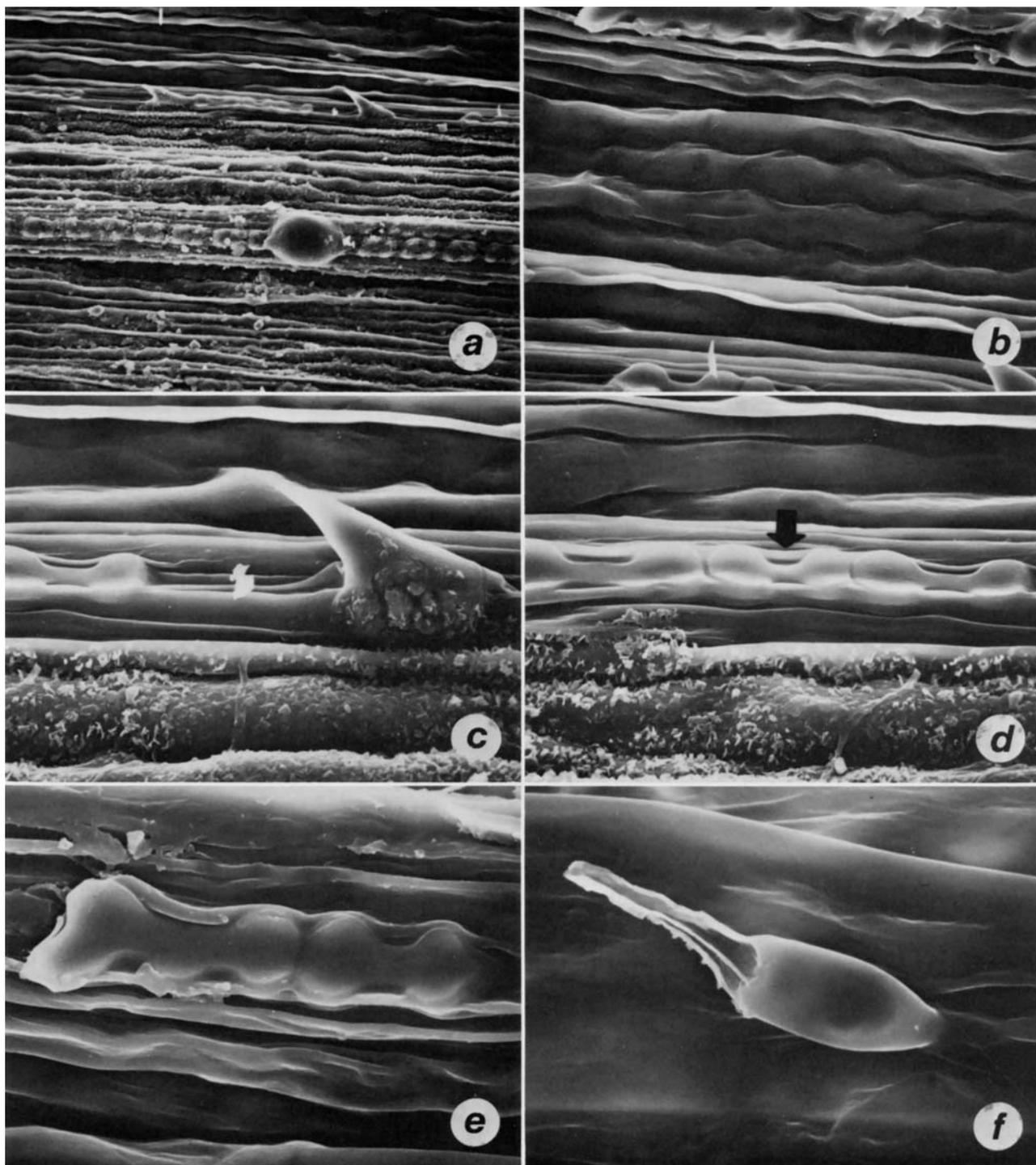


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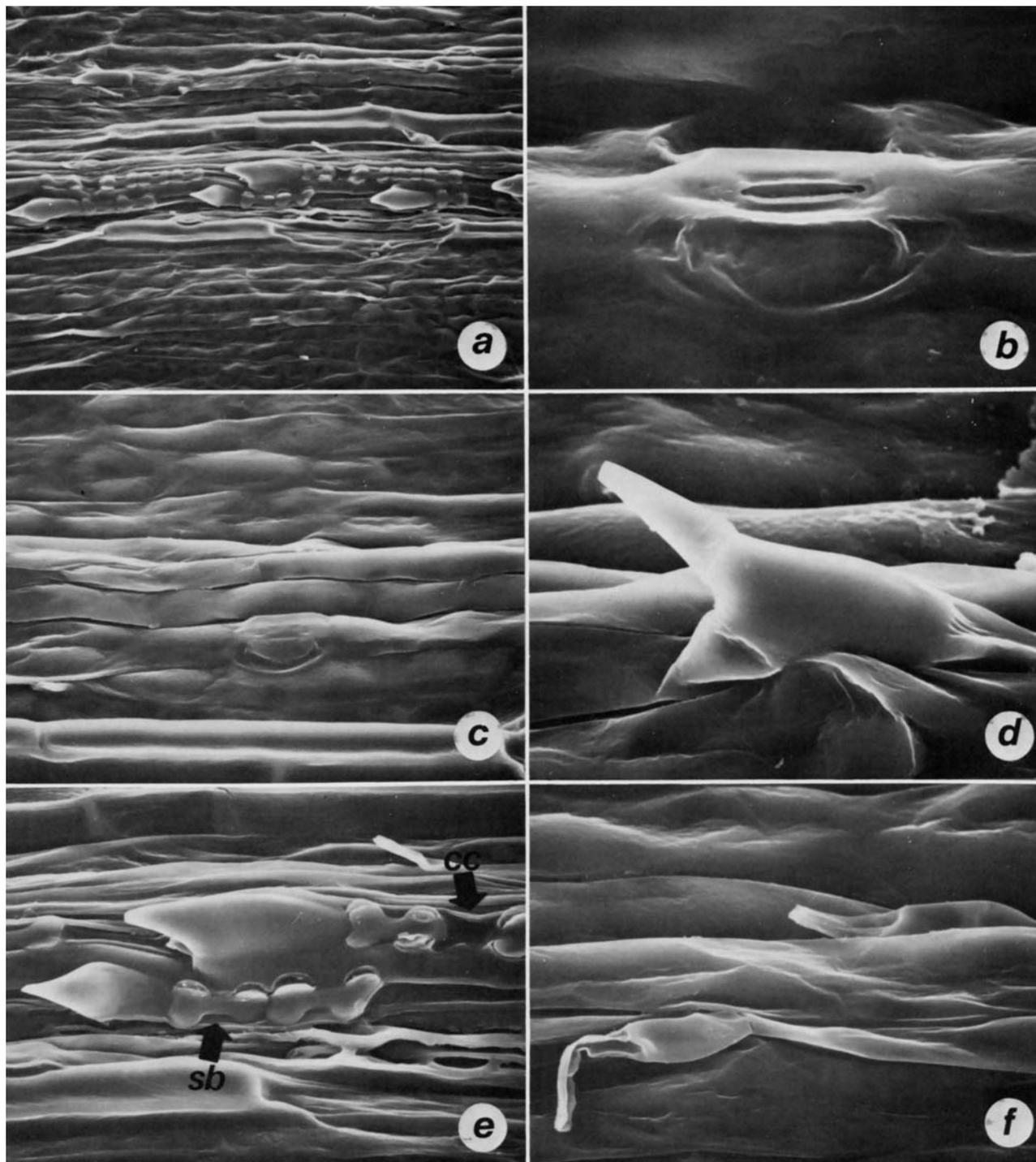


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