

MACRO-AND MICROMORPHOLOGY OF HIBISCUS SABDARIFFA L.
CULTIVATED IN EGYPT.

Part II-Flower, Fruit and Seed.

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ABSTRACT

The macro-and micromorphology of the flowers, fruits and seeds of Hibiscus sabdariffa L. are presented to show the diagnostic characters of these organs by which they could be identified and differentiated in the entire and powdered forms.

INTRODUCTION

In a previous communication¹, the macro-and micromorphology of the root, stem and leaf of Hibiscus sabdariffa L. Family Malvaceae carried were out.

This work deals with the macro-and micromorphology of the flowers, fruits and seeds of this plant.

EXPERIMENTAL

Materials :

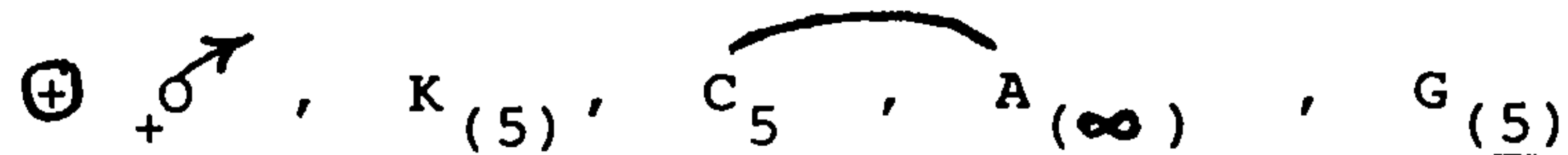
The flowers and fruits of Hibiscus sabdariffa L. were collected from plants grown in the Experimental Station, Faculty of Pharmacy, Assiut University. The identity of the plant was verified by Prof. Dr. A.Fayed, Prof. of plant taxonomy, Dept., of Botany, Faculty of Science, Assiut University.

The material used in this study was fresh or preserved in alcohol 70% containing 5% glycerin. The powder was prepared from air-dried plants.

Macromorphology

A- The Flower (Fig. 1,B)

It is actinomorphic, hermaphrodite, pedicellate and having the floral formula :



It is odourless and having a mucilagenous taste, measuring 3.0 to 4.0 cm in length.

1- The Epicalyx (Fig. 2,C)

Is represented by 8-10 linear-oblong or tuberculate bracteoles measuring 0.8 to 1.0 cm in length and 0.1 to 0.3 in diameter. It is purple in colour.

2- The Calyx (Fig. 2C)

Is persistent, consisting of 5 united sepals. They are lanceolate in shape, purple in colour with acute apices. Each sepal is 3-nerved, fleshy with spiny outer surface and smooth inner surface. They measure 1.2 to 2.5 cm in length and 0.7 to 1.5 cm in width.

3- The Corolla (Fig. 2E)

Is formed of five free, thin convoluted petals. They are purple in colour with crimson basal part, spathulate in shape with obtuse apex and smooth outer and inner surfaces. The petal measures 3.0 to 3.5 cm in length and 1.5 to 2.5 cm in width.

4- The Androecium (Fig. 2B)

Is formed of a staminal tube, travelling about half the length of the petals, measuring 1.5 to 2.0 cm in length, bearing very short filaments each ending with small, yellow two-lobed anthers.

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5- The Gynoecium (Fig. 2B)

The ovary is superior, formed of five united carpels, showing five locules. Each locule contains 3-5 ovules arranged on axile placenta. The surface of the ovary is hairy. It measures 0.4 to 0.7 cm in length and 0.3 to 0.5 cm in width. The style is long, emerges from the staminal tube and ends with five stigmas. The stigmas are dark red in colour. The style and stigma measure 1.0 to 1.5 cm in length.

6- The Pedicel (Fig. 2A)

Is erect, cylindrical, very short. It is purple in colour and measures 0.4 to 0.7 cm in length and 0.2 to 0.4 cm in diameter.

II- The Fruit (Fig. 1,B,3)

Is stalked and ovoid carcerulus green in colour when unripe, and reddish-brown after ripening. The outer surface is shining and hairy; On ripening the carcerulus splits into five many seeded portions. The fruit measures 2.0 to 3.5 cm in length and 1.0 to 2.5 cm in diameter. It is odourless and having a mucilaginous taste.

III- The Seed (Fig. 3,C)

Is dark-brown in colour, Kidney-shaped and measures from 0.3 to 0.6 cm in length, 0.2 to 0.4 cm in width and 0.2 cm in thickness. The seed shows two flat surfaces, It is thicker towards the dorsal side and thinner towards the ventral side, along which the raphe extends. The hilum and micropyle are neighbouring each other at the apex of the seed. It is anatropous. The seed is albuminous, the embryo is orthoplocous which is surrounded by a scanty endosperm. The embryo is formed of two large leafy and difficulty separable cotyledones. The two cotyledons bent back-ward enclosing the curved radicle. The seed is odourless, but has a slightly mucilaginous oily taste.

Micromorphology

1- The Flower:

1- The Epicalyx (Fig.4)

A transverse section in the epicalyx (Fig. 4,A) consists of hairy upper and lower epidermises, followed by a wide parenchymatous cortex and numerous vascular bundles arranged in a circle enclosing a central wide aerenchyma.

The upper and lower epidermises (Fig. 4,B,C) are formed of polygonal, isodiametric, tabular cells with straight anticlinal walls, covered with smooth cuticle, some cells contain cluster crystals of calcium oxalate measuring 28-55-83 u in diameter.

The epidermal cells carrying anisocytic stomata and both glandular and covering trichomes. The glandular ones are formed of unicellular stalk, multicellular (8-12 cells), biseriate, globular head, measuring 80-99-118 u in length and 60-68-75 u in width. The glandular hairs vary in shape and size, some are conical, unicellular with thick-cellulosic walls and acute apices measuring 300-441-582 u in length and 58-86-115 u in width, the other type occurs either single or stellate of 3-4 unicellular hairs, which show thinner cellulosic walls, wide lumina and acute apices and measure 455-502-550 u in length and 25-29-33 u in width. The epidermal cells measure 50-88-125 u in length, 30-56-82 u in width and 28-33-38 u in height.

The cortex (Fig. 4B) is formed of almost rounded, large thin-walled parenchymatous cells. Cluster crystals of calcium oxalate similar to those of the epidermis, are scattered in the cells.

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The vascular tissue (Fig. 4,B) is formed of small collateral vascular bundles (10-12), arranged in a circle within the cortical tissue. Each vascular bundle is formed of shining batche of phloem outside and rows of small vessels, separated by biseriate medullary rays, inwards.

The central aerenchyma (Fig. 4,B) consists of network structure, composed of elongated, thin parenchyma enclosing in between air cavities. Some cells of the aerenchyma contain cluster crystals of calcium oxalate.

2- The Calyx (Fig. 5,6)

A transverse section in the sepal (Fig. 5,A) shows three similar neural parts connected together with two thin inter-neural regions. It consists of hairy upper and lower epidermises enclosing in between a wide cortex followed by 4-5 collateral vascular bundles in each neural part.

The upper epidermis is formed of polygonal, tabular, axially elongated cells with straight anticlinal walls at the apical and middle parts (Fig. 6A,B), but with beaded anticlinal walls at the basal part (Fig. 6C). Those of the apical and middle parts measure 63-97-130 u in length, 20-48-75 u in width and 30-39-48 u in height, but those of the basal part measure 117-140-160 u in length and 60-75-90 u in width. They are covered with smooth cuticle, carrying some anisocytic stomata, which are present on the basal part as well as glandular and covering trichomes, which are similar to those of the epicalyx, and others show elongated head, composed of unicellular stalk, multicellular (18-20 cells), biseriate, elongated head. The latter measures 204-208-212 u in length and 48-53-58 u in width. The non-glandular hairs vary in shape and size. Some are conical, unicellular with thick striated cellulose walls, narrow lumina and acute or blunt apices,

measuring 565-589-612 u in length and 75-97-120 u in width. The other type is conical, unicellular with thick cellulosic walls, narrow lumena and acute apices, measuring 980-1010-1040 u in length and 18-39-60 u in width. The last type occurs either single or octopus-stellate of 2-4 unicellular hairs which show thinner cellulosic walls, wide lumena, acute apices and measure 155-425-695 u in length and 13-16-20 u in width. Cicatrices are present. Some epidermal cells contain cluster crystals of calcium oxalate.

The lower epidermis is formed of polygonal, tabular cells with straight anticlinal walls. They measure 63-96-122 u in length, 50-65-80 u in width and 28-40-53 u in height at the apical and middle parts (Fig. 6D, E), but measuring 38-52-65 u in length and 28-38-48 u in width at the basal part (Fig. 6F). They are covered with smooth cuticle, Some epidermal cells contain cluster crystals of calcium oxalate. The anisocytic stomata as well as glandular and covering trichomes resembling those of the upper epidermis are observed.

The cortex (Fig. 5,B) is formed of nearly rounded, parenchymatous cells with thin-cellulosic walls, showing intercellular spaces. Large mucilage cavities (ruthenium red test) are observed in the cortical tissue, measuring 240-370-500 u in diameter. Cluster crystals of calcium oxalate resembling those of the epidermis are scattered in the cortical tissue.

The vascular tissue (Fig. 5,B) is formed of collateral vascular bundles, with spiral and scalariform xylem vessels towards the upper epidermis and phloem towards the lower one, bi-or triseriate (in the xylem region), uniseriate (in the phloem region) medullary rays separate the vascular strands. The vessels measure 18-30-42 u in diameter. Cluster crystals of calcium oxalate are observed in the cells between the phloem tissues.

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3- The Corolla (Fig. 7,8)

A transverse section in the petal (Fig. 7,A) consists of hairy upper and lower epidermises enclosing in between a wide parenchymatous cortex followed by small collateral vascular bundles alternating with large mucilage cavities.

The upper epidermis shows variations in the shape and size of the epidermal cells. Those of the apical and middle parts (Fig. 8A,B) are similar in shape, being polygonal with straight anticlinal walls, usually papillosed, stomata and trichomes are not observed. The basal part (Fig. 8,C) shows larger cells (85-117-150 u in length and 85-100-115 u in width) than those of the apical and middle parts (30-70-105 u in length, 28-42-57 u in width and 28-39-51 u in height) and numerous glandular trichomes. The latter consist of unicellular stalk, multicellular (30-45 cells), tri-or multiseriate, club-shaped or elongated head. They measure 260-337-415 u in length and 75-110-145 u in width.

