

MACRO- AND MICROMORPHOLOGY OF *AILANTHUS ALTISSIMA* SWINGLE CULTIVATED IN EGYPT: LEAF, STEM, AND STEM-BARK

A. M. Abdel-Baky, F. M. M. Darwish, Z. Z. Ibraheim and Y. G. Gouda

Department of Pharmacognosy, Faculty of Pharmacy, Assiut University, Assiut, Egypt

نبات أيلانسس ألتيزيما سونجل من نباتات الزينة المنزرعة في مصر. يستعمل هذا النبات في الطب الشعبي لعلاج الدوسنتاريا والإسهال والبواسير، وأيضا لعلاج الأنيميا إلى جانب بعض الإستخدامات الأخرى. كما أن للنبات خواصا مضادة للالتهابات والبكتيريا. ويقوم الباحثون بدراسة المحتويات الكيميائية لأوراق النبات ورؤى أنه من المفيد إجراء دراسة عيانية ومجهريّة للأوراق والساق والقف لإمكان التعرف عليها سواء كانت كاملة أو على هيئة مسحوق.

The detailed macro- and micromorphological characters of the leaf, stem and stem bark of Ailanthus altissima Swingle syn. Ailanthus glandulosa Desf. (Tree of heaven) are studied with the aim to find out the diagnostic elements of these organs which facilitate their identification in both entire and powdered forms.

INTRODUCTION

Ailanthus altissima Swingle "Tree of heaven" (Fig. 1) is a large tree belonging to the family *Simaroubaceae*. This species is native to China, naturalized in the eastern United States of America, Europe, Australia and South Africa.¹⁻³ It is used in folk medicine as bechic, emmenagogue, and in treatment of dysentery, haemorrhoids, anaemia, spermatorrhea, diarrhoea, gastric and intestinal upsets, also it is used as taenifuge.^{3,4} The plant has antibacterial, antimalarial, insecticidal, and antileukemic activities.⁵⁻⁷ From *Ailanthus altissima*, alkaloids, flavonoids, ceryl alcohol and quassinoid bitter principles were isolated.⁸

This work describes the macro- and micromorphological characters of the leaf, stem, and stem-bark of *Ailanthus altissima* Swingle.

EXPERIMENTAL

Plant material

The plant was cultivated in the Experimental Station at Faculty of Agriculture, Assiut University, Assiut, Egypt, in April, 1994 and kindly identified by Prof. Dr. A. Faid,

Professor of Taxonomy, Faculty of Science, Assiut University, Assiut, Egypt. Fresh samples preserved in a mixture of 70% alcohol-glycerin-water (1:1:1) were used. For the study of the powder, the leaves, stem, and stem-bark were air-dried and powdered.

Habitat

Ailanthus altissima Swingle is deciduous tree with monopodial branches and attaining up to 70 feet in height. It carries greenish-yellow flowers and alternate compound leaves.

Macromorphology of the leaf

Leaf (Fig. 2A and B), alternate, pinnately compound, measuring 20 to 85 cm long, each formed of 13-32 stalked lanceolate, shortly petiolate leaflets, usually truncate at the base, with 2 to 4 coarse marginal teeth near the base. Leaflet 6 to 16 cm in length and 1.2 to 4.6 cm in width at the widest part, entire margin, asymmetric base, acuminate apex, reticulate pinnate venation, the midrib and lateral veins are more prominent on the lower surface. The upper surface, dark green, the lower being paler.

Petiole, cylindrical to subcylindrical, green, short, measuring 1 to 6 mm in length and 0.6 to



Fig. 1: A photograph of *Ailanthus altissima* Swingle (X 1/80)

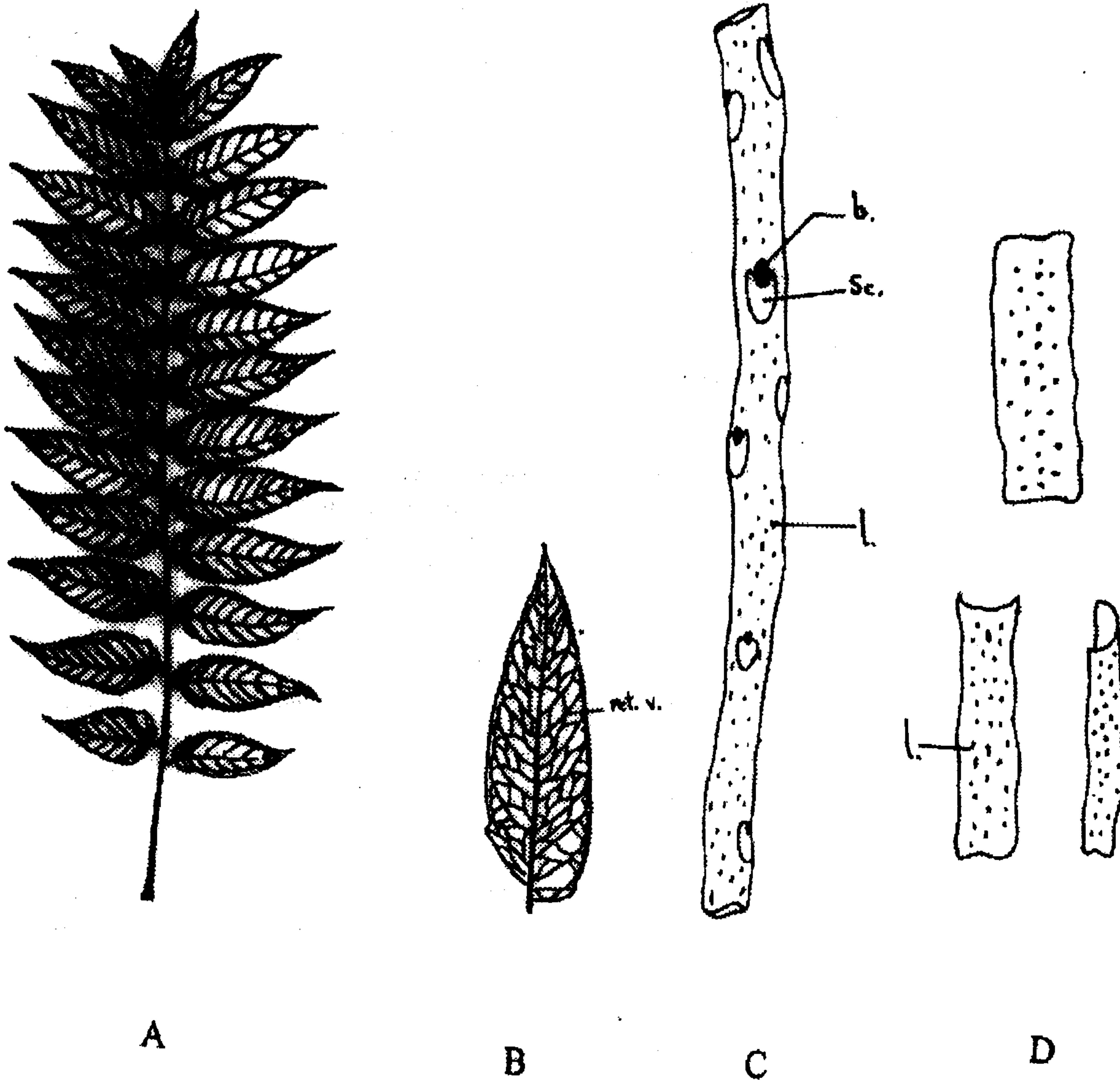


Fig. 2:

- | | |
|------------------------------------|---------|
| A: Morphology of the Compound Leaf | (X 1/5) |
| B: Morphology of the Leaflet | (X 1/2) |
| C: Morphology of the Young Stem | (X 3/4) |
| D: Morphology of the Stem-bark | (X 1/4) |

b., bud; ret. v., reticulate venation; l., lenticels; sc., scar of the fallen leaf.

2.0 mm in diameter.

The rachis of the leaf, cylindrical or somewhat triangular and hairy, reddish-brown at the part corresponding to the upper surface of the leaflets and green at the part corresponding to the lower surface of the leaflets.

The leaf has unpleasant odour and slight bitter taste.

Micromorphology of the leaflets

A transverse section in the leaflet (Fig. 3, A₁, A₂, A₃ and A₄) shows a dorsiventral structure with a palisade layer consisting of one row of cells. The midrib is more prominent on the lower surface showing a ridge on the upper one. The palisade layer is interrupted in the midrib by subepidermal zone of collenchymatous cells. Another layer of collenchyma is present in the lower part of the midrib. Also, glandular and nonglandular hairs are present on the midrib region.

The vascular bundle of the midrib is collateral, consisting of xylem and phloem and surrounded by a nonlignified pericyclic fibers. Another collateral vascular bundle is present above the main bundle. In young leaflets (Fig. 3A₁), this bundle appears as a single collateral bundle, consisting of xylem and phloem, and surrounded by the pericycle. On aging, the above bundle starts to enlarge (Fig. 3, A₂, and A₃), then it splits at the xylem region giving two collateral vascular bundles (Fig. 3A₄). While the upper one is surrounded by a mass of pericyclic fibers, the lower one is not.

In the ground tissue of the mesophyll and cortical tissues, clusters of calcium oxalate are present in addition to small rounded starch granules. Also 1-2 schizogenous oil glands are found above the main vascular bundle, and in some leaflets one gland is present between the new vascular bundles, these oil glands appear as cavities, stained red with Sudan III and surrounded by epithelial cells.

The upper epidermis (Fig. 3B)

The upper epidermis consists of one row of cells, rectangular to subrectangular in the lamina region, and nearly square to rounded in the

midrib region. In surface view (Fig. 3C₁), the cells appear polygonal, isodiametric or slightly elongated, measuring 9-16-25 μ in length, 4-11-15 μ in width and 4-7-10 μ in height (Fig. 3B).