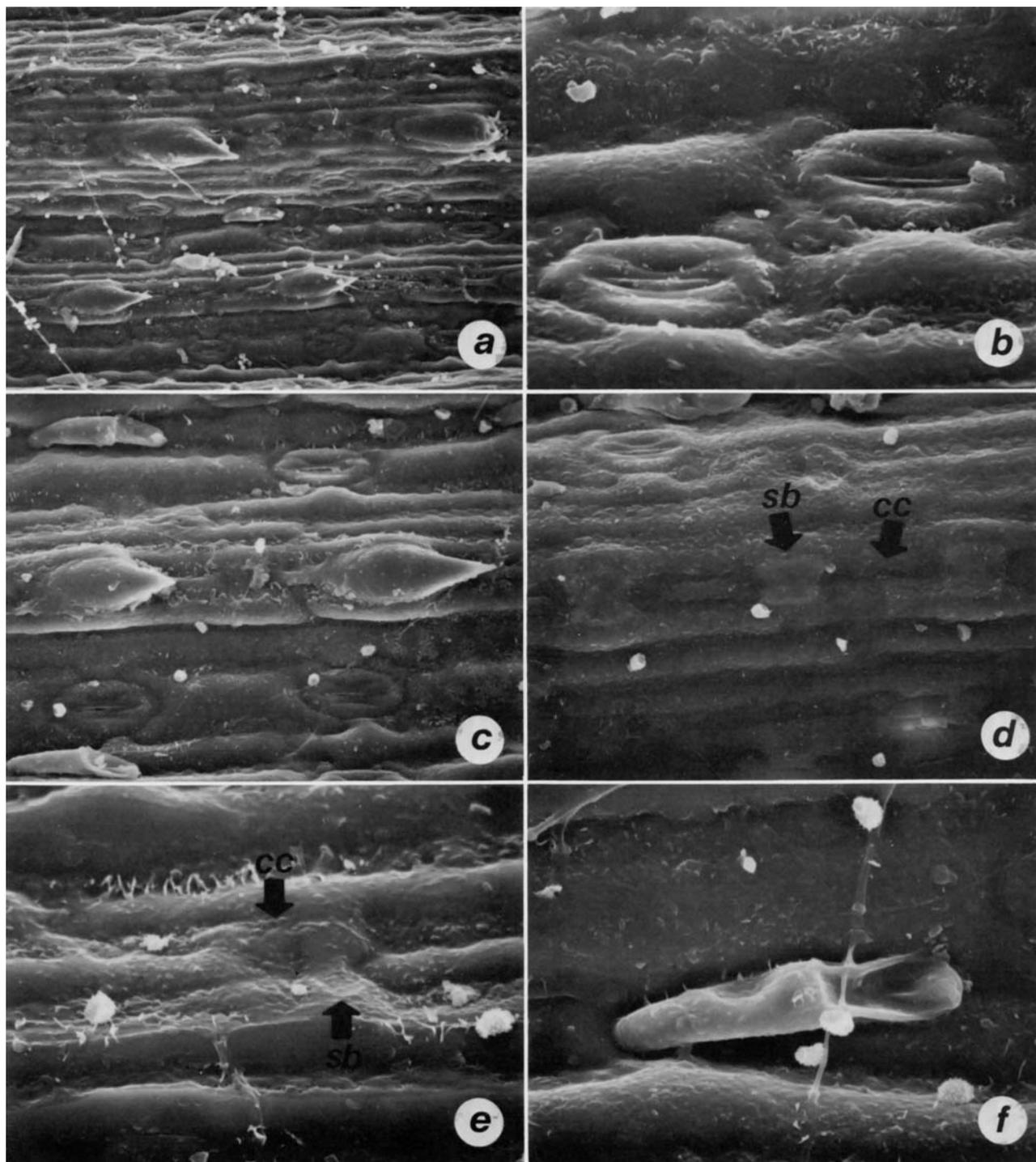


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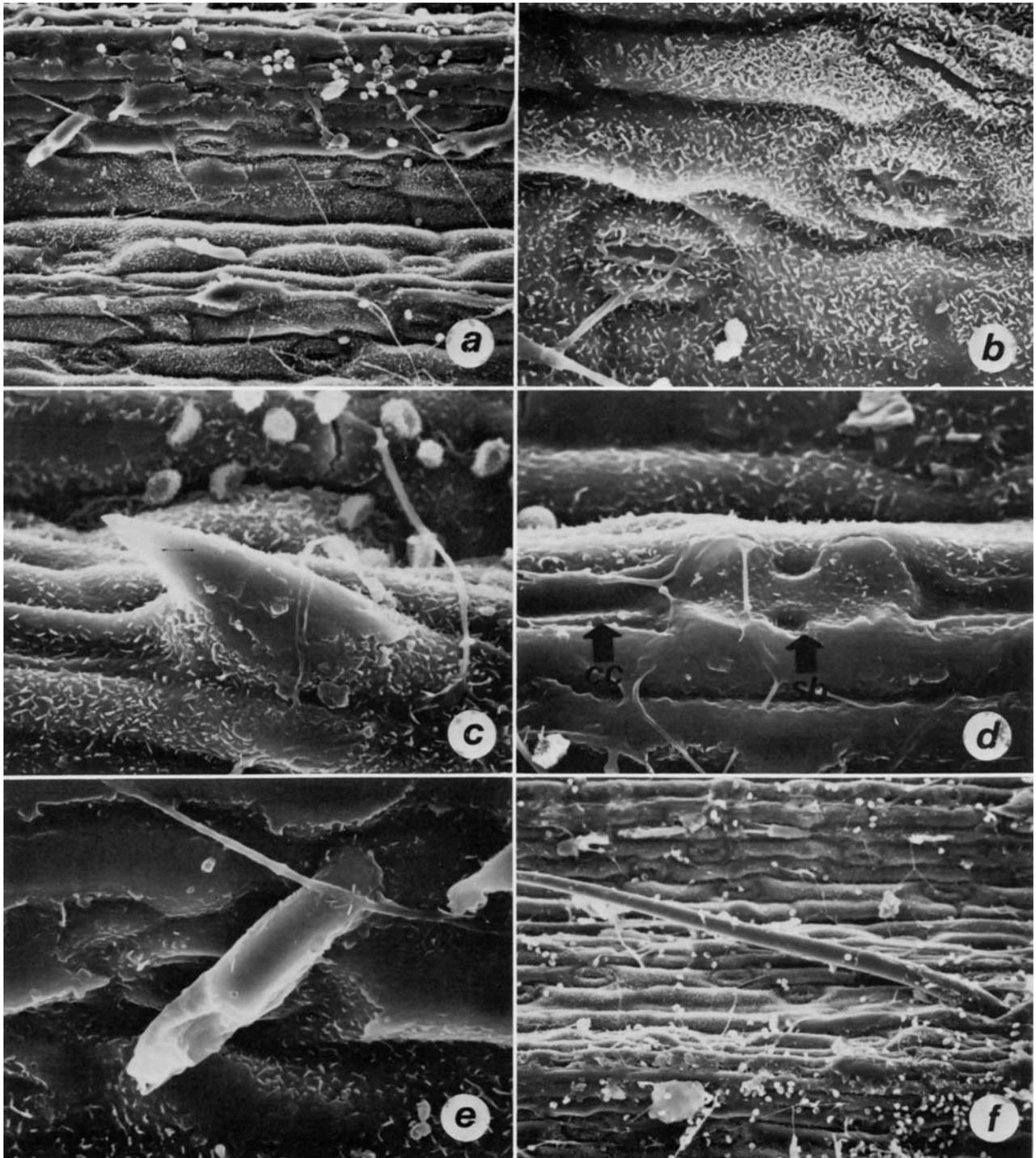