The lower epidermis does not show stomata. The apical and middle parts (Fig. 8,D,E) show polygonal, isodiametric cells carrying both glandular and covering trichomes. The glandular ones are formed of unicellular stalk, multicellular (10-20 cells), biseriate, elongated head, measuring 145-192-240 u in length and 45-57-70 u in width. The covering trichomes are either single or stellate of 2-4 unicellular hairs with thin-cellulosic walls, wide lumina and acute apices, they measure 540-812-108 u in length and 12-20-28 u in width. The epidermal cells of this region measure 40-62-85 u in length, 30-45-60 u in width and 28-51-75 u in height. The epidermal cells of the apical part show papillae. The basal part (Fig. 8,F) shows larger cells and only the glandular trichomes, resembling those of the upper surface. The cuticle covering both upper and lower surfaces, is smooth.

The cortex (Fig. 2,B) is formed of nearly rounded parenchymatous cells with thin-cellulosic walls showing intercellular spaces. Cluster crystals of calcium oxalate as well as few minute starch granules are scattered in the cortical tissue. Large mucilage cavities, measuring 500-750-1000 u in diameter, are observed.

The vascular tissue (Fig. 7,B) is formed of small collateral vascular bundles with spiral xylem vessels towards the upper epidermis and phloem towards the lower one, uni-or biseriate medullary rays separate the xylem vessels.

4- The Androecium (Fig.9)

The staminal tube and the filament:

The surface preparation in the staminal tube (Fig.g,D) and the filament (Fig. 9,E) are more or less similar except the latter is devoid of stomata and smaller in size. The epidermal cells are polygonal, tabular with straight anticlinal walls, showing papillae. They are covered with smooth cuticle and those of the staminal tube measure 60-87-115 u in length and 28-51-75 u in width, but those of the filament measure 35-52-70 u in length and 30-37-45 u in width. Occasional oval anisocytic stomata are observed in the staminal tube. Glandular trichomes, consisting of bicellular uniseriate stalk, multicellular (15-20 cells), triseriate, club- or oval shaped, are present and measure 315-337-360 u in length and 125-150-175 u in width.

The Anther (Fig. 9,A)

A transverse section in the anther shows two nearly equal anther-lobes, attached by the connective through which runs a small vascular strand. Each anther-lobe is formed of two² pollen sacs, containing numerous spiny pollen grains. The anther wall is formed of an epidermis followed by a fibrous layer and the remains of the tapetum.

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The epidermis (Fig. 9,B,F) of the anther is formed of polygonal mainly isodiametric cells, with thin-cellulosic, straight anticlinal walls, covered with smooth cuticle showing papillae. Stomata and trichomes are not observed. The epidermal cells measure 22-41-60 u in length, 20-22-35 u in width and 25-35-45 u in height.

The Fibrous layer (Fig. 9,B,C) is formed of one row of polygonal axially elongated cells with lignified bar-like thickened walls. They measure 40-55-70 u in length and 18-29-40 u in width.

The pollen grains (Fig. 9,G) are brownish-yellow in colour, spherical in shape, having spiny exine. They measure 200-225-250 u in diameter.

5- The Gynoecium (Fig. 10)

The Ovary :

A transverse section in the ovary (Fig. 10,A) is circular in outline, showing 5-locules, each contains numerous ovules arranged in a vertical row, and a central vascular bundle.

The epidermis of the ovary (Fig. 10 B) is formed of polygonal isodiametric cells with straight anticlinal walls and covered with smooth cuticle showing anisocytic stomata. The epidermal cells measure 17-31-45 u in length and 12-21-30 u in width. Some of them containing cluster crystals of calcium oxalate. Both glandular and covering trichomes are present on the epidermis. The glandular trichomes are formed of unicellular stalk, multicellular (15-25 cells), biseriate elongated head, and measure 175-202-230 u in length and 45-60-75 u in width. The non-glandular ones are unicellular with thin-cellulosic walls, wide lumina and acute apices, measuring 1335-1780-2225 u in length and 45-60-75 u in width.

The style (Fig. 10,C)

A surface preparation of the style consists of polygonal, isodiametric cells with straight anticlinal walls, showing papillae. They measure 30-75-85 u in length and 30-45-60 u in width. Stomata are not observed.

The stigma :

A surface preparation of the stigma shows dense, long papillae in the apical part (Fig. 10,E) and polygonal, axially elongated cells in the lower part (Fig. 10,D). The latter shows anisocytic stomata and glandular trichomes which are similar to those of the ovary. The papillae of the stigma measure 400-442-485 u in length and 30-47-65 u in width. The cells of the apical part are polygonal, isodiametric and measure 28-49-70 u in length and 22-35-48 u in width.

6- The Pedicel (Fig. 11)

A transverse section in the pedicel (Fig. 11,A) is nearly circular in outline. It shows hairy epidermis followed by a wide cortex, large number (15-20) of collateral vascular bundles enclosing a central wide parenchymatous pith.

The epidermis (Fig. 11,C) is formed of polygonal cells with straight anticlinal walls and covered with thin smooth cuticle. It carries anisocytic stomate and both glandular and covering trichomes. Some epidermal cells contain cluster crystals of calcium oxalate. The epidermal cells measure 35-50-65 u in length, 22-33-45 u in width and 17-22-28 u in height. The glandular trichomes are similar to those of the epicalyx. The non-glandular ones vary in shape and size. Some are conical unicellular with thick cellulosic walls and acute apices, measuring 540-570-600 u in length and 55-67-80 u in width. The other occurs either single or stellate of 2-4 unicellular hairs, with thin-cellulosic walls, wide lumina and acute apices, measuring 745-845-945 u in length and 25-30-36 u in width.

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The cortex (Fig. 11,B) is formed of nearly rounded parenchymatous cells with thin-cellulosic walls, showing intercellular spaces. Numerous mucilage cavities are scattered in the cortical tissue, measuring 150-250-350 u in diameter.

The endodermis (Fig. 11,B) is formed of thin-walled parenchymatous cells containing numerous starch granules.

The pericycle (Fig. 11,B) is formed of small cellulosic thin-walled parenchymatous cells, above each vascular bundle.

The vascular tissue (Fig. 11 B) is formed of small collateral vascular bundles (15-20). Each is formed of shining batche of phloem outward and rows of xylem vessels inward. The vessels are separated by thin-walled biseriate medullary rays. Between the phloem and xylem, the cambium is represented by 2-3 rows of thin-walled meristematic cells. The vascular bundles are separated by parenchymatous cells, some of them contain cluster crystals of calcium oxalate resembling those of the cortex. The vessels measure 17-22-28 u in diameter.

The pith (Fig. 11,B) is formed of more or less rounded parenchymatous cells, and wide intercellular spaces. Cluster crystals of calcium oxalate as well as starch granules are scattered in the cells. Mucilage cavities are not observed.

Powdered Flower

The powdered flower is reddish-brown in colour, odourless and having a mucilaginous taste. It is characterized microscopically by the following.

- 1- Numerous glandular and covering trichomes from the epicalyx, calyx, corolla, filament, ovary, stigma and pedicel.
- 2- Numerous cluster crystals of calcium oxalate.

- 3- Fragments of fibrous layer of anther showing polygonal cells with lignified, bar-like thickened walls.
- 4- Numerous spiny pollen grains, some of which are ruptured with yellow excretions.
- 5- Fragments of papillosed stigma.
- 6- Fragments of the epidermal cells of the anther with the brownish-yellow contents.
- 7- Fragments of the epidermal cells of the hairy ovary showing anisocytic stomata and both glandular and covering trichomes.

B- The Fruit:

The Pericarp: (Fig. 12,13).

A transverse section in the pericarp (Fig. 12,A) is formed of an epicarp and endocarp enclosing in between a wide mesocarp. The mesocarp shows, an outer wide parenchymatous region traversed towards the inner side by a few number of vascular bundles, each being accompanied with a group of lignified fibres, and an inner lignified region being differentiated into two distinct layers, the first is fibrous towards the epicarp, while the second is Sclerenchymatous towards the endocarp.

The epicarp (Fig. 12,B,C) is formed of one row of tabular, somewhat subrectangular, isodiametric, polygonal cells with straight anticlinal walls and covered with smooth cuticle. The epidermal cells contain numerous cluster crystals of calcium oxalate, measuring 37-41-45 u in diameter. The epidermal cells measure 50-90-131 u in length, 30-52-75 u in width and 50-62 75 u in height.

Stomata of anisocytic type are of common occurrence usually large, oval in shape. They measure 140-163-188 u in length and 92-96-100 u in width.

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Both glandular and covering trichomes are present. The glandular one is formed of unicellular stalk, multicellular (16-22 cells), elongated head. They measure 155-180-205 u in length and 30-43-58 u in width. The covering trichomes are unicellular with thick lignified straight walls, narrow lumena acute apices, slightly curved at the base. They measure 1600-1675-1750 u in length and 30-43-58 u in width.

The mesocarp (Fig. 12,B)

The hypodermis is formed of a single row of cells similar to the epidermal cells but larger in size.

The remainder of outer parenchymatous region of the mesocarp is formed of large thin-walled parenchymatous cells with intercellular spaces. Few vascular bundles are observed in the inner part, each with vessels towards the epicarp and phloem towards the endocarp, each vascular bundle is accompanied with a group of fibres which are spindle in shape with slightly thick lignified walls, wide lumena and acute to acuminate apices. The vessels measure 22-28-34 u in diameter, while the fibres measure 995-1072-1150 u in length and 28-80-51 u in width

The inner region of the mesocarp shows two distinct layers, the first is formed of continuous group of fibres with strongly thickened and lignified walls, narrow lumena and acute apices measuring 485-557-625 u in length and 25-35-45 u in width, u in width, the second is formed of 5-9 rows of sclereids which are tangentially arranged, fusiform in shape with thick lignified walls, narrow lumena and acute or blunt apices, measuring 100-141-182 u in length and 20-28-38 u in width.

The endocarp (Fig. 12,B,13) is formed of one row of tangentially elongated cells, with thin-cellulosic straight to slightly sinuous walls, covered with smooth cuticle. They measure 57-134-211 u in length, 22-31-40 u in width and 8-12-16 u in height.

III- The seed (Fig. 14)

A transverse section in the seed (Fig. 14,A) shows a testa of 4 layers, enclosing an endosperm and much folded embryo. The 4 layers of the testa are the epidermis, The hypodermis, pigment layer and the nutritive layer.

The epidermis (Fig. 14,B) is formed of one row of cells. In surface view (Fig. 14,C), they appear polygonal more or less isodiametric with straight anticlinal walls and covered with smooth cuticle. The epidermal cells carry stellate covering trichomes of 2-4 unicellular hairs with thick-cellulosic walls, narrow lumina and acute apices, measuring 125-288-450 u in length and 13-18-25 u in width. The epidermal cells measure 100-122-145 u in length, 38-69-100 u in width and 30-34-38 u in height.