The epidermal cells of the young and old leaflets have straight anticlinal walls and covered with heavy striated cuticle. Stomata are not observed, but glandular and nonglandular hairs or their cicatrices are present (Fig. 3C₁). The glandular hairs consist of uniseriate multicellular (2-3 cells) stalks and multicellular (9-13 cells) heads (Fig. 3B). They measure 24-26-28 μ in diameter and 27-34-42 μ in height. The nonglandular hairs (Fig. 4D), are either unicellular, covered with slightly striated cuticle measuring 44-68-97 μ in length and 4-6-8 μ in width, or multicellular (4-7 cells) uniseriate, covered with slightly striated cuticle, measuring 44-120-198 μ in length and 4-9-11 μ in width.

The lower epidermis (Fig. 3B)

The lower epidermis is formed of one layer of square to subrectangular cells, polygonal in surface view, mostly isodiametric. In the young leaflets (Fig. 3C₃), the cells have wavy anticlinal walls and are covered with smooth cuticle. In old leaflets (Fig. 3C₄), the cells have nearly straight anticlinal walls and are covered with striated cuticle. The lower epidermal cells are slightly smaller than that of the upper surface, measuring 7-14-23 μ in length, 5-8-13 μ in width and 4-5-6 μ in height. Stomata, on lower epidermis, anomocytic, surrounded by 5-6 cells measuring 11-14-17 μ in length and 9-10-11 μ in width. Glandular and nonglandular hairs, are similar to those of the upper epidermis.

The epidermal cells of the midrib region (Fig. 3C₂) are somewhat elongated with straight anticlinal walls and carrying glandular and nonglandular hairs.

The mesophyll (Fig. 3D)

The mesophyll consists of one row of palisade cells, interrupted by collenchyma in the midrib region. The palisade cells, columnar without intercellular spaces, measuring 21-23-26 μ in length and 2-3-5 μ in width. The spongy

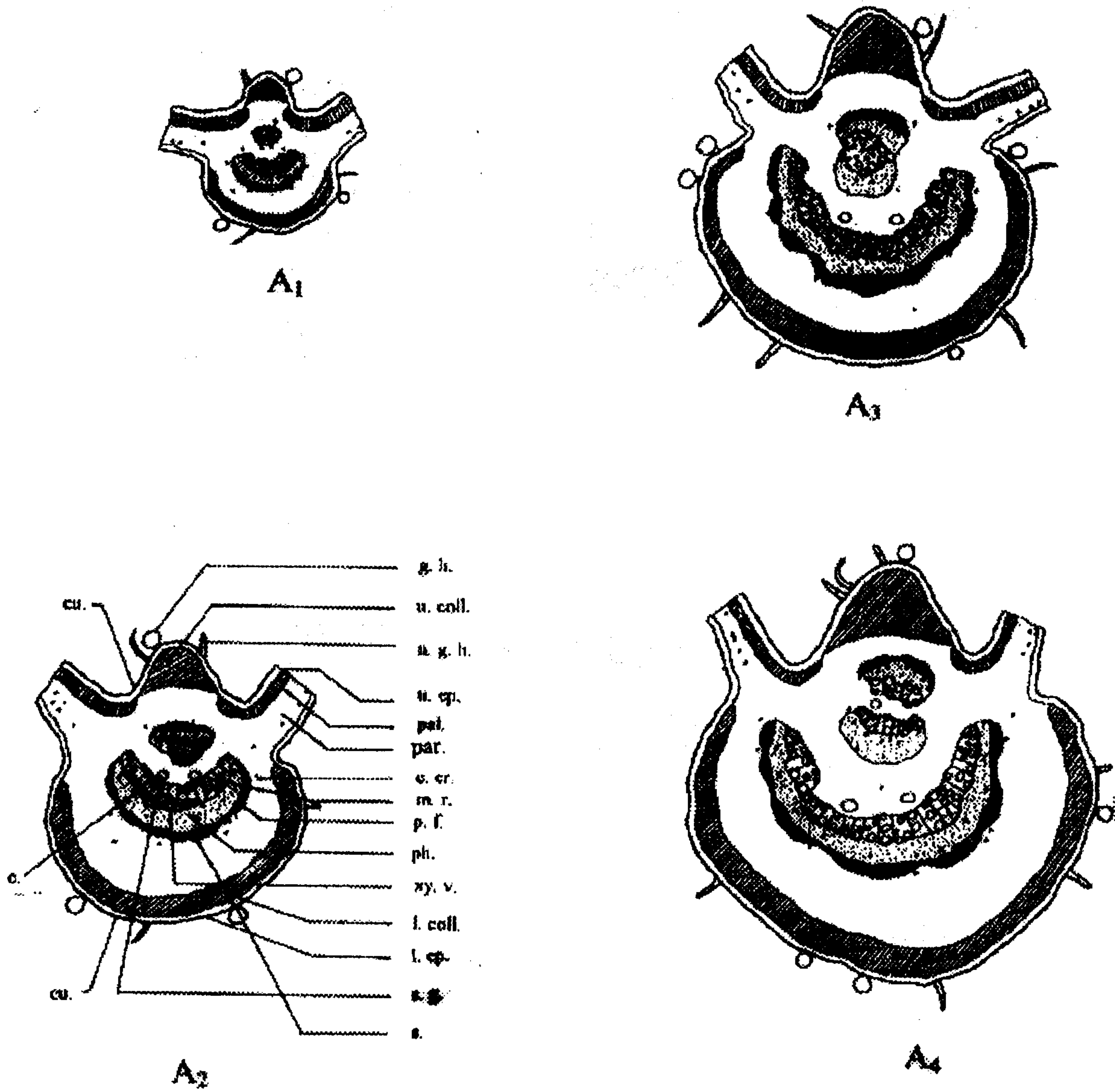


Fig. 3:

A) A₁, A₂, A₃, A₄: T. S. Diagram of the Leaflet

(X 90)

c., cambium; c. cr., cluster crystals of calcium oxalate; cu., cuticle; g. h., glandular hair; l. coll., lower collenchyma; l. ep., lower epidermis; m. r., medullary ray; n. g. h., non-glandular hair; p. f., pericyclic fibers; pal., palisade layer; par., parenchyma; ph., phloem; s., starch granules; s. g., schizogenous oil gland; u. coll., upper collenchyma; u. ep., upper epidermis; xy. v., xylem vessels.

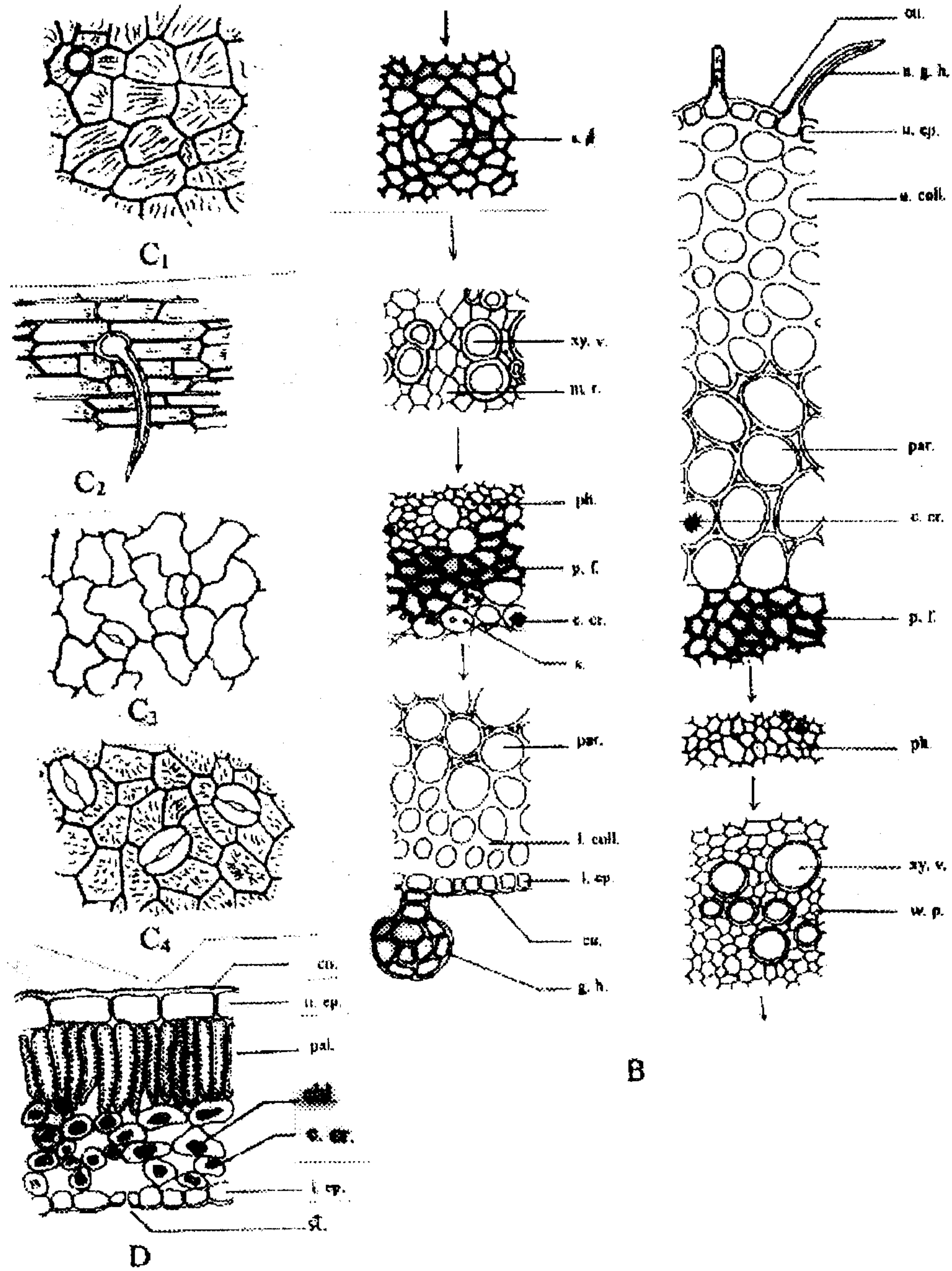


Fig. 3: Cont.