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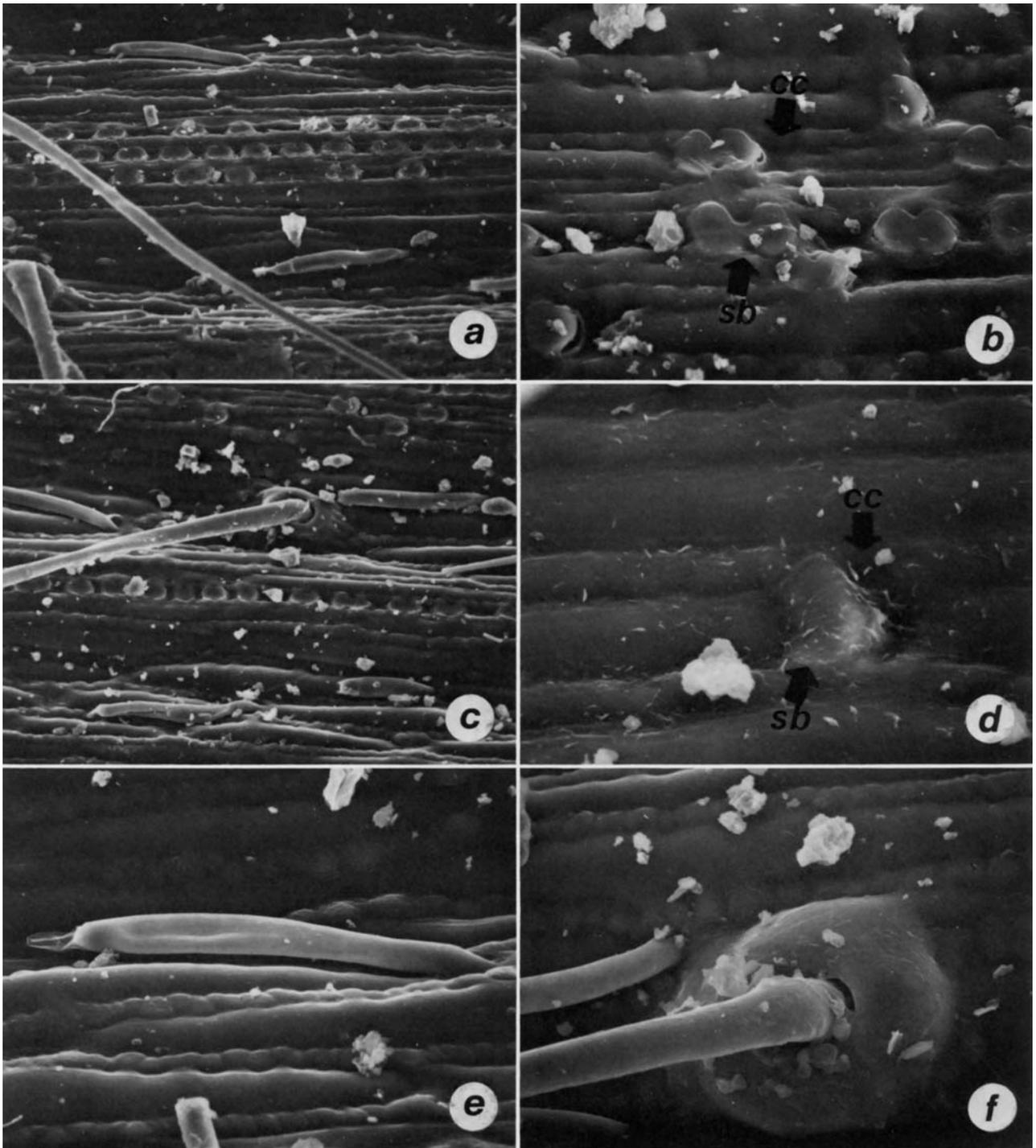


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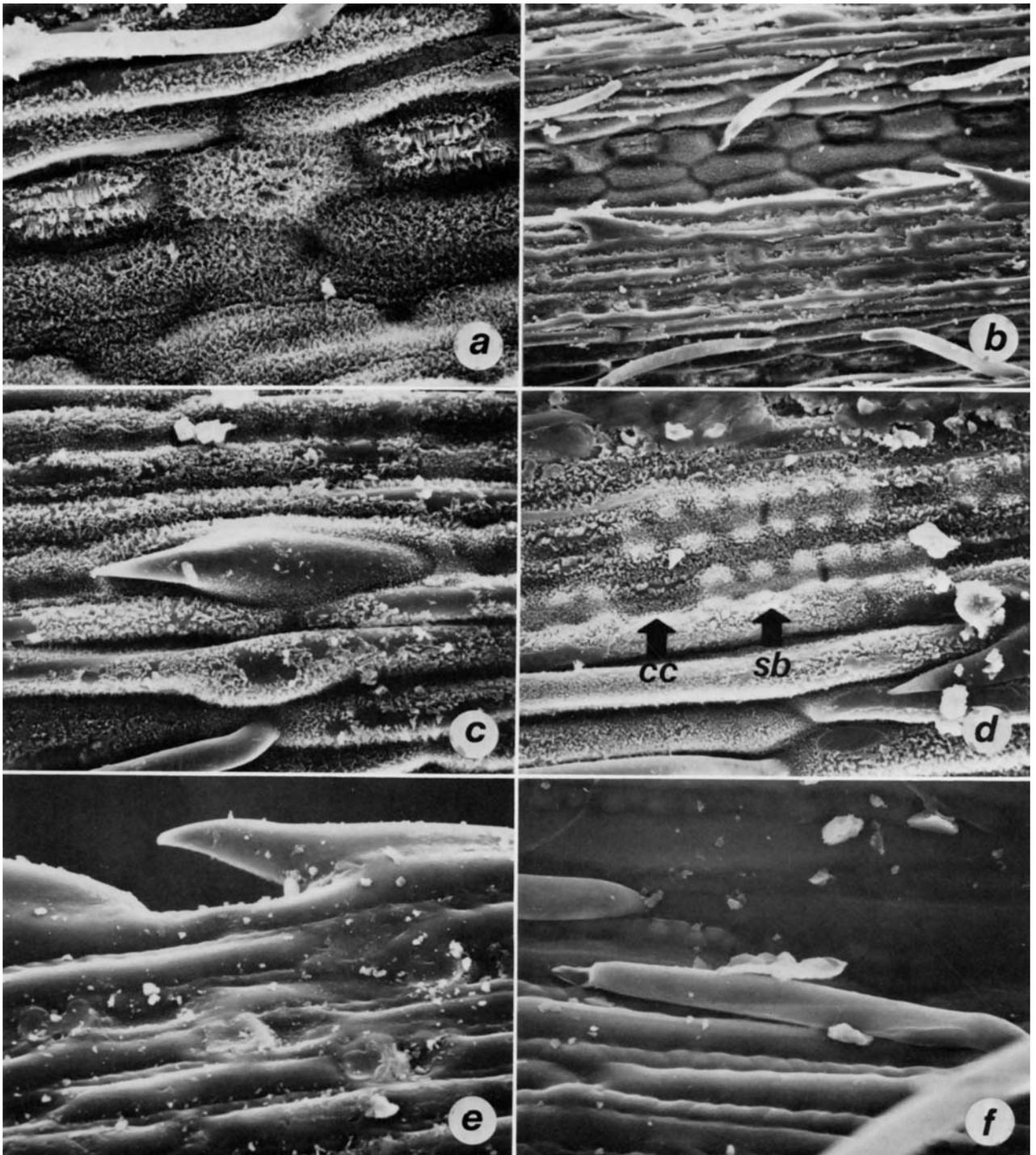