The hypodermis (Fig. 14,B,B) is formed of one row of radially elongated sclerenchymatous cells. They are rectangular in shape with strongly thickened and lignified walls, narrow lumina and measure 137-175-213 u in length and 35-42-50 u in width.

The pigment layer (Fig. 14,B,C) is formed of one row of polygonal cells with straight anticlinal walls. The cells are filled with deep reddish-brown contents, and measure 87-115-143 u in length, 37-56-75 u in width and 35-40-45 u in height.

The nutritive layer (Fig. 14,B) is formed of thin-walled parenchymatous cells which are tangentially elongated.

The endosperm (Fig. 14,B) is formed of polygonal 5 to 6 sided cells, which have straight cellulosic thick walls, measuring 50-69-88 u in length and 8-14-20 u in width. The cells of the endosperm contain fixed oil and aleurone grains.

The cells of the embryo (Fig. 14,B,C) are polygonal, radially elongated with straight or slightly curved thin walls.

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They contain fixed oil and aleurone grains similar to the endosperm. The cells of the embryo measure 50-62-75 u in length and 12-21-31 u in width.

The Powder

Powdered fruit including the seed is blackish-brown in colour, having a slight odour and mucilaginous taste. Microscopically it is characterized by the following :

- 1- Fragments of the epidermis of the pericarp showing polygonal cells with straight anticlinal walls, carrying anisocytic stomata, glandular and covering trichomes.
- 2- Numerous cluster crystals of calcium oxalate.
- 3- Fragments of the sclereid cells of the mesocarp of the pericarp.
- 4- Fragments of the endocarp cells, which are tangentially elongated, with slightly sinuous anticlinal walls.
- 5- Fragments of the lignified fibres and the xylem vessels of the pericarp.
- 6- Fragments of seed coat formed of polygonal cells, carrying covering stellate trichomes.
- 7- Fragments of the pigment layer of the seed with reddish-brown contents.
- 8- Fragments of the sclereid cells of the hypodermis of the seed.
- 9- Fragments of the endosperm and embryo with fixed oil globules and aleurone grains.

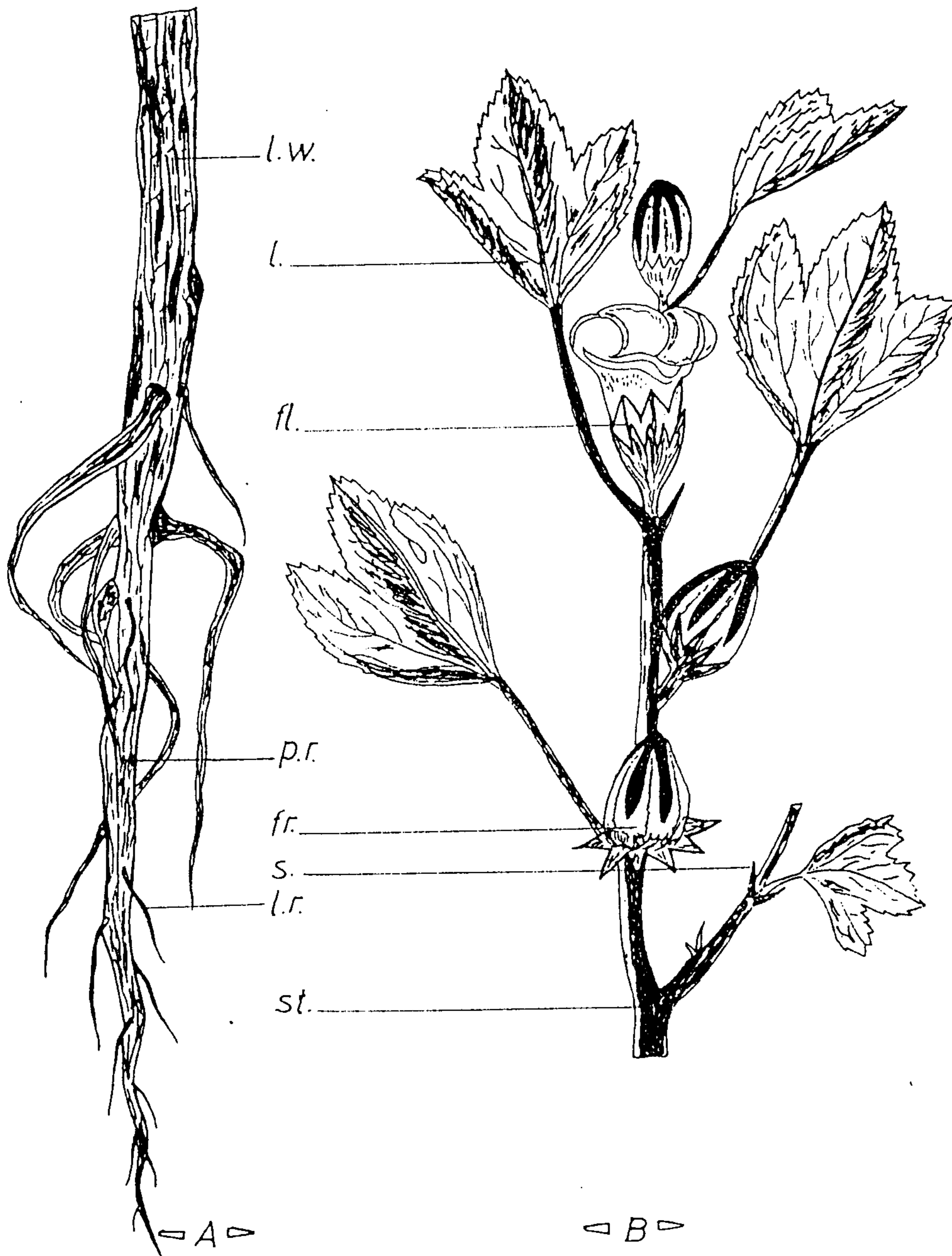


Fig. 1 : Sketch of Hibiscus sabdariffa L.

A- The root (x0.7)

B- Aerial part of the plant (x0.5)

fl., flower; fr., fruit; l., leaf; l.r., lateral rootlets; l.w., longitudinal wrinkles; p.r., primary root; s., stipule; st., stem.

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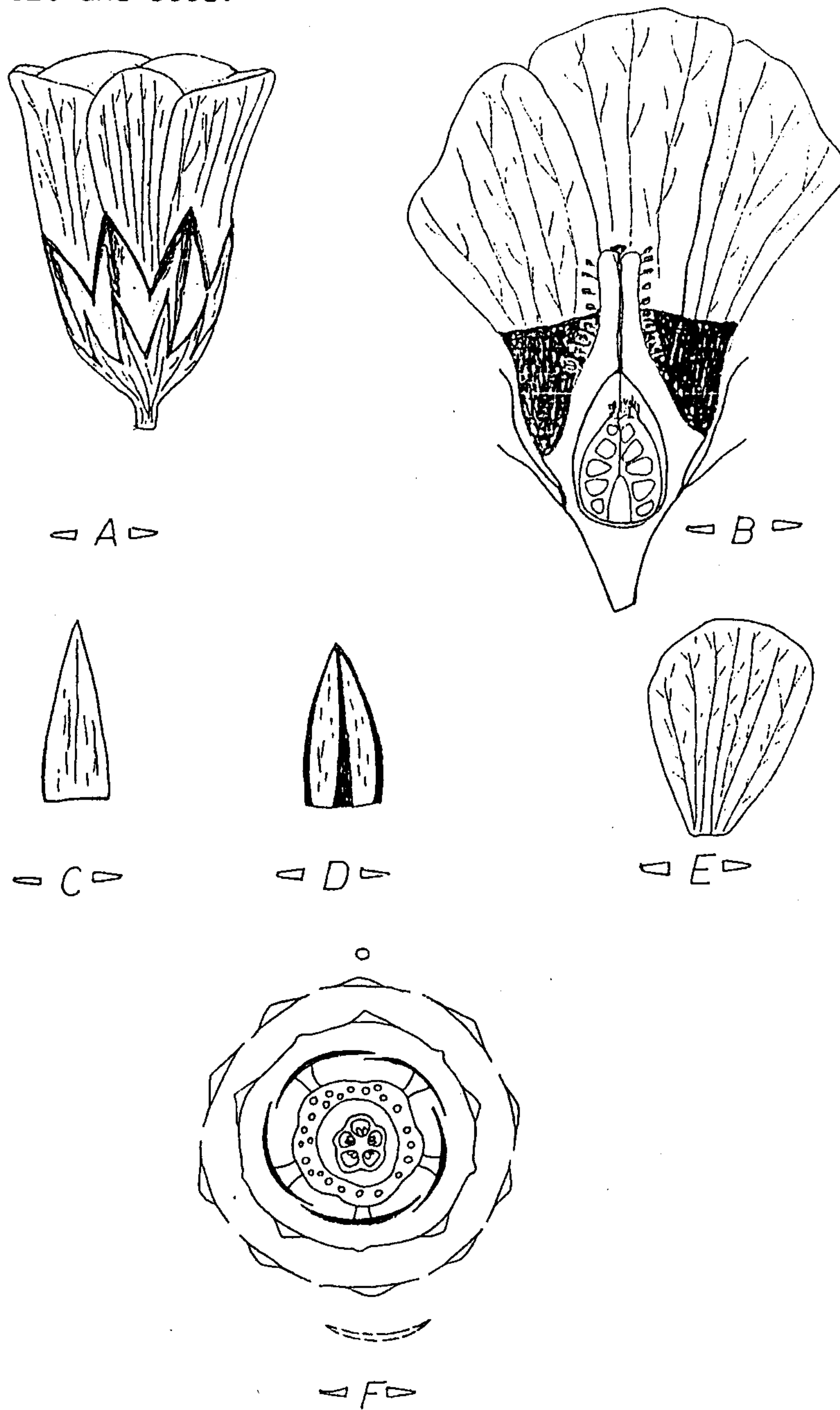


Fig. 2 : The flower of Hibiscus sabdariffa L.