B) T. S. Sector of the Leaflet

(X 530)

C) Surface Preparation of the Leaflet

(X 530)

C1: upper epidermis

C2: epidermis of the midrib

C3: lower epidermis of young leaflet

C4: lower epidermis of old leaflet

D) T. S. Sector of the Lamina

(X 530)

chl., chloroplast; st., stomata.

tissue consists of 3 to 4 rows of irregular parenchyma cells with wide intercellular spaces containing chloroplasts and cluster crystals of calcium oxalate, as well as small starch granules. Some xylem vessels are present between the parenchyma cells of the mesophyll. The cluster crystals of calcium oxalate, solitary or in rows specially near the veins measuring $3\text{-}6\text{-}7\ \mu$ in diameter.

The cortical tissue (Fig. 3B)

The cortical tissue shows an upper and lower subepidermal collenchymatous masses. The upper one is formed of 4-10 rows and the lower one is formed of 2-4 rows. The rest of the cortical tissues below the upper collenchyma and above the lower one is formed of rounded to oval parenchyma cells with wide intercellular spaces, some of them containing cluster crystals of calcium oxalate. The parenchyma cells of the endodermis show some starch granules which are small, rounded, simple or rarely compound of 2-3 components.

Above the vascular bundles, there are 1-3 schizogenous oil glands measuring $13\text{-}17\text{-}22\ \mu$ in diameter.

The vascular tissues (Fig. 3B)

The vascular tissues are surrounded by pericyclic fibers, (Fig. 3B), polygonal, with wide lumina and nonlignified thin walls, in (Fig. 4D) with tapering apices, measuring $66\text{-}110\text{-}150\ \mu$ in length and $5\text{-}7\text{-}9\ \mu$ in width.

The Phloem (Fig. 3A₂ and 3B)

The phloem forms a narrow zone consisting mainly of phloem parenchyma, sieve tubes and companion cells, but no phloem fibers. Occasional clusters of calcium oxalate are present.

The xylem (Fig. 3B)

The xylem is formed of lignified vessels and polygonal slightly lignified wood parenchyma, Vessels (Fig. 4D) spiral, annular and reticulate measuring $4\text{-}10\text{-}16\ \mu$ in diameter. No fibers were observed.

Medullary rays uniseriate or biseriate in transverse section appear as somewhat elongated, thin walled, nonlignified cells.

The rachis (Fig. 4A)

A transverse section in the rachis is rounded, somewhat triangular in outline. The rachis is composed of epidermis and cortical tissues, surrounding the main vascular stele. In the pith, there are additional 2-6 collateral vascular bundles composed of xylem and phloem. Also there are number of schizogenous oil glands in the outer region of the pith.

The epidermis (Fig. 4B)

The epidermis is formed of one layer of polygonal to subrectangular axially elongated with straight anticlinal walled cells measuring $5\text{-}6\text{-}7\ \mu$ in height, $4\text{-}7\text{-}9\ \mu$ in width and (Fig. 4C), $7\text{-}12\text{-}15\ \mu$ in length. The epidermal cells are covered with smooth cuticle, carrying glandular and nonglandular hairs but no stomata. The glandular hairs are few in number and one of the types is similar to those of the leaflets (Fig. 3B), or has multicellular uni-, bi- and triseriate stalks and multicellular heads of $8\text{-}14\text{-}20$ cells (Fig. 4D). They measure $28\text{-}32\text{-}37\ \mu$ in diameter and $37\text{-}48\text{-}62\ \mu$ in height. The nonglandular hairs are similar to those of the leaflets (Fig. 4D).

The cortical tissue (Fig. 4B)

The cortical tissue is formed of an outer collenchymatous zone and an inner parenchymatous one. The collenchymatous zone is formed of up to 15 rows of rounded and oval cells with moderately thick cellulosic walls. The parenchymatous zone is formed of 6-9 rows of rounded and oval cells with wide intercellular spaces. Also 1-2 of the inner rows are of elongated and slightly collapsed parenchyma cells. The parenchyma cells contain cluster crystals of calcium oxalate as well as small starch granules similar to those of the leaflets. The inner most layer of the cortical tissue appears as elongated parenchyma cells containing small simple rounded starch granules.

The pericycle (Fig. 4B)

The pericycle is formed of isolated groups of pericyclic fibers separated from each other by parenchymatous cells forming a ring surrounding the phloem. Fibers, polygonal in outline with lignified walls, wide lumina, and (Fig. 4D)