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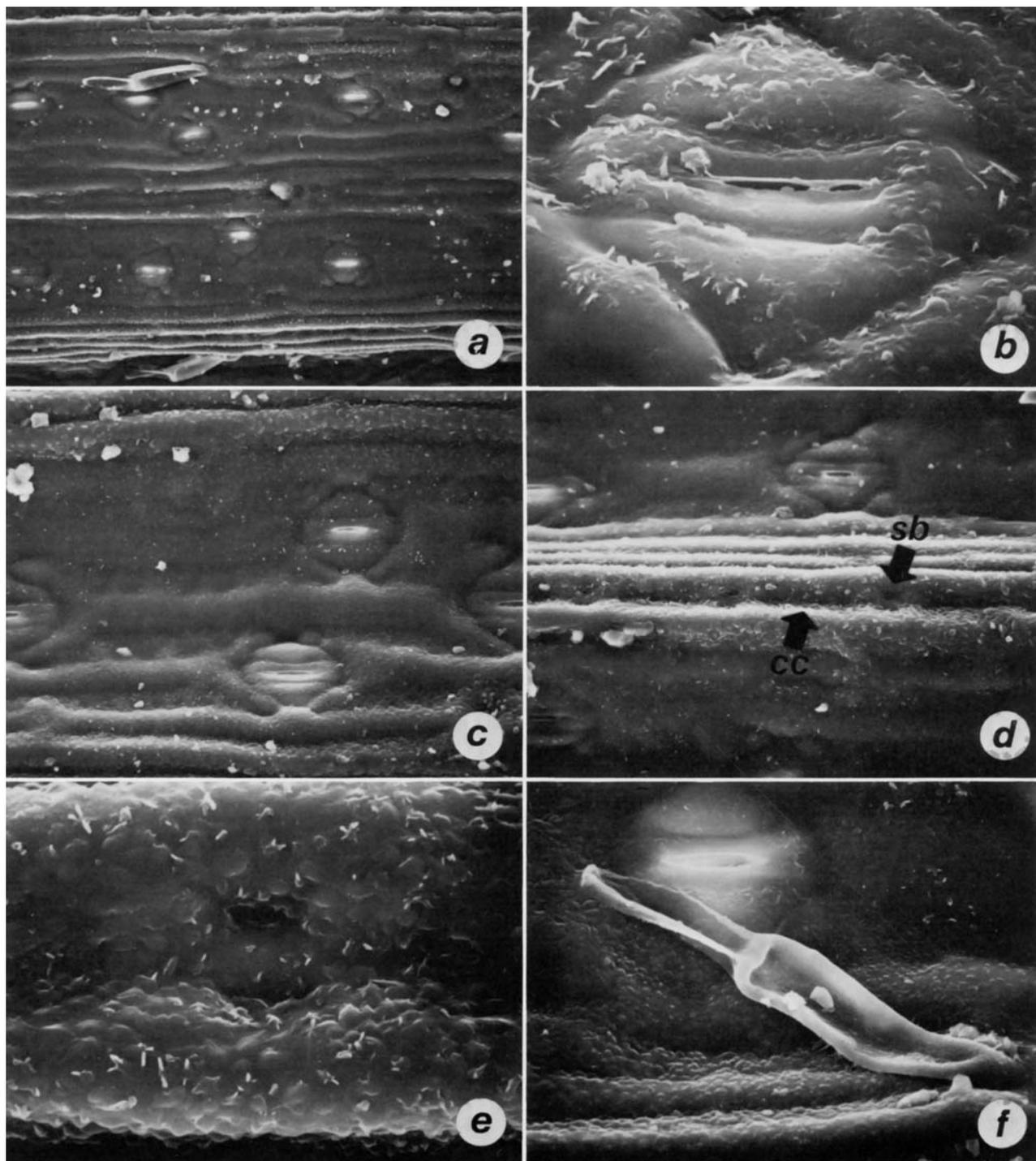


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