- | | |
|----------------------|--------|
| A- Entire flower. | (x1) |
| B- Longitudinal cut. | (x1.7) |
| C- The epicalyx | (x2) |
| D- The sepal | (x0.7) |
| E- The petal | (x0.7) |
| F- Floral diagram. | |

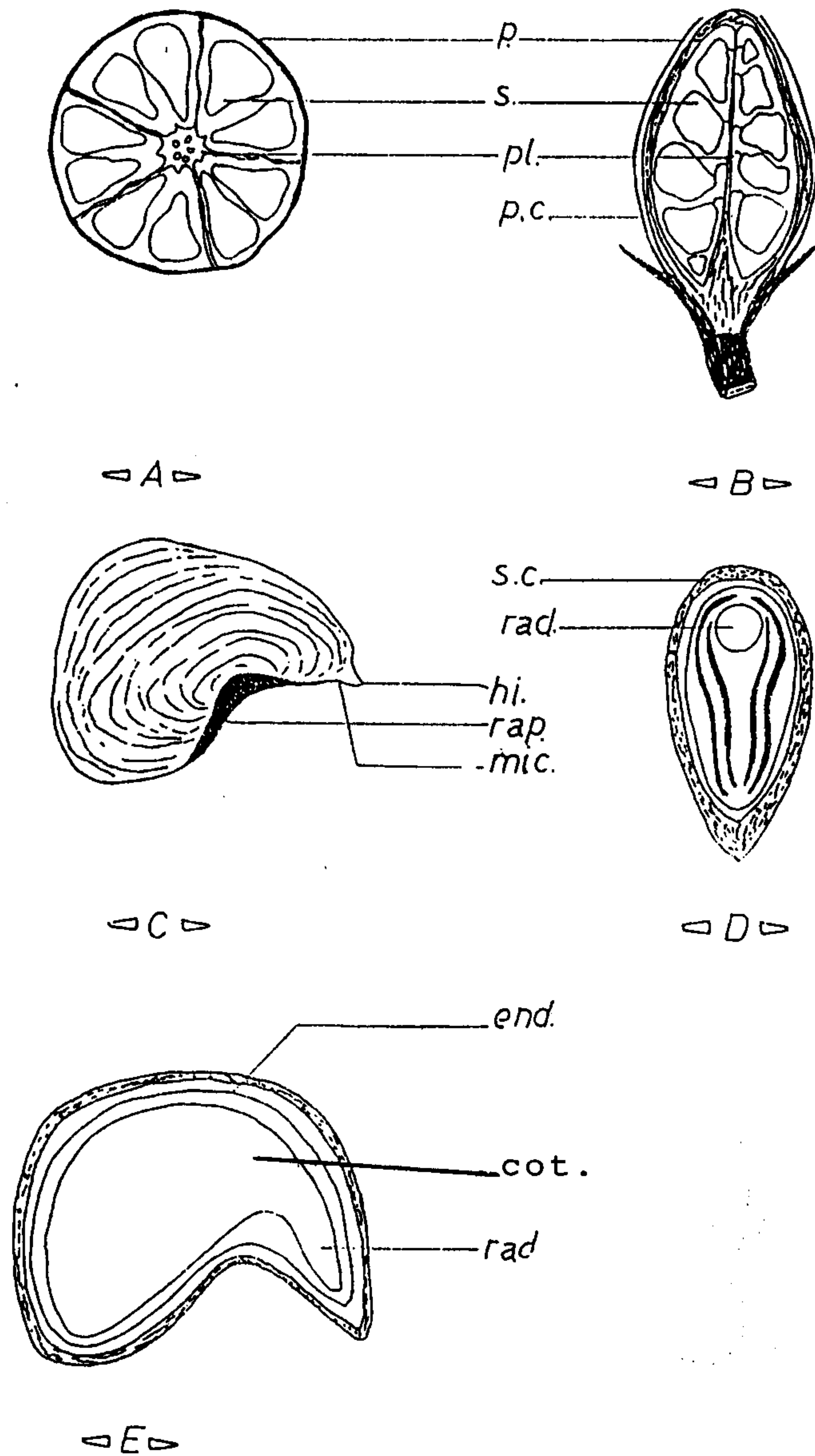


Fig. 3 : The fruit of Hibiscus sabdariffa L.

A- T. cut of the fruit.

B- L. cut of the fruit.

C- Entire seed.

(x6.4)

D- T. cut of the seed.

E- L. cut of the seed.

Cot., cotyledons; end., endosperm; hi., hilum;

mic., micropyl; p., pericarp, pl., placenta;

p.c., persistent calyx; rad., radicle; rap.,

raphe; s., seed; s.c., seed coat.

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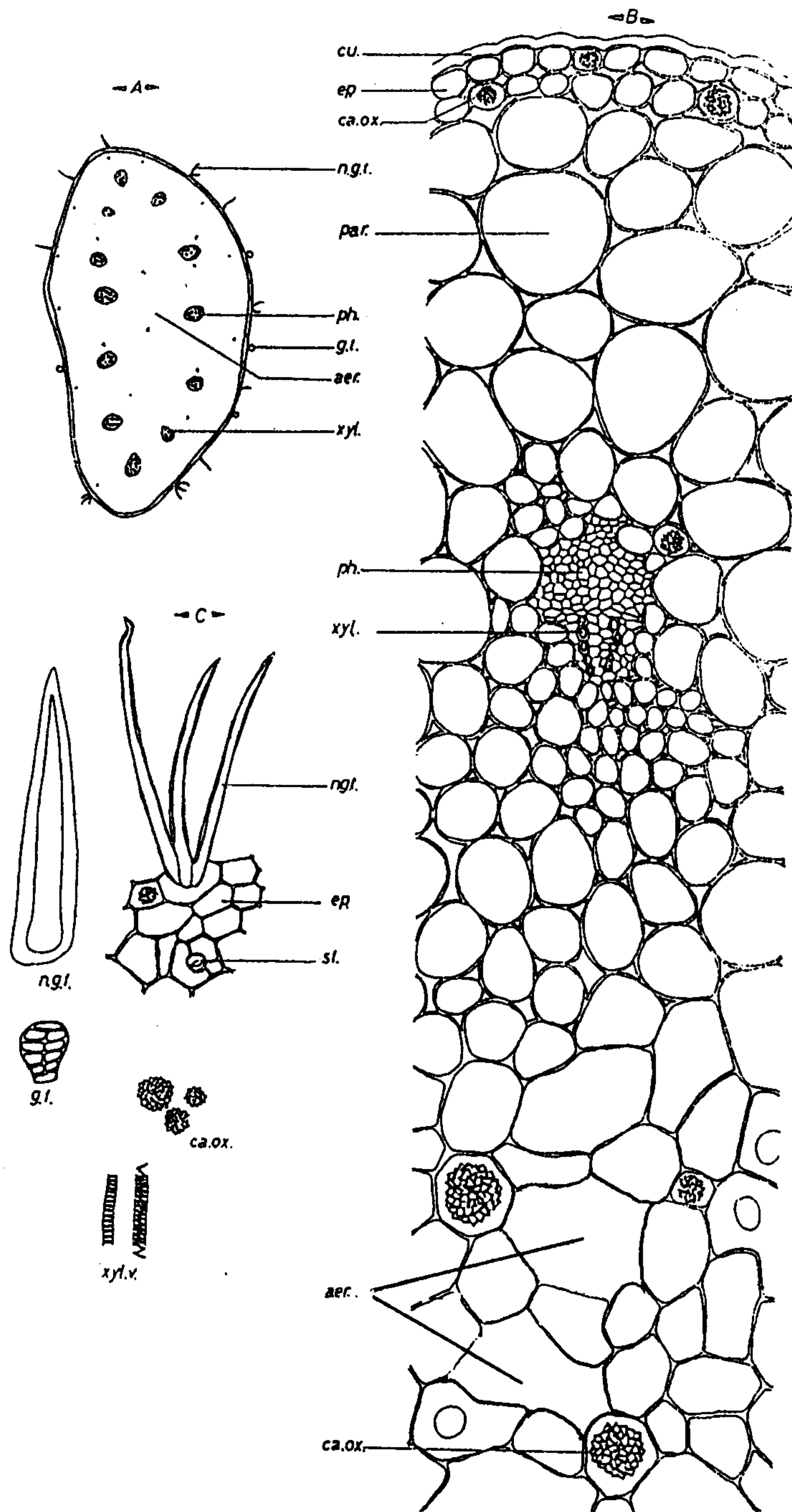


Fig. 4 : The epicalyx of *Hibiscus sabdariffa* L.
A- Diagrammatic transverse section (x7)
B- Detailed sector. (x90)
C- Surface preparation. (x59)
aer., aerenchyma; ca.ox., calcium oxalate; cu.,
cuticle; ep., epidermis; g.t., glandular trichome;
n.g.t., non-glandular trichome; par., parenchyma;
ph., phloem; st., stomata; xyl., xylem; xyl.v.,
xylem vessel.