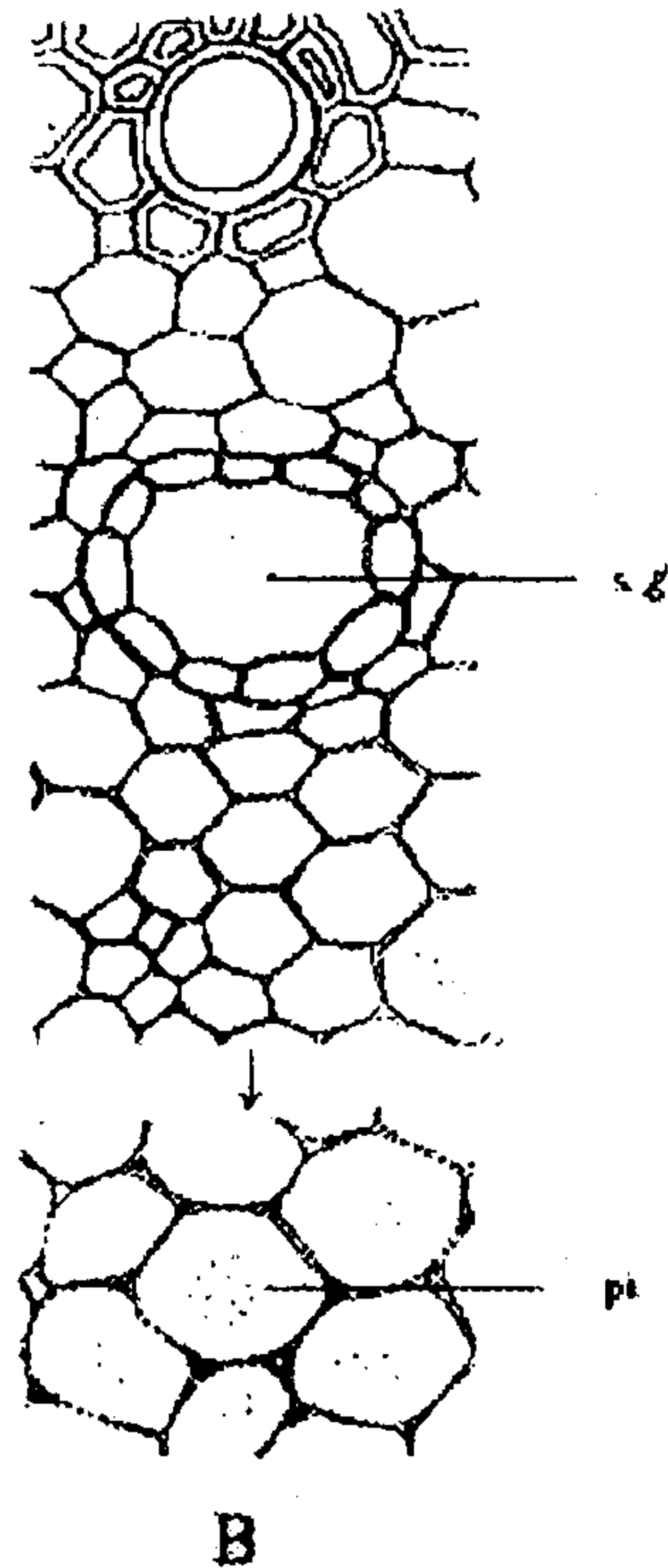
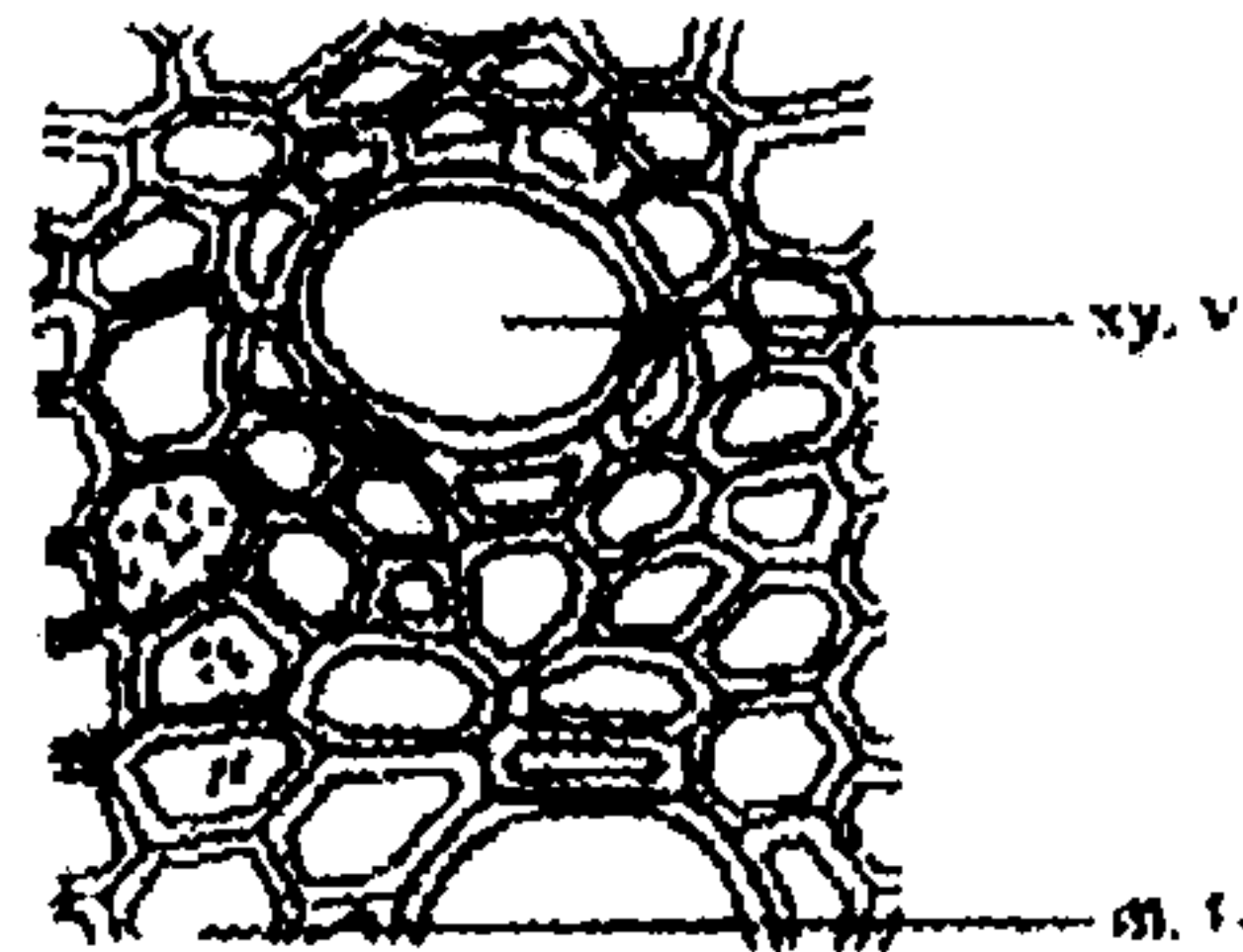
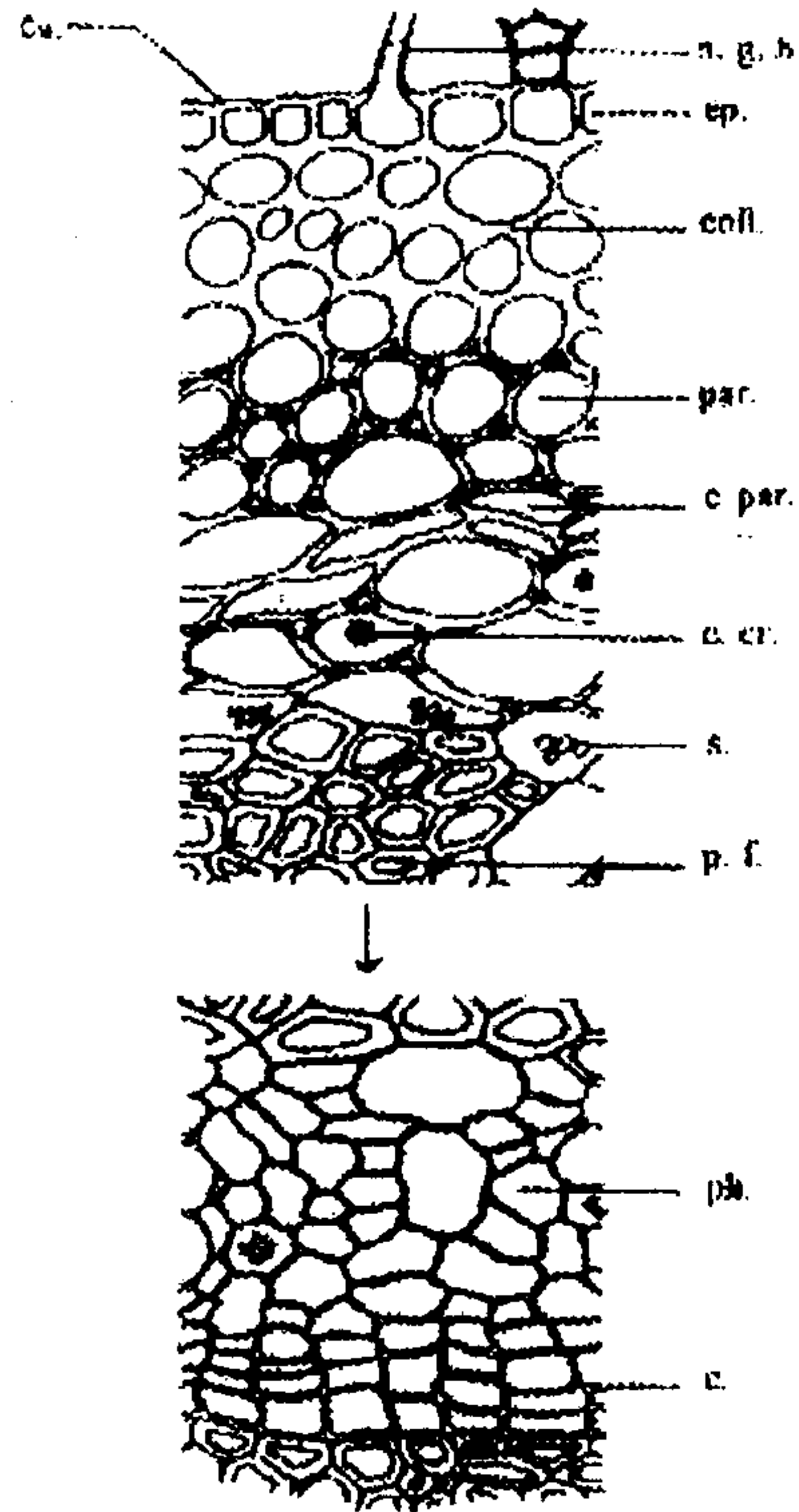
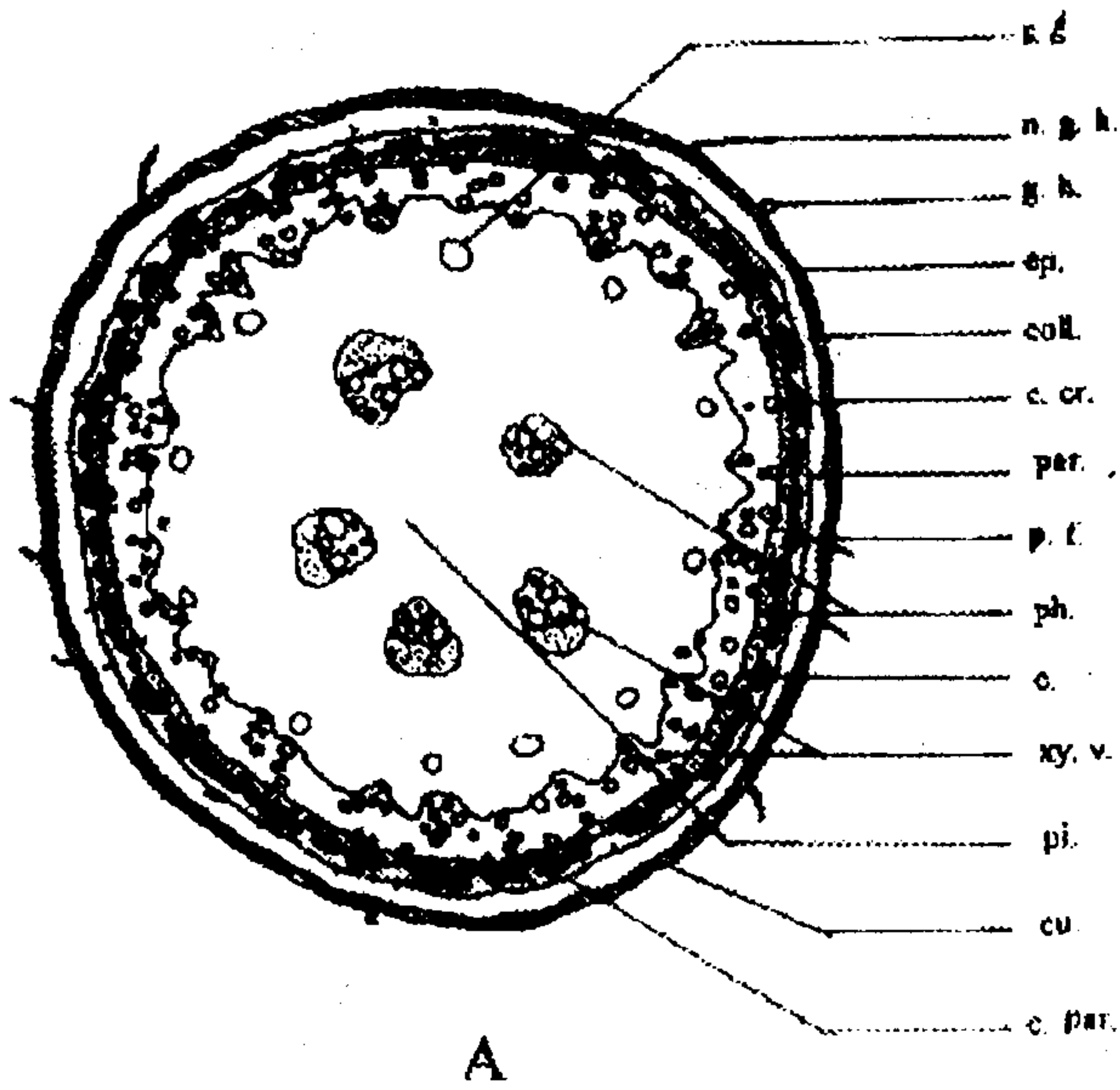


Fig. 4:

- A) T. S. Diagram of the Rachis (X 42)
 c., cambium; c. cr., cluster crystals of calcium oxalate;
 c. par., collapsed parenchyma; coll., collenchyma; cu.,
 cuticle; ep., epidermis; g. h., glandular hair; n. g. h.,
 non-glandular hair; p. f., pericyclic fibers; par.,
 parenchyma; ph., phloem; pi., pith; s. g., schizogenous
 oil gland; xy. v., xylem vessels.
- B) T. S. Sector of the Rachis (X 530)
 m. r., medullary ray.