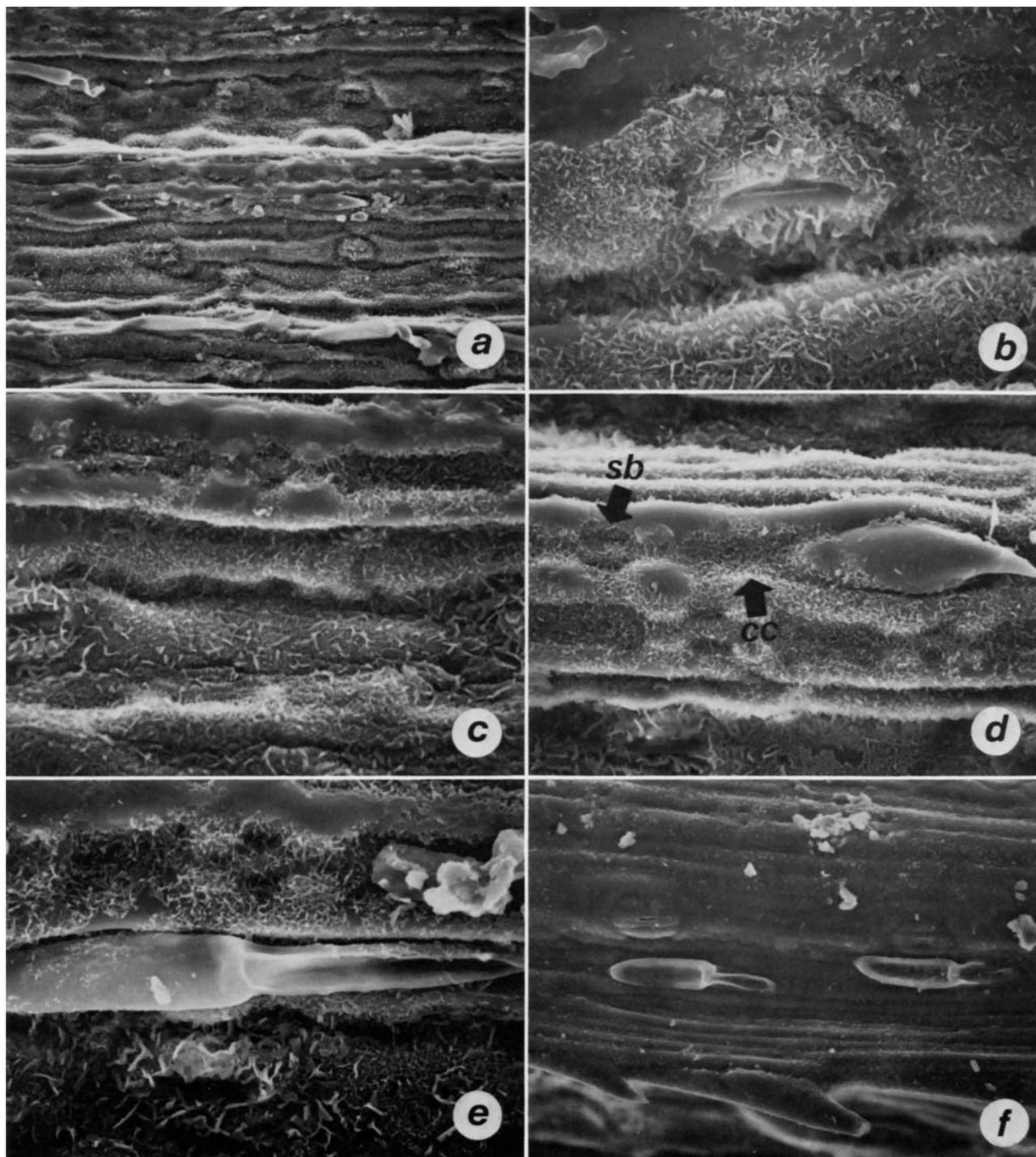


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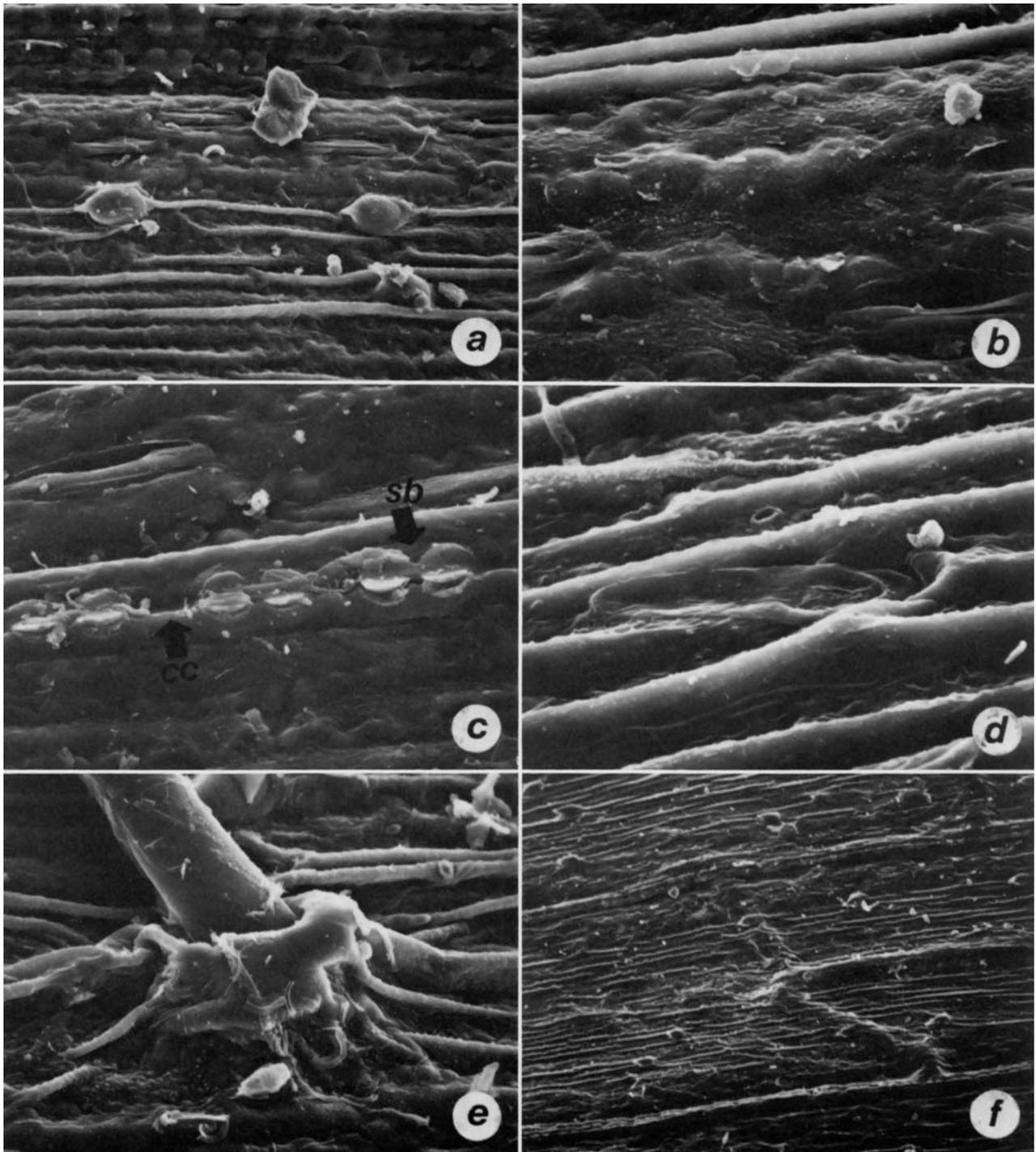


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