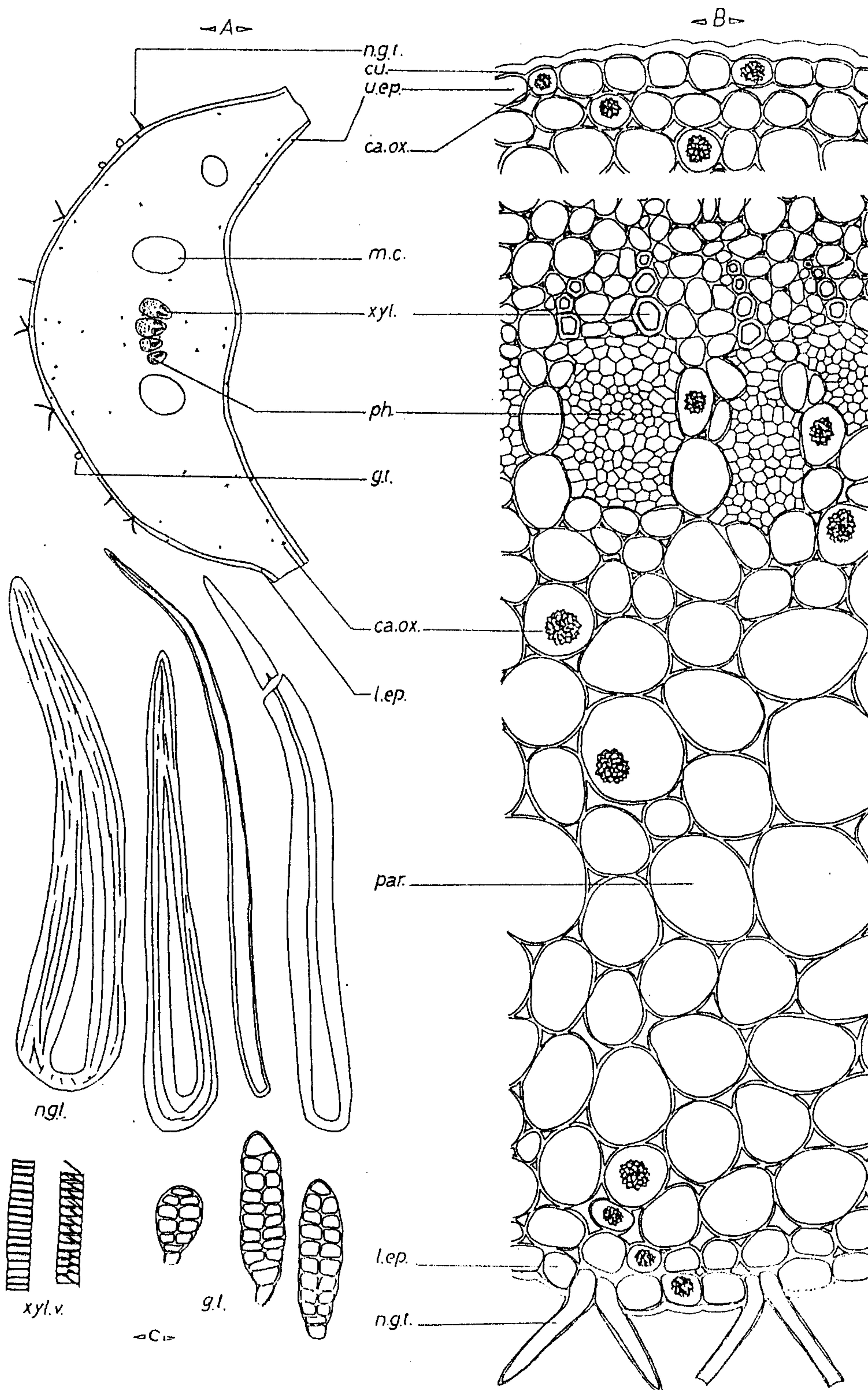


Fig. 5 : The calyx of Hibiscus sabdariffa L.

A- Diagrammatic transverse section in the middle part (x15)

B- Detailed sector. (x126)

C- Glandular and non-glandular trichomes. (x126)

ca.ox., calcium oxalate; cu., cuticle; g.t., glandular trichome; l.ep., lower epidermis; m.c., mucilage cavity; n.g.t., non-glandular trichome; par., parenchyma; ph., phloem; u.ep., upper epidermis; xyl., xylem; xyl.v., xylem vessel.

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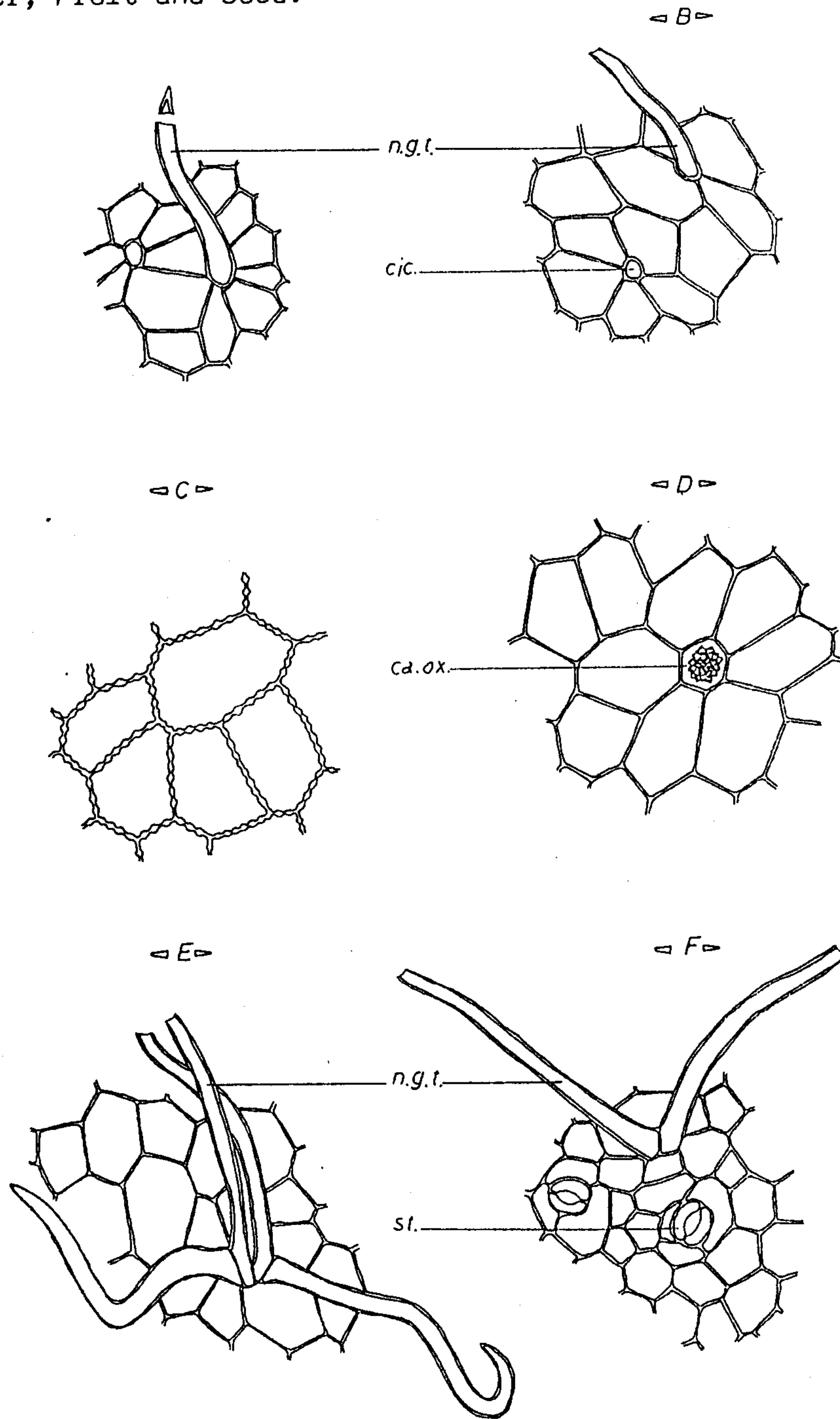


Fig. 6 : The calyx of Hibiscus sabdariffa L.
 A- Upper surface preparation in the apical part. (x126)
 B- Upper surface preparation in the middle part. (x126)
 C- Upper surface preparation in the basal part. (x126)
 D- Lower surface preparation in the apical part. (x126)
 E- Lower surface preparation in the middle part. (x126)
 F- Lower surface preparation in the basal part. (x126)
 ca,ox., calcium oxalate; cic., cicatrix; n.g.t., non-glandular trichome; st., stomata.

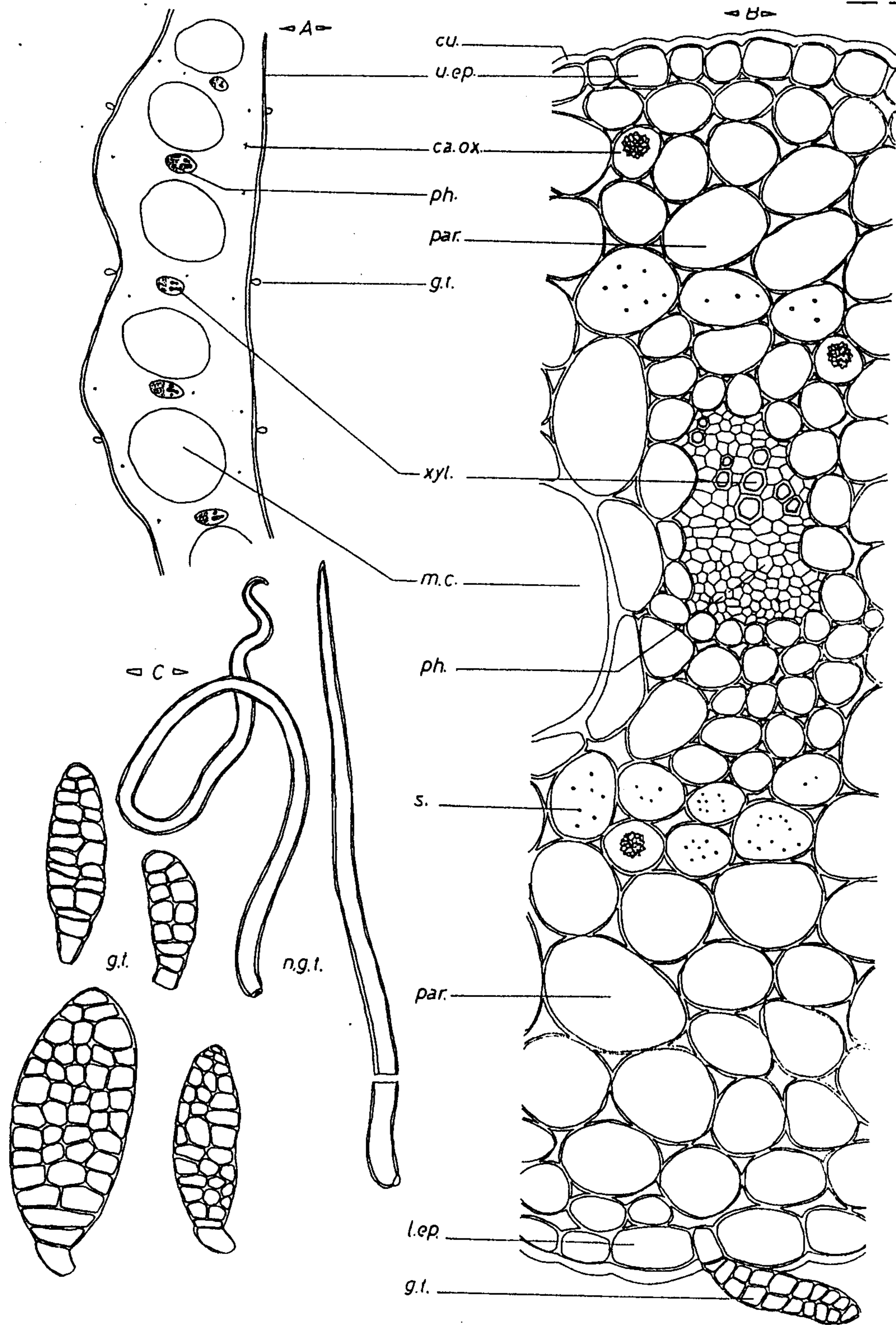


Fig. 7 : The corolla of Hibiscus sabdariffa L.
 A- Diagrammatic transverse section in the corolla. (x15)
 B- Detailed sector. (x126)
 C- Glandular and non-glandular trichomes. (x126)
 ca.ox., calcium oxalate; cu., cuticle; g.t., glandular trichome; l.ep., lower epidermis; m.c., mucilage cavity; n.g.t., non-glandular trichome; par., parenchyma; ph., phloem; s., starch; u.ep., upper epidermis; xyl., xylem.