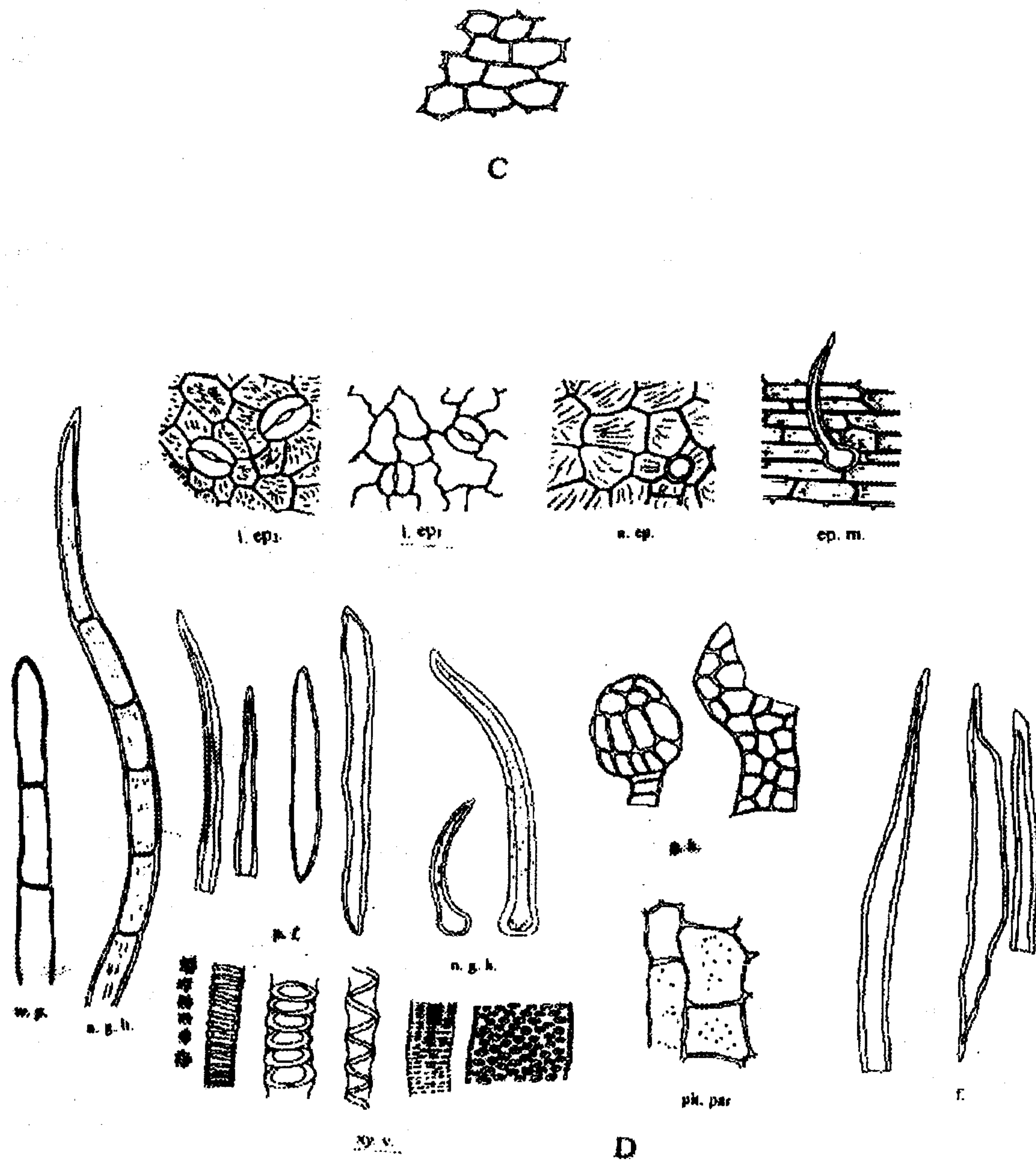


Fig. 4: Cont.

C) Epidermis of the Rachis

(X 530)

D) Isolated Elements of the Leaf

(X 530)

ep. m., epidermis of the midrib; f., fibers; l. ep1., lower epidermis of the young leaflet; l. ep2., lower epidermis of the old leaflet; pit. par., pitted parenchyma; u. ep., upper epidermis; w. p., wood parenchyma.

tapering ends, measuring 6-9-12 μ in width. Some of the parenchyma cells between the pericyclic fibers contain cluster crystals of calcium oxalate.

The vascular system (Fig. 4B)

The vascular system shows a complete ring of xylem and phloem with a central wide pith, where 2-6 additional collateral vascular bundles are present.

The phloem (Fig. 4B)

The phloem zone is formed of a continuous ring surrounding the xylem and separated by few layers of tangentially elongated thin-walled cellulosic cells of the cambium. It is formed of phloem parenchyma, sieve tubes and companion cells, phloem fibers being absent, occasional cluster crystals of calcium oxalate are present in the phloem parenchyma.

The xylem (Fig. 4B)

The xylem region is formed of vessels, fibers, and wood parenchyma and traversed by medullary rays. The xylem vessels are lignified with pitted, annular, spiral and reticulate thickening (Fig. 4D), and measuring 12-32-48 μ in diameter.

The fibers are elongated with tapering ends and lignified walls with moderate wide lumina (Fig. 4D), measuring 8-10-12 μ in diameter.

The wood parenchyma are polygonal cells with lignified walls, some of them are pitted.

The medullary rays are uniseriate or biseriata elongated subrectangular lignified cells, some of them are pitted.

The pith (Fig. 4B)

The pith is a wide zone, formed of wide parenchyma cells with additional 2-6 collateral vascular bundles. The outer part of the pith showing numerous schizogenous oil glands measuring 16-32-43 μ in diameter. The parenchyma cells of the pith are rounded to oval in shape, slightly lignified and sometimes with pitted walls. Cluster crystals of calcium oxalate and starch granules are not observed.

The powder of the leaf

The powdered leaf is dark green in colour with a faint characteristic odour and a bitter taste.

It is characterized microscopically by the following (Fig. 4D)

- 1- Fragments of the upper epidermis of the leaf, polygonal with straight anticlinal walls, covered with striated cuticle and carrying glandular and non-glandular hairs, in addition to cicatrices, but no stomata.
- 2- Fragments of the lower epidermis of the leaflets, polygonal with straight or wavy anticlinal walls, covered with smooth or striated cuticle, carrying glandular, and nonglandular hairs, with anomocytic stomata surrounded by 5-6 cells.
- 3- Fragments of elongated epidermal cells of the midrib region, carrying glandular and non-glandular hairs.
- 4- Glandular hairs with uniseriate stalks of 2-3 cells and multicellular heads of 9-13 cells.
- 5- Non-glandular hairs, of two types, unicellular or multicellular uniseriate 4-7 cells.
- 6- Fragments of fibers, elongated with tapering ends and somewhat wide lumina.
- 7- Cluster crystals of calcium oxalate, solitary or in rows especially near the veins. The number of clusters in each row up to 20 clusters.
- 8- Fragments of spiral, annular, pitted and reticulate xylem vessels with lignified walls.
- 9- Fragments of the epidermal cells of the rachis (Fig. 4C) with slightly straight anticlinal walls covered with smooth cuticle carrying glandular and nonglandular hairs. The nonglandular hairs are similar to those of the leaflets. The glandular hairs are similar to those of the leaflets or have bi-, or triseriate stalks and multicellular heads.
- 10- Fragments of pitted lignified wood parenchyma of the rachis.

Macromorphology of the stem

The stem of *Ailanthus altissima* Swingle

(Fig. 2C) is woody, erect, cylindrical to subcylindrical in shape with monopodial branching. The young branches have green to yellowish-green colour with smooth surface. It shows internodes measuring 2 to 4 cm in length. The old stem is light brown in colour with small spots of lenticels and scars of the fallen leaves. The stem carries compound petiolate leaves.

The stem is broken with fibrous fracture. It has faint characteristic odour and slight bitter taste.

Micromorphology of the stem

A transverse section in the young stem (Fig. 5A) is circular to slightly irregular in outline, showing epidermis covered with thin cuticle followed by a cortex and a pericycle surrounding a continuous ring of vascular tissues with a wide parenchymatous pith in the center.

The epidermis (Fig. 5B)

The epidermal cells are polygonal to subrectangular in shape, slightly elongated measuring 5-6-8 μ in width, 4-5-6 μ in height, and 8-13-21 μ in length, covered with smooth cuticle (Fig. 5C), and carrying glandular and nonglandular hairs. Non-glandular hairs, unicellular measuring 22-38-53 μ in length or multicellular, uniseriate, 3-11 cells measuring 77-145-219 μ in length (Fig. 5C). The glandular hairs are occasional with uniseriate multicellular stalks (3 cells) and multicellular heads similar to those of the leaf (Fig. 5C). No stomata were observed.

The cortex (Fig. 5B)

The cortex is formed of outer zone of 2-3 rows of somewhat small thick walled collenchymatous cells, followed by a zone of oval, rounded parenchyma cells with thin walls and wide intercellular spaces, few cells are pitted and some of them contain cluster crystals of calcium oxalate measuring 3-7-11 μ in diameter. The inner part of the cortex shows 2-3 layers of elongated, slightly collapsed parenchyma cells.

Starch granules are observed in the endodermal cells as small, rounded, simple granules.