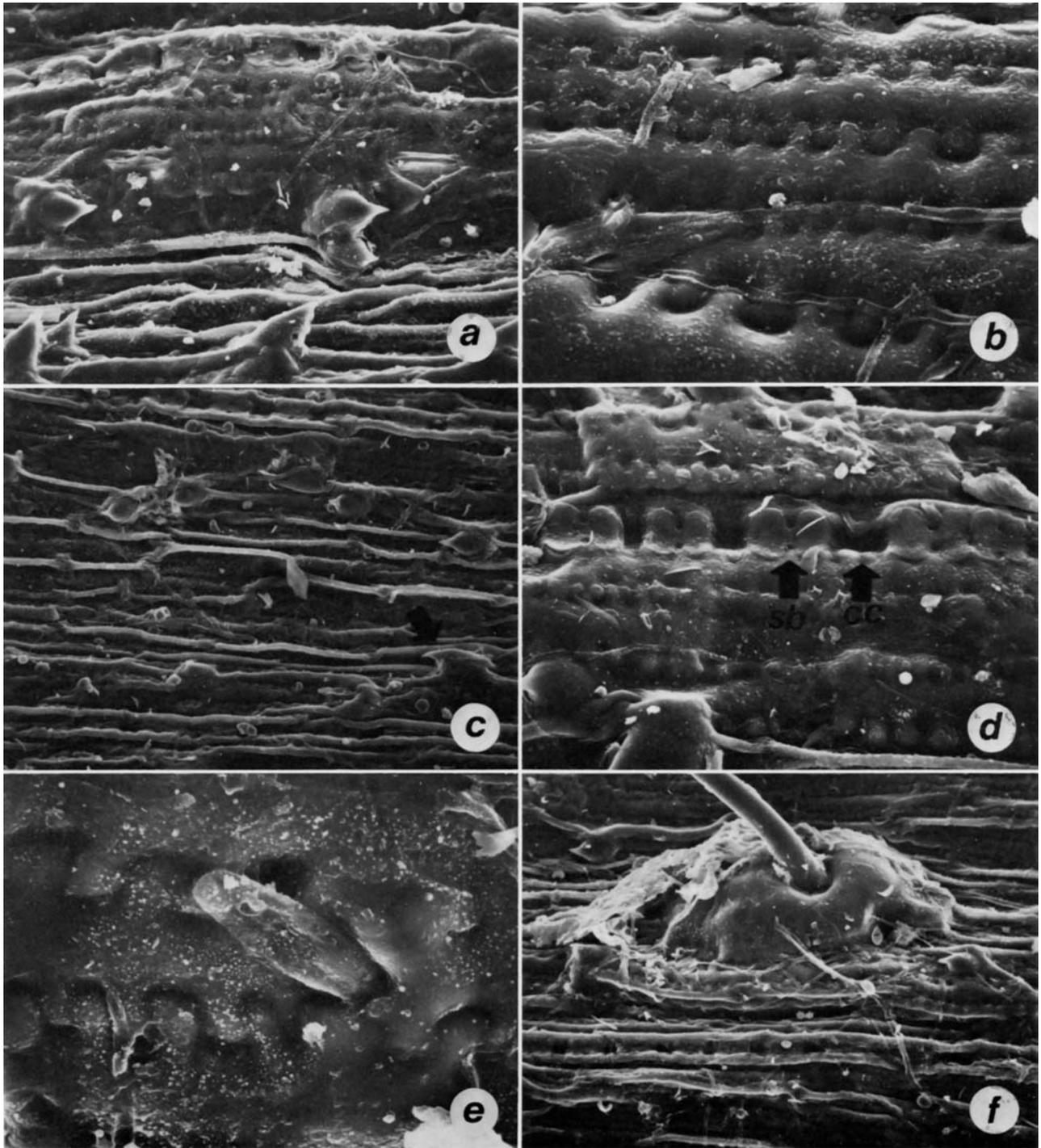


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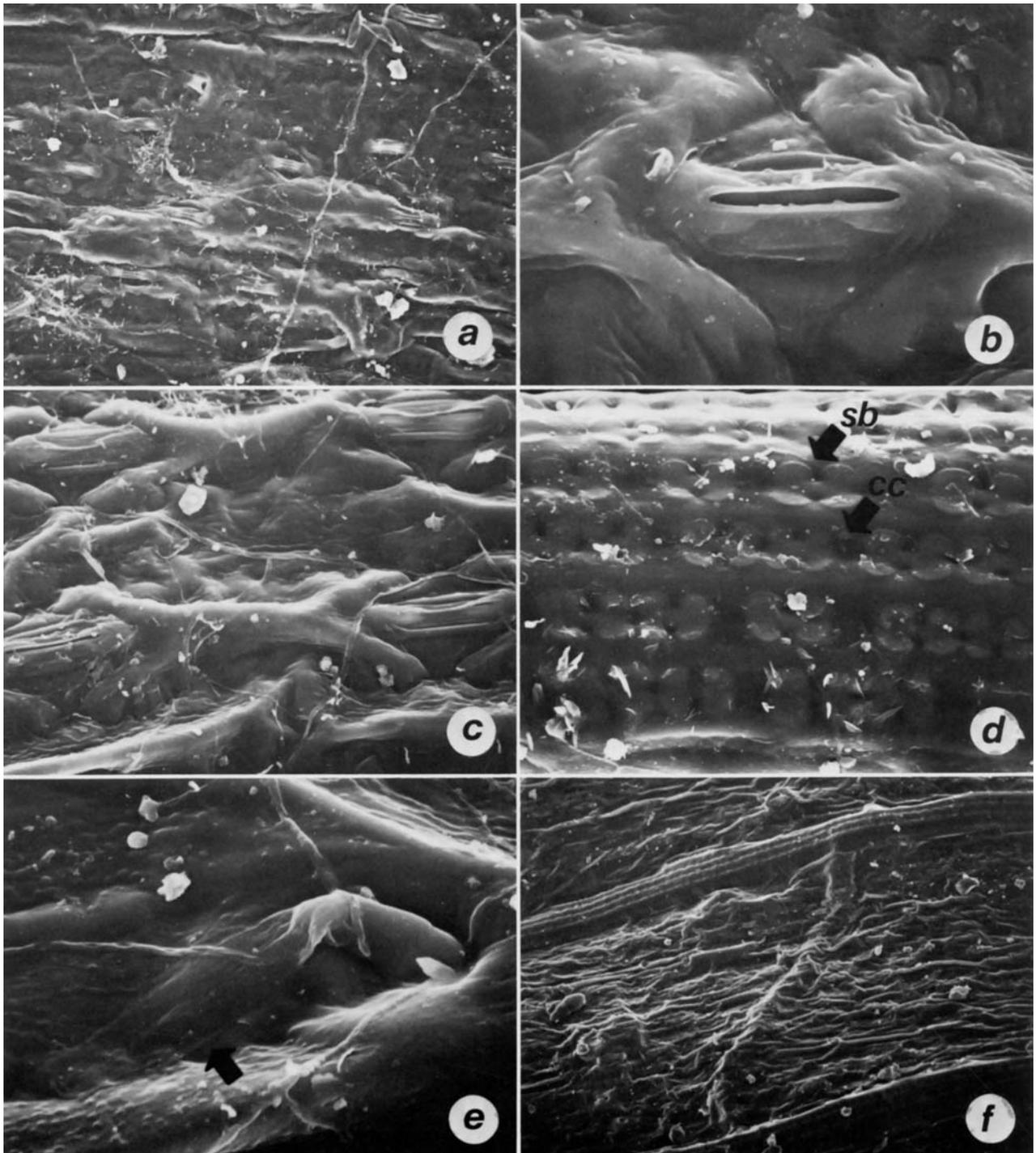