Macro-and Micromorphology of Hibiscus Sabdariffa L. Cultivated in Egypt.
Part 11 Flower, Fruit and Seed.

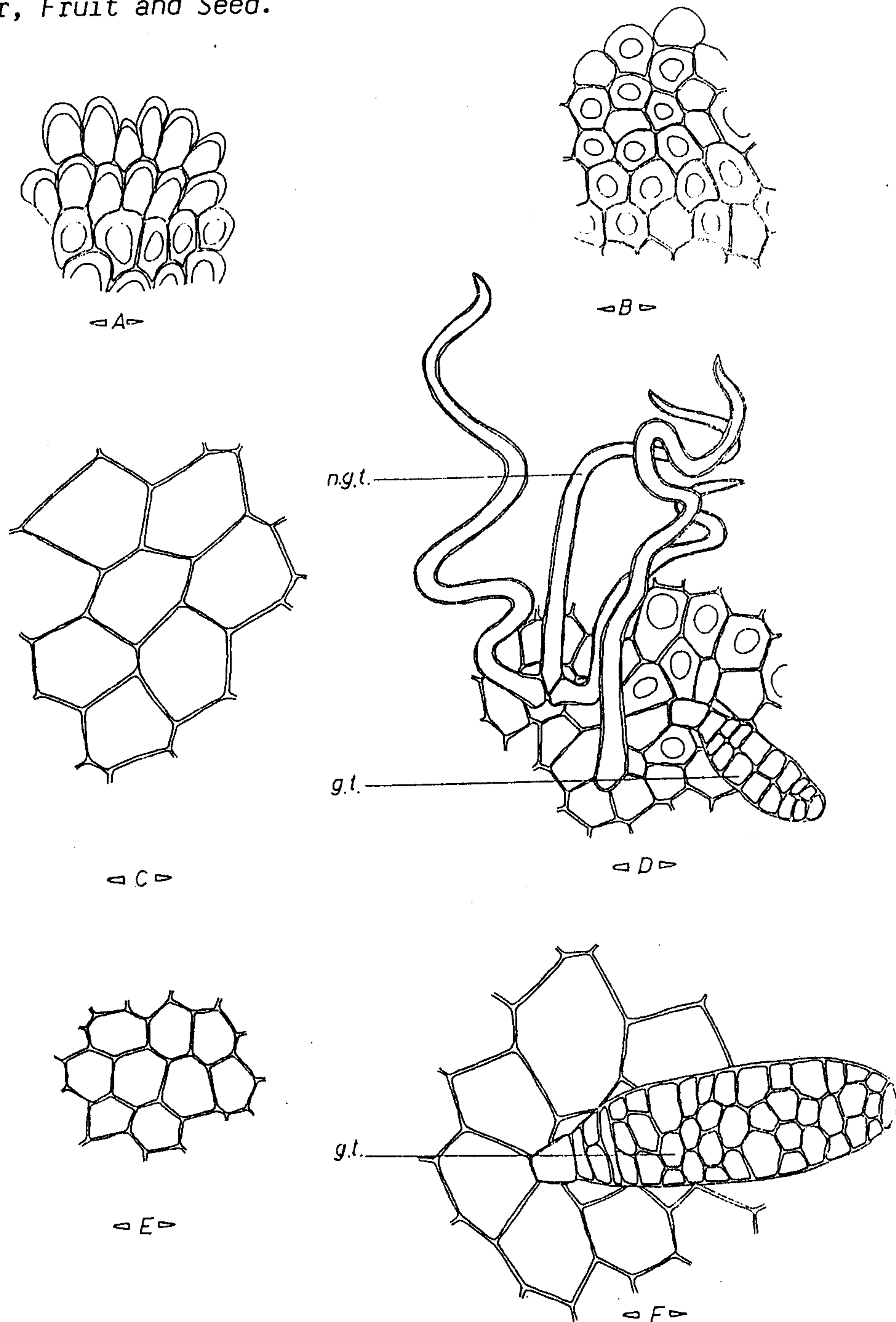


Fig. 8 : The corolla of Hibiscus sabdariffa L.
 A- Upper surface preparation in the apical part. (x126)
 B- Upper surface preparation in the middle part. (x126)
 C- upper surface preparation in the basal part. (x126)
 D- Lower surface preparation in the apical part. (x126)
 E- Lower surface preparation in the middle part. (x126)
 F- Lower surface preparation in the basal part. (x126)
 g.t., glandular trichome; n.g.t., non-glandular trichome.

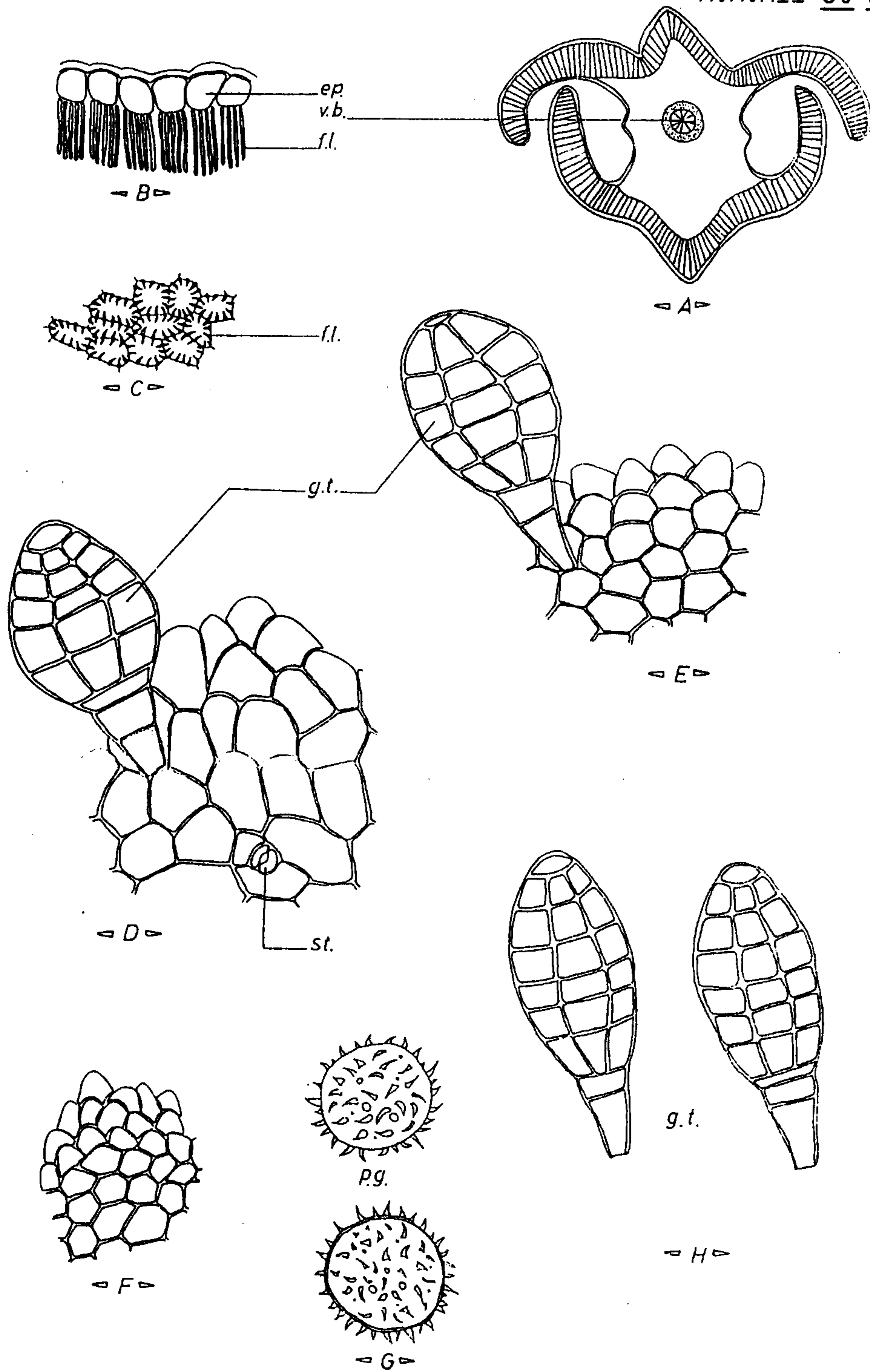


Fig. 9 : The androecium of Hibiscus sabdariffa L.

A- Diagrammatic transverse section in the anther.	(x31)
B- Detailed sector in the anther.	(x126)
C- Fibrous layer of the anther.	(x126)
D- Surface preparation in the staminal tube.	(x126)
E- Surface preparation in the filament.	(x126)
F- Surface preparation in the anther	(x126)
G- Pollen grains.	(x68)
H- Glandular trichomes.	(x126)

ep., epidermis; f.l., fibrous layer; g.t., glandular trichome; p.g., pollen grains; st., stomata; v.b., vascular bundle.

Macro-and Micromorphology of *Hibiscus Sabdariffa* L. Cultivated in Egypt.
Part:11-Flower, Fruit and Seed.