The pericycle (Fig. 5B)

The pericycle is formed of irregular groups of fibers which are interrupted by parenchyma cells. These fibers usually have tapering apices with thick, lignified walls and moderate wide lumina (Fig. 5C). The walls of the fibers are regular in outline, some are irregular in one side only. The fibers measure 5-6-9 μ in width. Some of the parenchyma cells which interrupt the groups of fibers contain cluster crystals of calcium oxalate.

The phloem (Fig. 5B)

The phloem zone is separated from the xylem by cambium. The cambium is formed of several layers of thin-walled elongated cellulose cells, free of contents. The phloem is formed of phloem parenchyma, sieve tubes, companion cells and phloem fibers. The phloem parenchyma are subrectangular to polygonal in shape, some of them contain cluster crystals of calcium oxalate. They are interrupted by small groups of phloem fibers with tapering apices, wide lumina and moderately thickened slightly lignified walls (Fig. 5C).

The medullary ray uniseriate or biseriate consisting of elongated rectangular cells with thin cellulose walls.

The xylem (Fig. 5B)

The xylem is formed of lignified vessels, fibers, tracheids and wood parenchyma. The vessels have spiral, pitted and annular thickening (Fig. 5C), measuring 9-25-43 μ in diameter. Wood parenchyma, lignified, with thick walls, some are pitted. Tracheids, elongated with tapering ends, having lignified, reticulate and pitted walls, measuring up to 188 μ in length and 8-12-19 μ in diameter. Wood fibers, elongated, with wide lumina, tapering apices and lignified walls, measuring 6-7-9 μ in width (Fig. 5C).

Medullary rays, uniseriate or biseriate, with moderately thickened, lignified walls, some are pitted.

The pith (Fig. 5B)

The pith is formed of a wide zone of polygonal to rounded nonlignified parenchyma cells, occasionally pitted, increasing in size

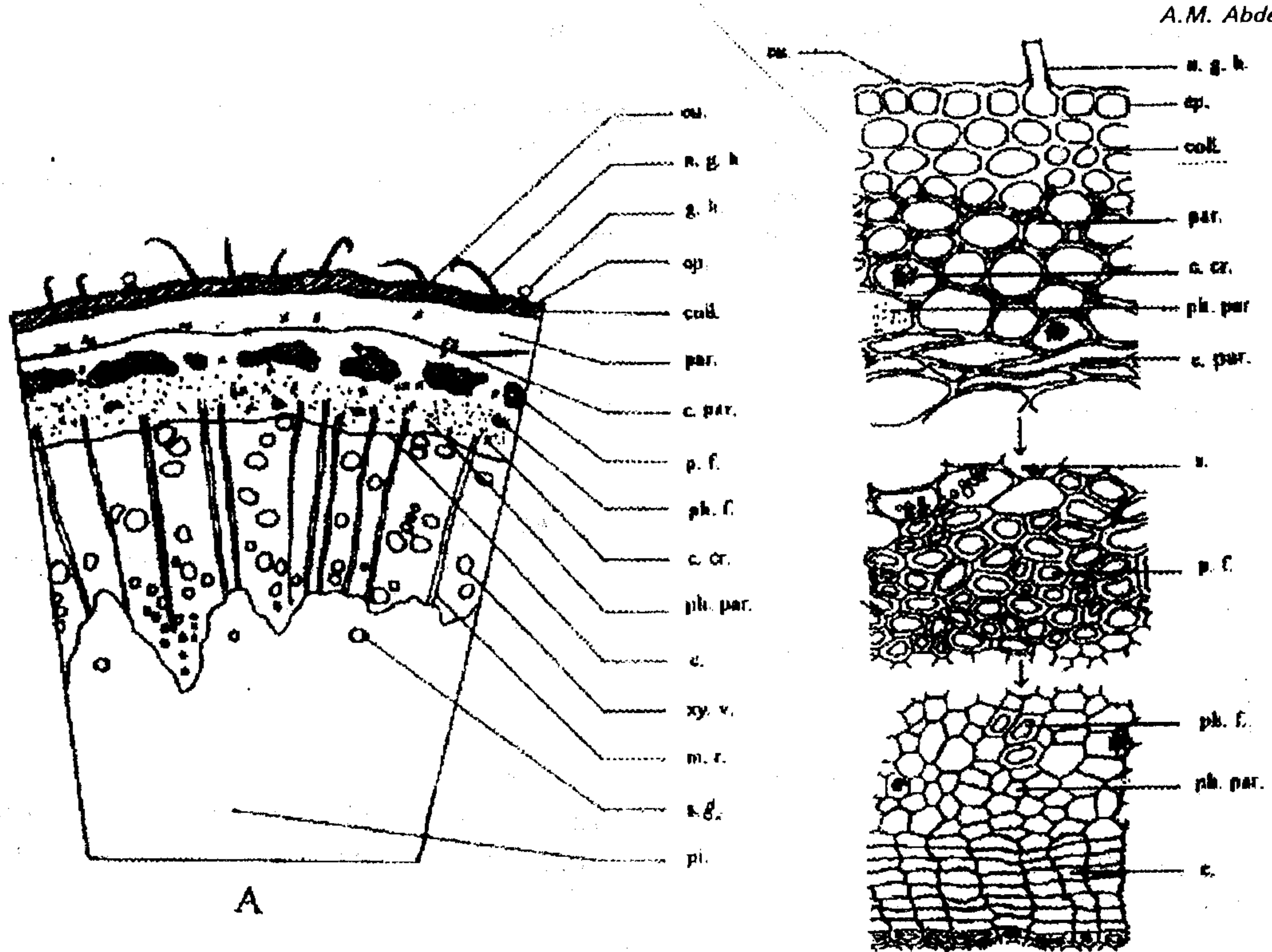


Fig. 5:

- A) T. S. Diagram of the Stem (X 98)
 c., cambium; c. cr., cluster crystals of calcium oxalate; c. par., collapsed parenchyma; coll., collenchyma; cu., cuticle; ep., epidermis; g. h., glandular hair; m. r., medullary ray; n. g. h., non-glandular hair; p. f., pericyclic fibers; par., parenchyma; ph. f., phloem fibers; ph. par., phloem parenchyma; pi., pith; s. g., schizogenous oil gland; xy. v., xylem vessels.
- B) T. S. Sector of the Stem (X 530)
 pit. par., pitted parenchyma; pit. w. p., pitted wood parenchyma; s., starch.

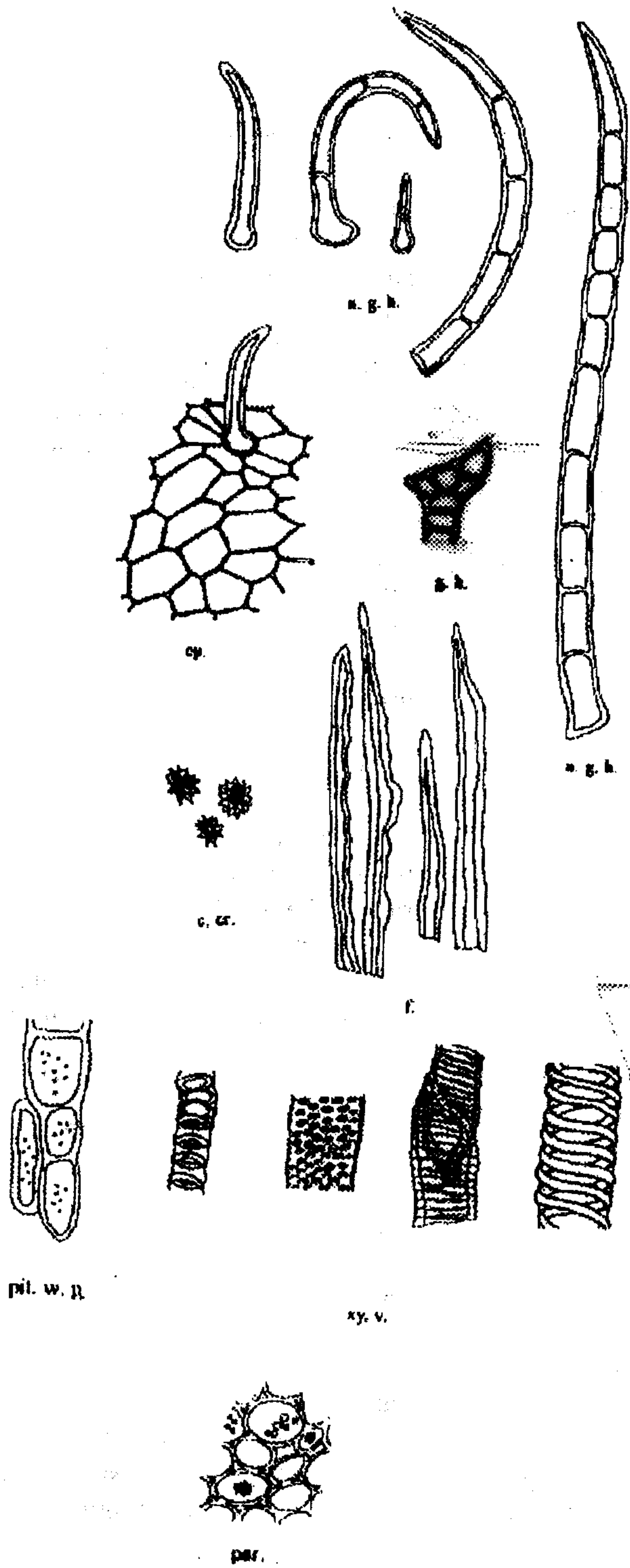


Fig. 5: Cont.

C) Isolated Elements of the Stem

(X 530)

towards the center. Calcium oxalate crystals and starch granules are absent.

The outer part of the pith shows a number of schizogenous oil glands, each consisting of a cavity surrounded by epithelial cells measuring 10-17-28 μ in diameter.