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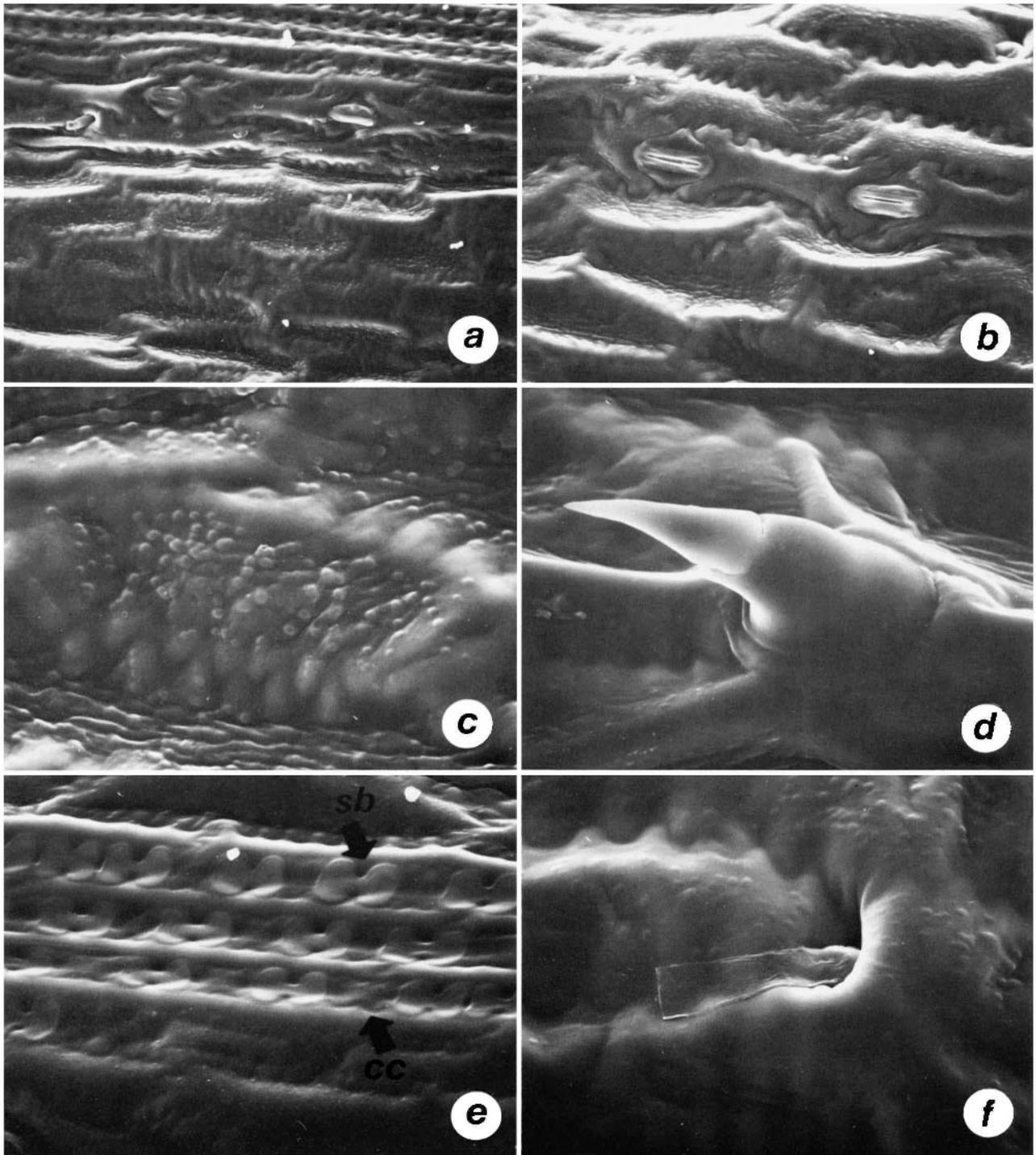


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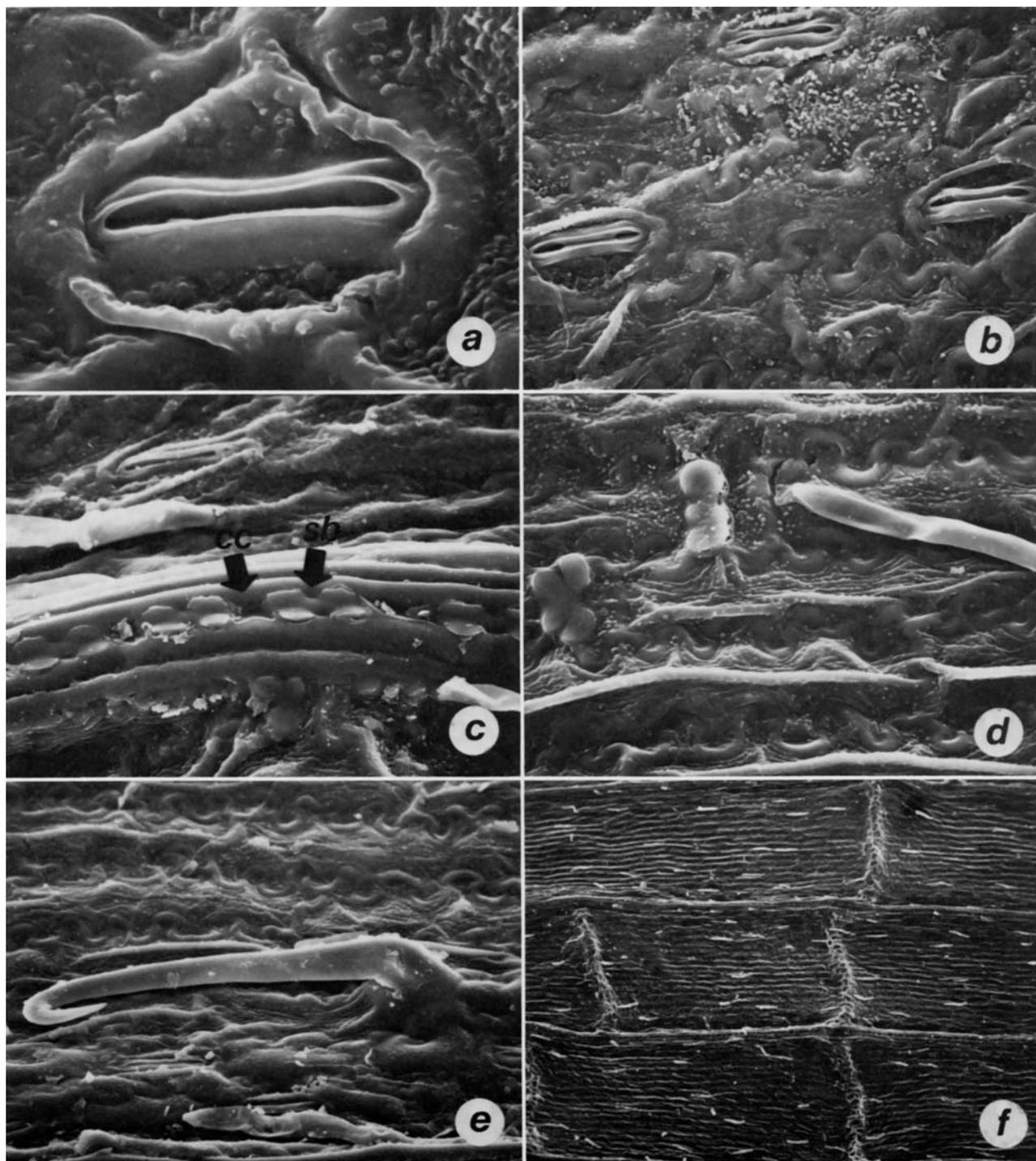