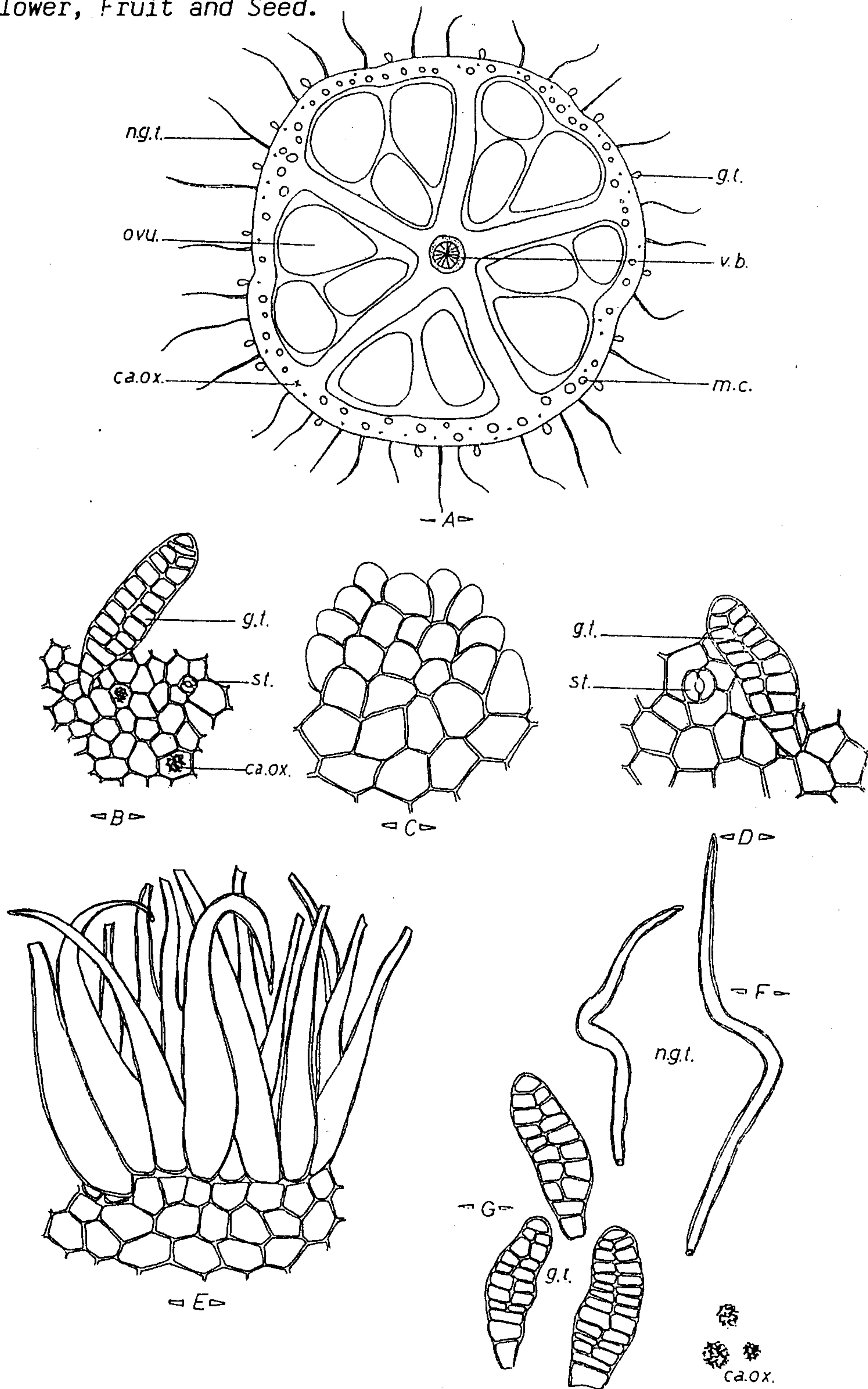


Fig. 10 : The gynoecium of *Hibiscus sabdariffa* L.

- A- Diagrammatic transverse section in the ovary. (x7)
 B- Surface preparation in the ovary. (x126)
 C- Surface preparation in the style. (x126)
 D- Surface preparation in the stigma(lower part) (x126)
 E- Papillosed stigma (apical part) (x126)
 F- Non-glandular trichomes of the ovary. (x31)
 G- Glandular trichomes of the ovary. (x126)
 ca.ox., calcium oxalate; g.t., glandular trichome;
 m.c., mucilage cavity; n.g.t., non-glandular
 trichome; ovu., ovule; st., stomata; v.b., vascu-
 lar bundle.

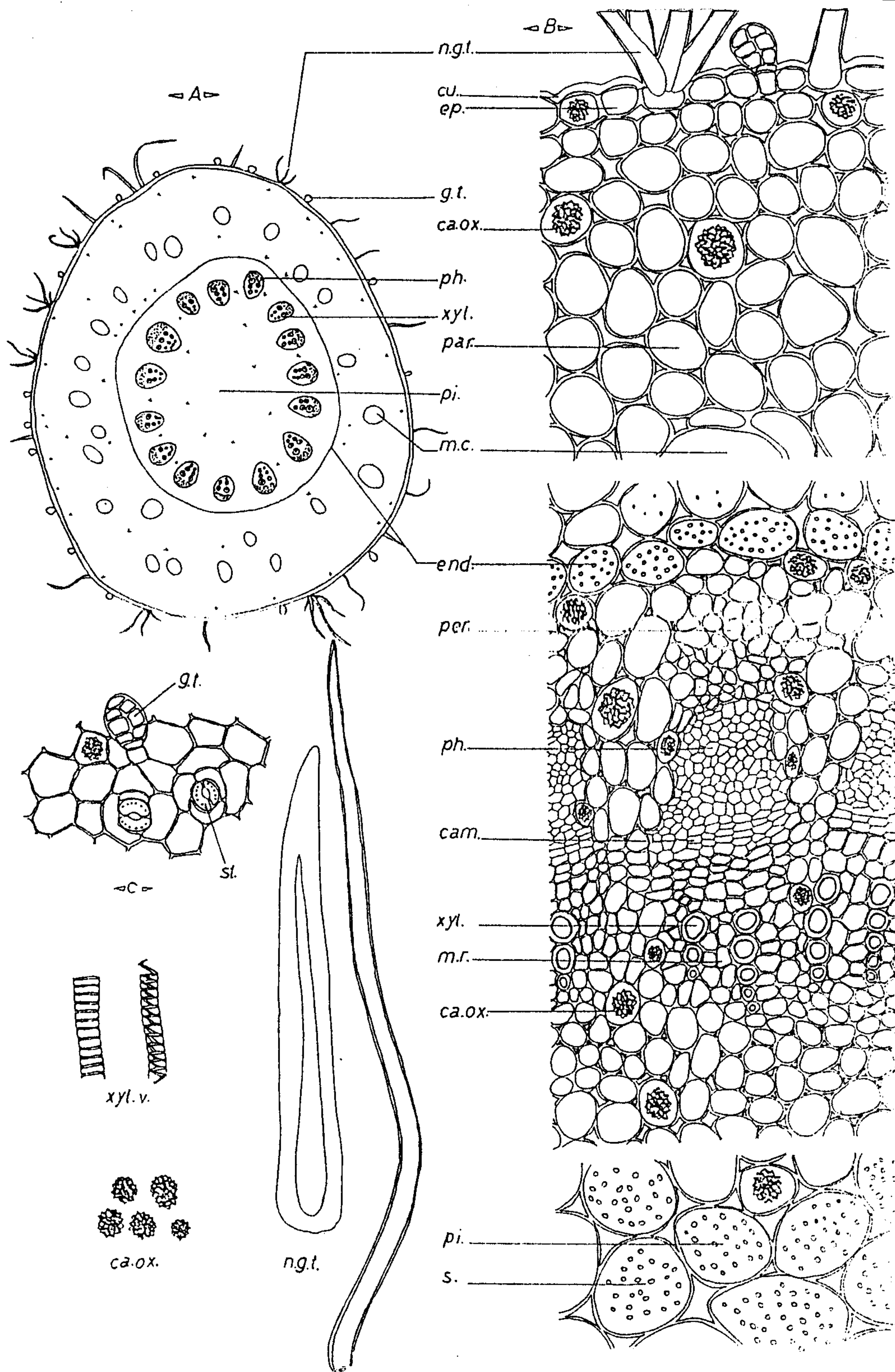


Fig. 11. The pedicel of *Hibiscus sabdariffa* L.

A- Diagrammatic transverse section in the pedicel (x 14)

B- Detailed sector. (x126)

C- Surface preparation and non-glandular trichomes. (x126)

cam., cambium; ca.ox., calcium oxalate; cu., cuticle; end., endodermis; g.t., glandular trichome; m.r., medullary ray; m.c., mucilage cavity; n.g.t., non-glandular trichome; par., parenchyma; per., pericycle; ph., phloem; pi., pith; s., starch; xyl., xylem; xyl.v., xylem vessel.

Macro- and Micromorphology of *Hibiscus Sabdariffa* L. Cultivated in Egypt.
Part:11-Flower, Fruit and Seed.

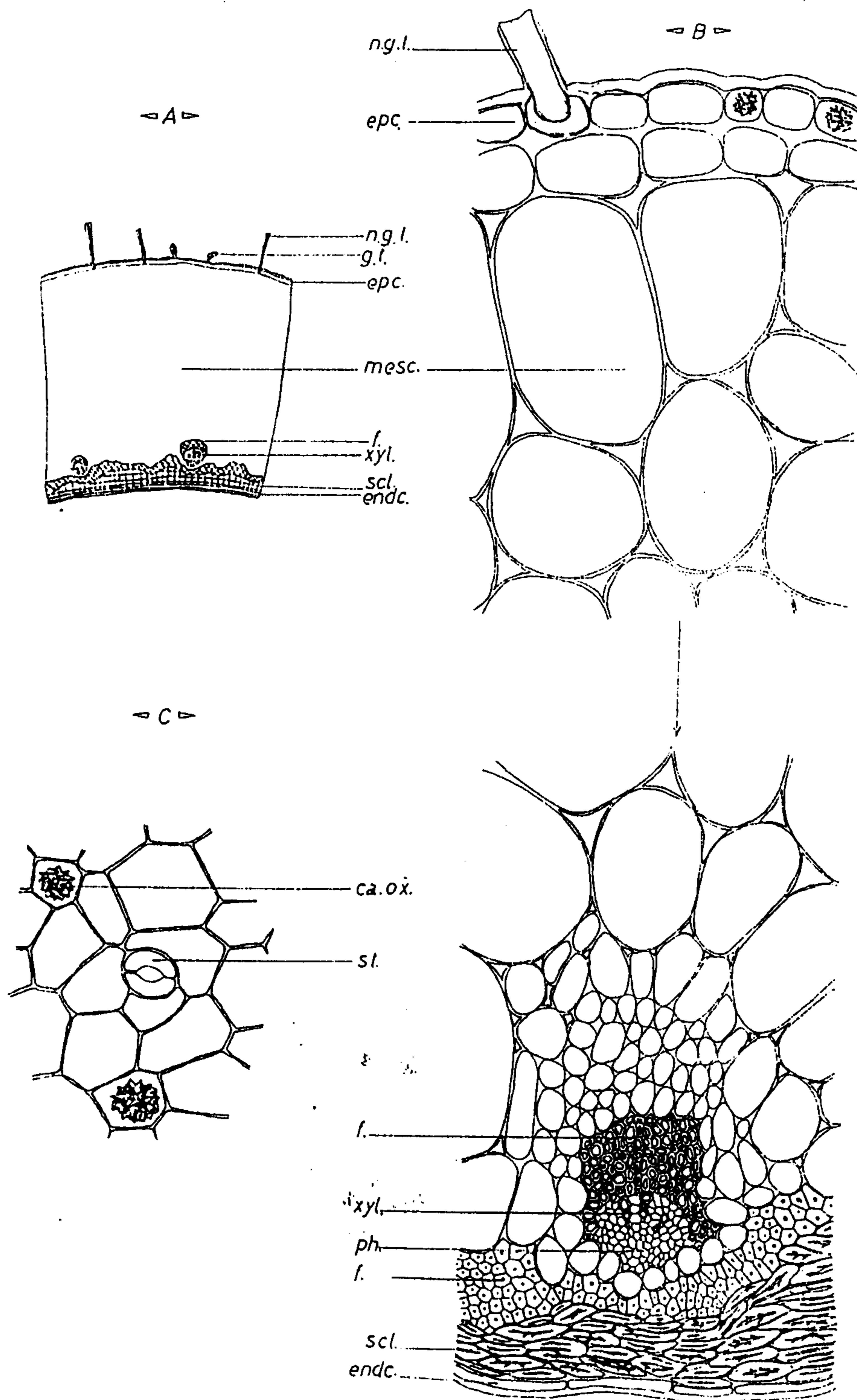


Fig. 12. The pericarp of *Hibiscus sabdariffa* L.