The powder

The powdered stem is greenish to yellowish-green, with a faint characteristic odour and a slight bitter taste.

The important microscopical features (Fig. 5C) are:

- 1- Fragments of epidermal cells, polygonal, with straight anticlinal walls, covered with smooth cuticle, carrying unicellular and multicellular uniseriate nonglandular hairs, and glandular hairs with uniseriate multicellular stalks and multicellular heads.
- 2- Fragments of cortical parenchyma, rounded to oval occasionally containing cluster crystals of calcium oxalate and small rounded starch granules.
- 3- Fragments of xylem vessels, lignified, with spiral, annular and pitted thickening.
- 4- Fragments of wood parenchyma with lignified, sometimes pitted walls.
- 5- Fragments of tracheids with lignified, pitted and reticulate thickening.
- 6- Fragments of phloem fibers, pericyclic fibers and wood fibers, lignified, with tapering apices and wide lumina. The walls of the fibers are regular in outline, some are irregular in one side only. The phloem fibers are slightly lignified.
- 7- Numerous cluster crystals of calcium oxalate, scattered solitary or in rows.

Macromorphology of the stem-bark

The stem-bark of *Ailanthus altissima* Swingle (Fig. 2D), occurs in flat or curved pieces. It measures 0.5 mm in thickness, 3-5 cm in width and 4-20 cm in length.

The outer surface is brownish-green to light brown in colour with numerous lenticels, while the inner surface is yellowish-green in colour, finely longitudinally striated. The fracture is

fibrous.

The stem-bark has faint characteristic odour and bitter taste.

Micromorphology of the stem-bark

Transverse and longitudinal sections in the stem-bark (Fig. 6A, and 7) showed three distinct regions: the cork, the cortex, and the phloem regions. The cork consists of several rows of radially elongated cells. The cortex is comparatively wide, formed of outer 4-6 rows of collenchymatous cells followed by thin-walled irregular shaped parenchyma cells containing starch granules, clusters and prisms of calcium oxalate. The cortical parenchyma is interrupted by lignified sclereids, scattered either in small or large groups.

The innermost layer of the cortex shows groups of lignified pericyclic fibers associated with sclereids forming the pericyclic region. These groups of fibers and sclereids are separated by parenchyma cells.

The phloem appears as a wide zone traversed by uniseriate or biseriate medullary rays. The phloem region consists of phloem parenchyma, sieve tubes companion cells and groups of phloem fibers. Clusters of calcium oxalate and starch granules are present.

The cork (Fig. 6B)

The cork layer is formed of several rows (up to 30 rows) of radially arranged cells, elongated, tabular or subrectangular. The outer row of the cork contains yellowish-brown contents, the rest being free of contents, with nonlignified walls. The cork cells measure 6-11-15 μ in width and 1-4-7 μ in height. In top view (Fig. 6C), the cork cells appear polygonal, with straight anticlinal walls, measuring 7-10-15 μ in length. The innermost layer of the cork is the phellogen consisting of thin-walled, tangentially elongated cells.

The cortex (Fig. 6B)

The outer layer of the cortex is collenchymatous consisting of 2-3 rows, followed by thin-walled, rounded, oval to elongated parenchyma cells measuring

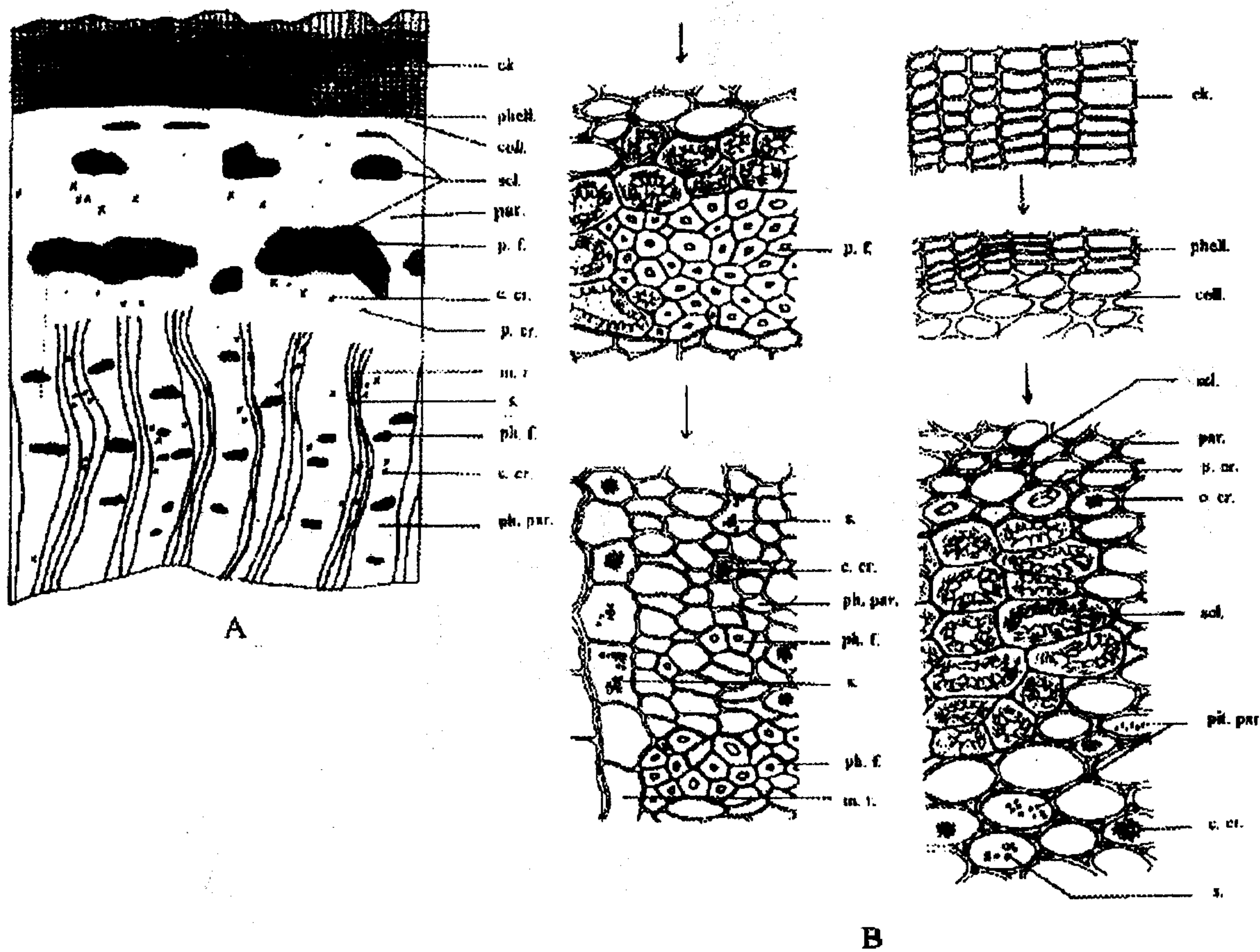


Fig. 6:

A) T. S. Diagram of the Stem-bark

(X 82)

c. cr., cluster crystals of calcium oxalate; ck., cork; coll., collenchyma; m. r., medullary ray; p. cr., prism crystals of calcium oxalate; p. f., pericyclic fibers; par., parenchyma; ph. f., phloem fibers; ph. par., phloem parenchyma; phell., phellogen; s., starch; scl., sclerieds.

B) T. S. Sector of the Stem-bark

(X 530)

pit. par., pitted parenchyma.

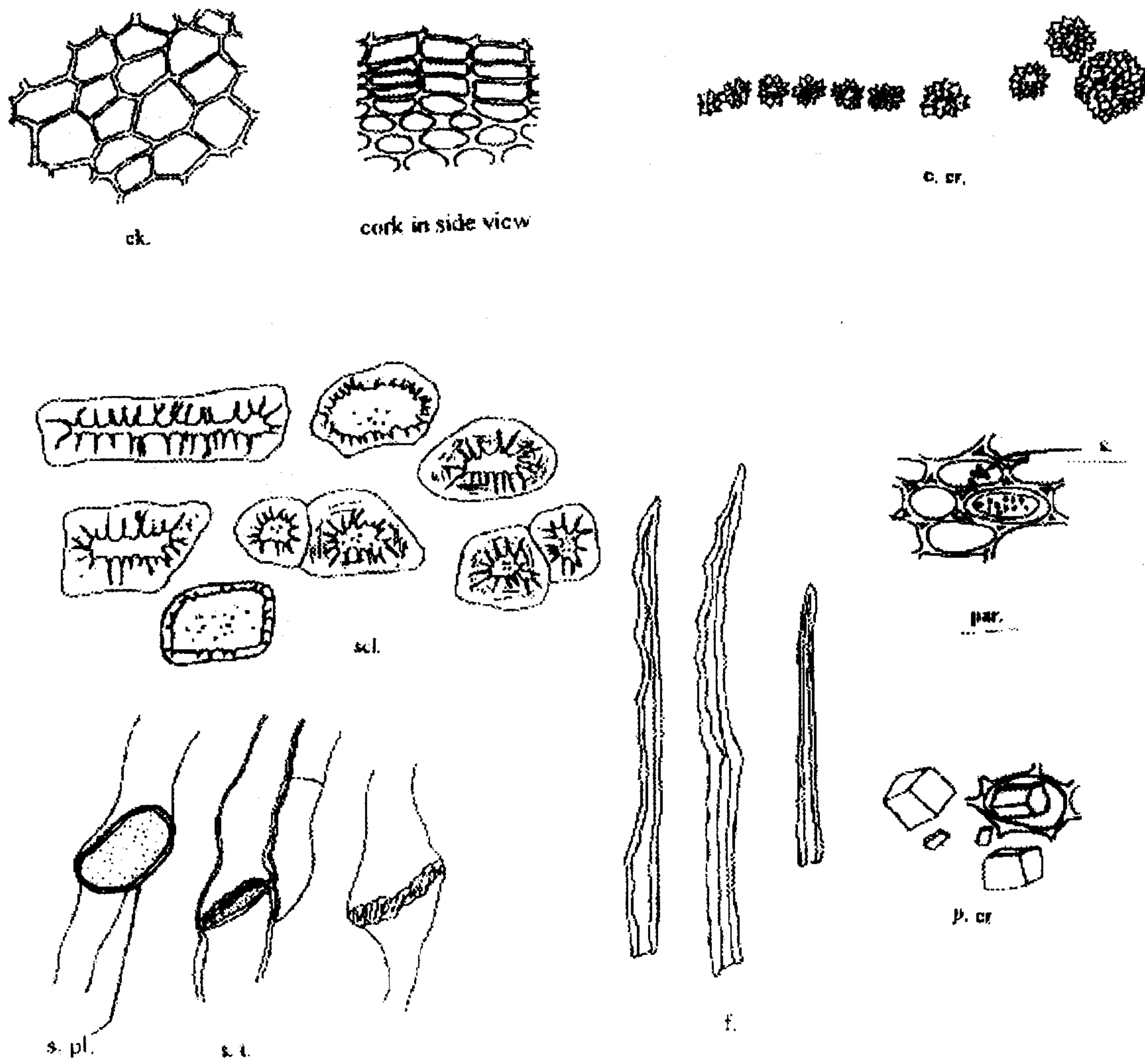


Fig. 6: Cont.