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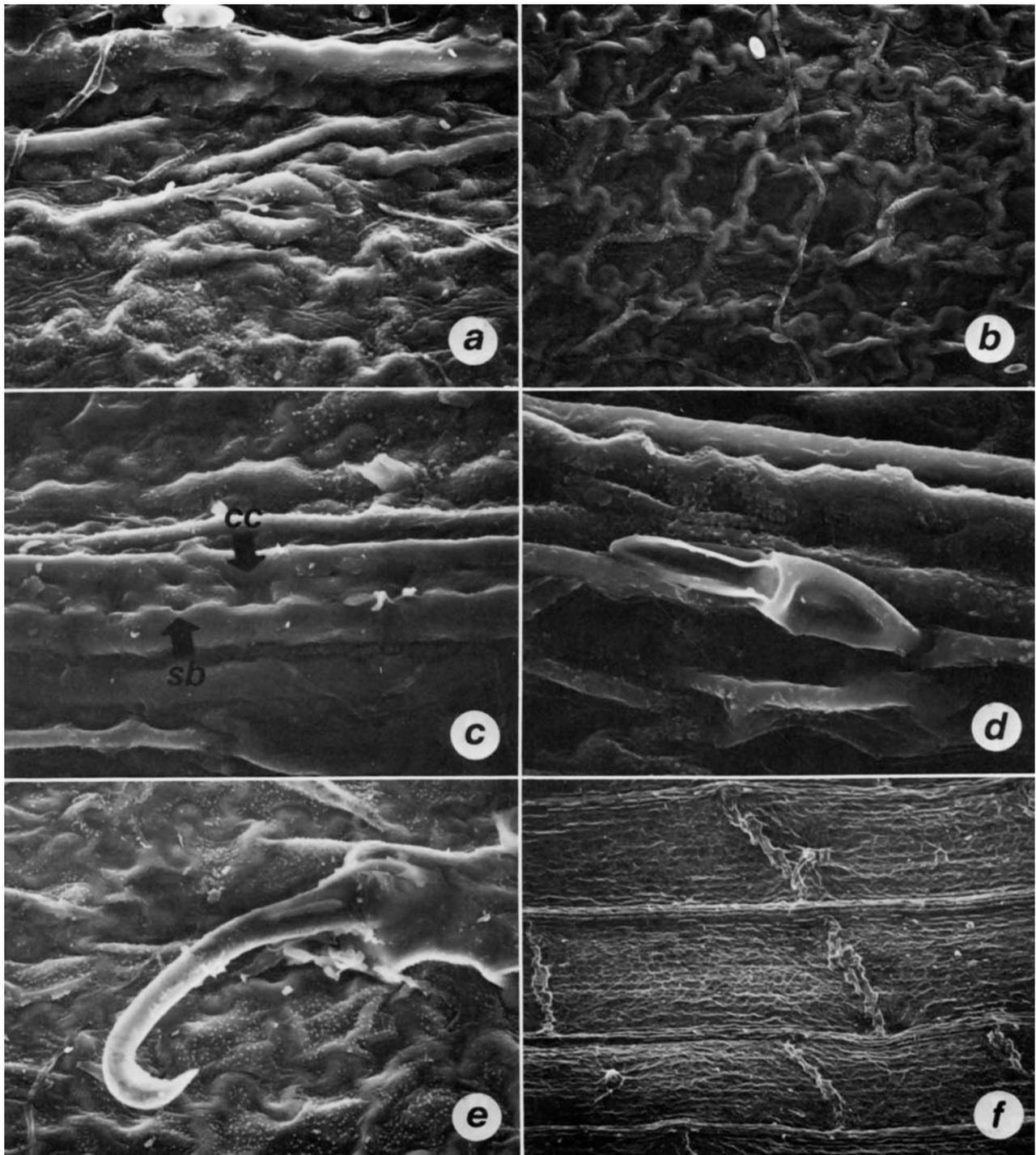


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