- A- Diagrammatic transverse section. (x 10)
 B- Detailed sector. (x 82)
 C- Surface preparation. (x126)
 ca.ox., calcium oxalate; endc., endocarp; epic., epicarp;
 f., fibre; g.t., glandular trichome; mes., mesocarp; n.g.t.,
 non-glandular trichome; ph., phloem; scl., sclereides; st.,
 stomata.

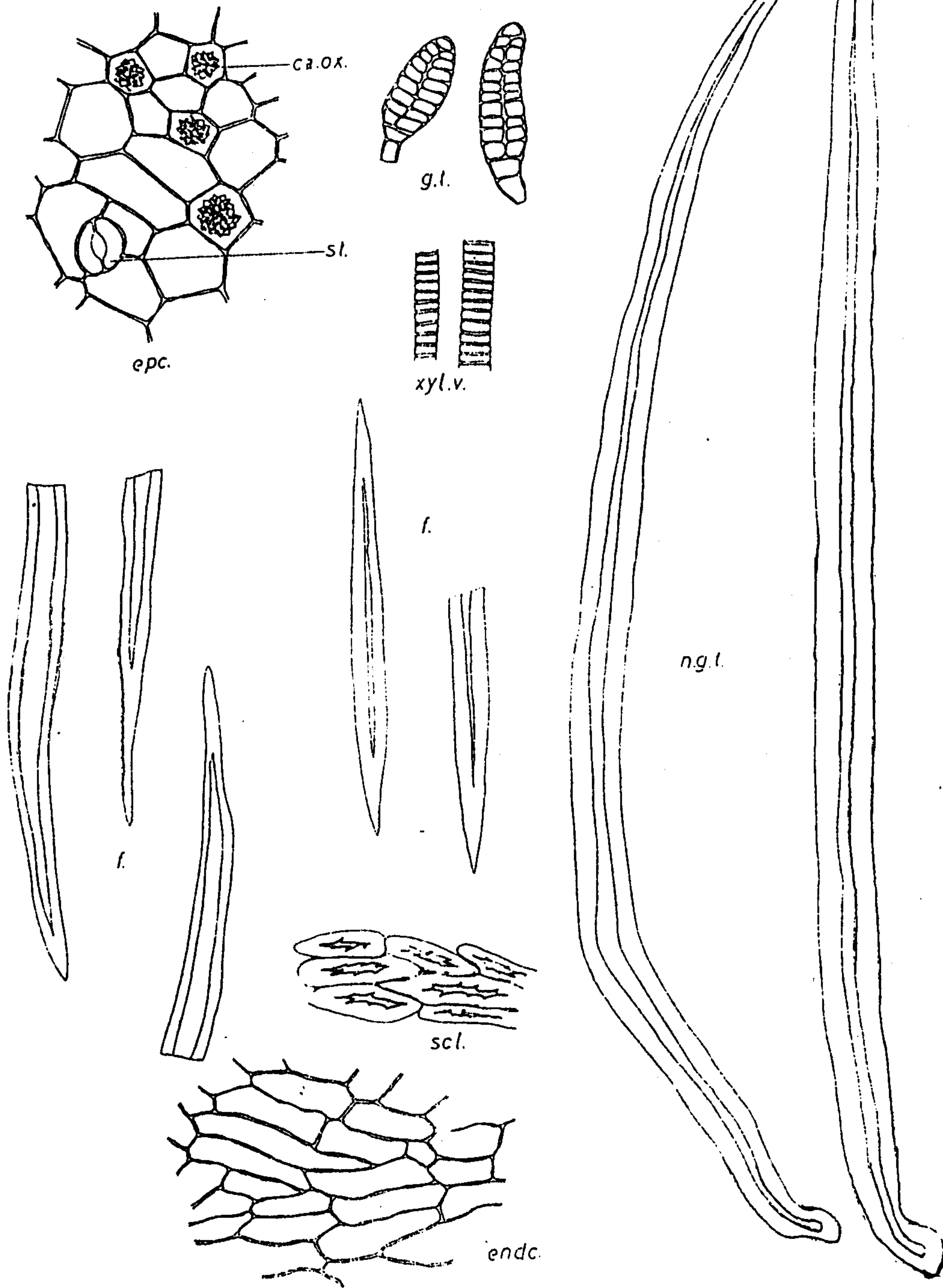


Fig. 13. Powdered pericarp of Hibiscus sabdariffa L. (x126)
 ca.ox., calcium oxalate; endc., endocarp; epic., epicarp;
 f., fibre; g.t., glandular trichomes; scl., sclereides; st.,
 stomata; xyl.v., xylem vessel.

Macro-and Micromorphology of *Hibiscus Sabdariffa* L. Cultivated in Egypt Part : II-Flower, Fruit and Seed.

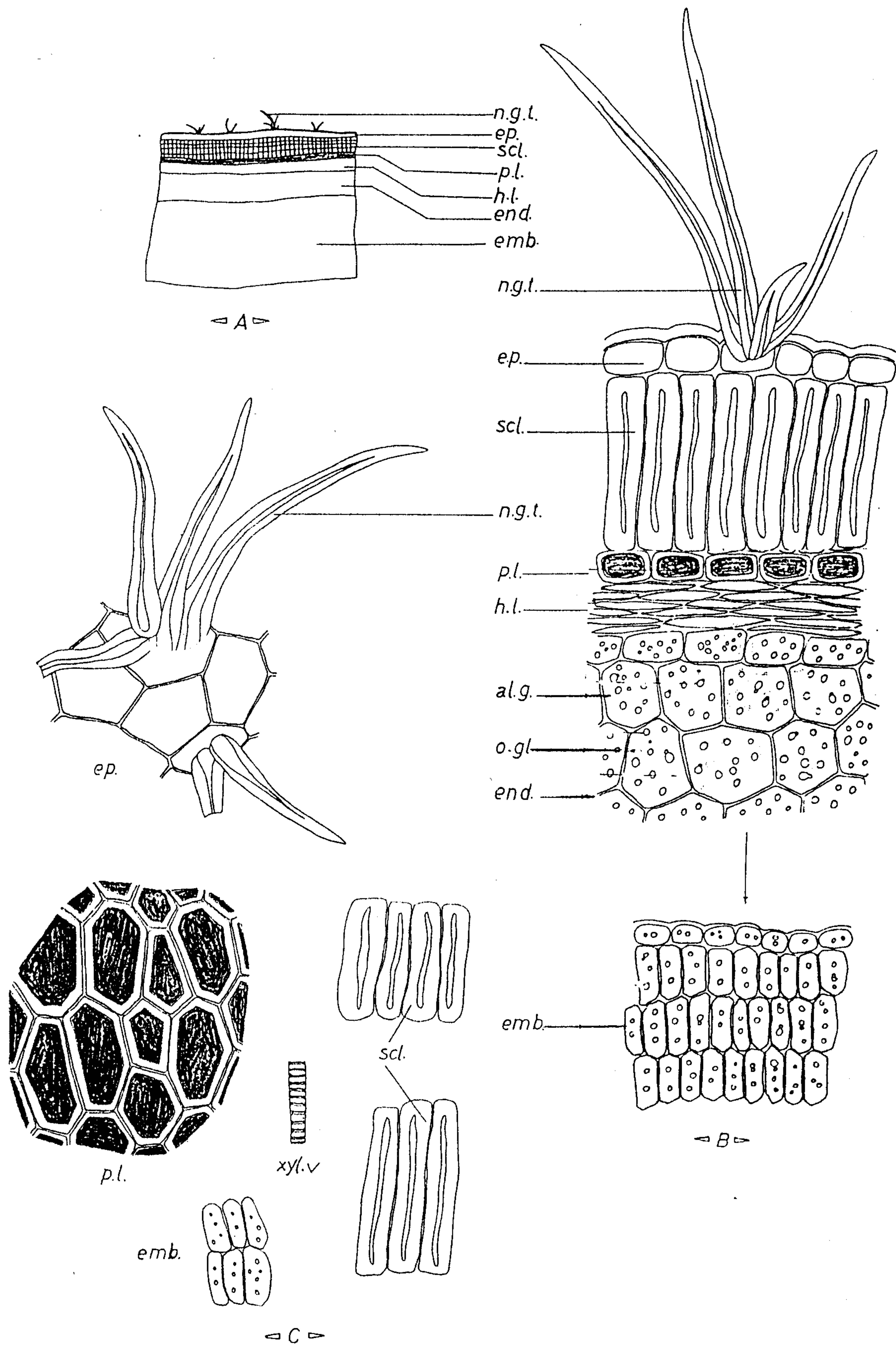


Fig. 14. The seed of *Hibiscus sabdariffa* L.

A - Diagrammatic transverse section.

(X 27)

B - Detailed sector.

(X130)

C - The powder.

(X130)

al.g., aleurone grain; emb., embryo; and., endosperm; ep., epidermis; h.l., hyaline layer; n.g.t., non-glandular trichome; o.gl., oil globule; p.l., pigment layer; scl., sclereides.

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- 1- A.A.Ali, M.A.Makboul, A.A.Attia and D.T.Ali, *Bull. Pharm. Sci., Assiut University*, 12, p. 1 (1989).

الدراسة العيانية والمجهرية لنبات
الهيبيسكسى سابدارييفال . (الكركديه)
الجزء الثانى : الازهار ، الثمار والبذور

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يتناول هذا البحث دراسة الصفات العيانية والمجهرية لازهار وثمار
وبذور نبات الهيبيسكسى سابدارييفال . المنزرع فى مصر والتي تسهل التعرف
على هذه الاجزاء وأيضا النبات فى الحالتين الصحيحه أو على هيئته
مسحوق .