C) Isolated Elements of the Stem-bark
f., fibers; s. pl., sieve plate; s. t., sieve tube.

(X 530)

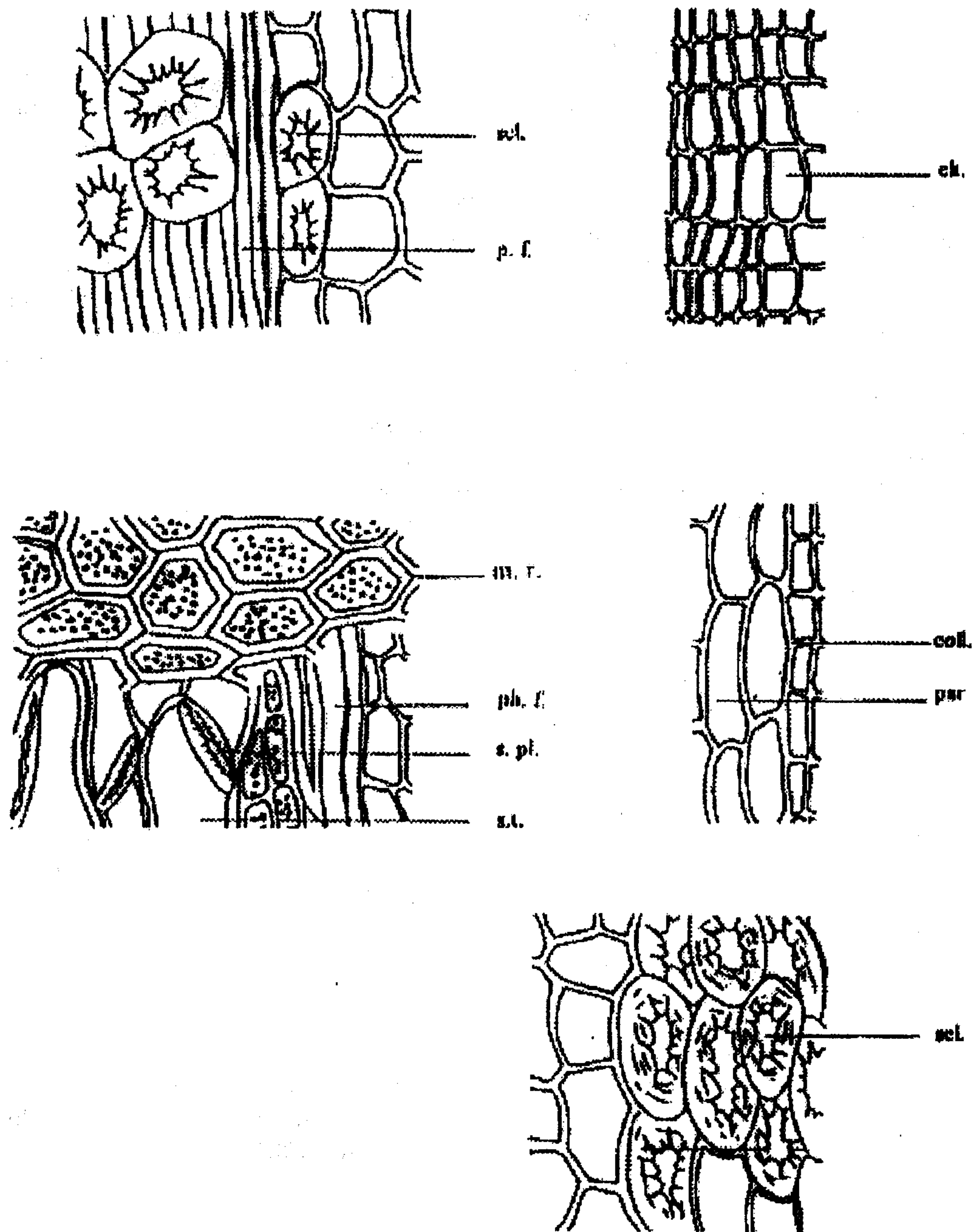


Fig. 7:

Detailed L. S. of the Stem-bark

(X 652)

ck., cork; coll., collenchyma; m. r., medullary ray; p. f., pericyclic fibers; par., parenchyma; ph. f., phloem fibers; s. t., sieve tube; s. pl., sieve plate; scl., sclerieds.

10-16-25 μ in length, and 5-10-13 μ width. They contain few prisms of calcium oxalate measuring 4-8-10 μ in length, numerous cluster crystals of calcium oxalate measuring 5-10-17 μ in diameter, in addition to small aggregated starch granules.

Numerous groups of sclerenchymatous cells are scattered in the cortical region either in small or large groups. The small groups (3-7 sclereids) are present mainly in the outer part, while the large groups (10-24 sclereids) are present mainly in the inner part. The individual sclereid appears as rounded, oval, subrectangular or isodiametric cell with thick, lignified, faintly or markedly striated walls and wide or narrow lumen traversed by simple pits. Each sclereid measures 10-33-60 μ in length and 6-12-21 μ in width.

The pericycle consists of large groups of pericyclic fibers and sclereids, separated by parenchyma cells. The individual sclereid is similar to those present in the cortex. The pericyclic fibers (Fig. 6C) have thick, lignified walls, somewhat narrow lumina with acute to acuminate apices. Some of them have one irregular side (Fig. 6C), while the others are regular. These fibers measure up to 200 μ in length and 4-7-12 μ in width. Some of the parenchyma cells between the pericyclic fibers contain cluster crystals of calcium oxalate.

The Phloem (Fig. 6B, and 7)

The phloem zone is formed of phloem parenchyma, phloem fibers, sieve tubes and companion cells. The phloem parenchyma are rounded to subrectangular, smaller in size than those of the cortical parenchyma having thin walls. They contain small, simple, rounded starch granules. Cluster crystals of calcium oxalate are also present. The sieve elements are distinguishable, showing the companion cells and sieve tubes with sieve plates (Fig. 6C, and 7). The phloem fibers solitary or in groups (2 to 16), thick, lignified walls, narrow lumina and acute to acuminate apices (Fig. 6C), separated by uniseriate or biseriate medullary rays, formed of elongated polygonal parenchymatous cells containing cluster crystals of calcium oxalate and starch granules similar to those of the phloem

but more abundant.

Powdered bark

The powdered stem-bark is yellowish-brown to light-brown, with faint characteristic odour and bitter taste.

The powder is characterized by the following fragments (Fig. 6C)

- 1- Fragments of the cork cells in top view showing polygonal thin-walled cells with yellowish-brown contents.
- 2- Fragments of the cortex showing oval or elongated parenchyma cells, occasionally pitted containing clusters and prisms of calcium oxalate.
- 3- Fragments of lignified phloem and pericyclic fibers with thick walls, narrow lumina and acute to acuminate apices.
- 4- Fragments of sieve tubes showing sieve plates.
- 5- Fragments of sclereids either solitary or in groups. The single sclereid shows thick, lignified and pitted striated walls with narrow or wide lumina.
- 6- Few prisms and numerous cluster crystals of calcium oxalate. The clusters present either solitary or in rows which are very characteristic. Each row consists of up to 15 clusters.
- 7- Fragments of parenchyma cells containing small rounded starch granules.

REFERENCES

- 1- "The Macdonald Encyclopedia of Trees", Macdonald and Co. Ltd., London and Sydney, (1982).
- 2- M. A. Dirr, " Manual of Woody Landscape Plants", 82 Stipes Publishing Company, Champaign, Illinois, (1983).
- 3- J. M. Watt, and M. G. Breyer, "The Medicinal and Poisonous Plants of Southern and Eastern Africa", E. and S. Living Stone LTD. Edinburgh and London, 940 (1962).
- 4- L. M. Perry, " Medicinal Plants of East and Southeast Asia", 387 MIT Press

- Cambridge, Massachusetts, and London, England, (1980).
- 5- E. Verga, K. Szendrei, J. Reisch, and G. Maroti, *Planta Med.*, 40, 337 (1980).
 - 6- Atta-ur-Rahman (Ed.), "Studies in Natural Product Chemistry", Vol. VII 369 Elsevier Science Publisher, B. V., Amsterdam (1990).
 - 7- J. Polonsky, "Progress in the Chemistry of Organic Natural products", 47, 222 (1985).
 - 8- T. Ohmoto, R. Tanaka, and T. Nikaido, *Chem. Pharm. Bull.*, 24 (7), 1532 (1976).