

MACRO- AND MICROMORPHOLOGY OF STEMS AND LEAVES OF *TERMINALIA ARJUNA* (Bedd.)

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تزرع أشجار الترمينا ليا ارجونا "بيد" فى الطرق العامة وذلك لأغراض الظل وقد تبين لنا من المراجع المختلفة أن أنواع أخرى من جنس الترمينا ليا لها إستعمالات طبية شعبية عديدة مثل علاج الدوسنتاريا ، الروماتيزم ، الكحة ، القرح والأمراض الجلدية وفى الدباغة ويجرى الآن عمل دراسة للمكونات الكيميائية لهذا النبات. ويشتمل هذا البحث على دراسة تفصيلية للصفات العيانية والمجهريّة لسيقان وأوراق النبات بهدف التعرف على أجزائه سواء كاملة أو على هيئة مسحوق.

The macro- and micromorphology of the stems and leaves of Terminalia arjuna (Bedd.) are presented with the aim of finding their characters by which they could be identified and differentiated, both in the entire and powdered forms.

INTRODUCTION

Terminalia arjuna (Bedd.¹ or W. and A.²) Family Combretaceae (synonym. Terminaliaceae³) is a large tree with huge often butterseed trunk and horizontally spreading branches². It is native of India (Indian almond)¹.

Terminalia species is used to treat cough, eye diseases and ulcers, astringent and tonic, purgative when green, in large doses it is narcotic⁴, also it is used as a dressing for swollen rheumatic joints. The sap of the young leaves, cooked with oil from the kernel, is suggested to treat leprosy; leaves mixed with oil, may be rubbed on the breast to cure pain. The bark and root-bark are useful for bilious fevers, diarrhia, catarrh and externally in skin diseases^{4,5}.

Some species are used as vermifuge, diuretic and for hemorrhoids⁶. The use of decoction of several *Terminalia* species is widespread in the traditional native medicine of Central African Republic⁷. Other species of *Terminalia* are prescribed as anti-dysenteric and antimicrobial remedies and are reportedly useful in the last phase of AIDS⁸.

A survey of literature revealed the absence of any previous botanical or complete phytochemical studies on the plant under investigation.

The preliminary phytochemical screening revealed the presence of tannins, flavonoids, sterols and/or triterpenes, the phytochemistry of the plant is currently under investigation. The present study is concerned with the macro- and micromorphological characters of both the stem and leaf.

EXPERIMENTAL

Material

Terminalia arjuna (Bedd.) are collected from Assiut University and identified by Dr. Abdel Aziz Fayed, Professor of Taxonomy, Faculty of Science, Assiut University. Fresh stems and leaves were used.

Habitat

Terminalia arjuna (Bedd.) is a large tree with horizontally spreading branches up to 15 meters in height. Leaves are usually simple oblong and flowers appearing in Spring, they are small greenish white in slender axillary spikes. The fruit is a dark brown, 5-winged capsule.

MACROMORPHOLOGY

I- The stem (Fig 1)

The main trunk is erect, cylindrical, woody, horizontally branched and reaching about 10-15 meters in height and 50-80 cm in diameter. The outer surface is pale brown, rough and wrinkled. The terminal and lateral branches are thinner and have short internodes measuring from 2-4 cm in length. The older lower parts are pinkish-grey, rough, longitudinally wrinkled and bear the scars of fallen leaves. The stem is odourless and with acrid taste. The bark is hardly separated from the wood. The outer surface is pinkish-grey with longitudinal wrinkles, transverse fissures and lenticels.

II- The leaf (Fig 1)

The plant carries alternate, exstipulate, simple leaves. The leaf is usually oblong or elliptic oblong with entire margin and subacute apex, coriaceous texture with rounded base. The leaves measure about 4-7 cm in width at its widest part. The upper surface is dull green in colour while the lower one is pale greenish-brown, petiolate and the petiole measures 5-8 mm with one or two small glands at the top immediately below the leaves. The main veins are 10-14 arcuate pairs. The leaf possesses a faint characteristic odour and acrid astringent taste.

MICROMORPHOLOGY

I- The stem

A transverse section through the young stem (Fig 2-A) is nearly rounded in outline. It shows an outer hairy epidermis surrounding a comparatively wide cortical tissue. The latter consists of an outer collenchymatous layer and inner parenchymatous one. The parenchyma cells of the cortex contain cluster crystals of calcium oxalate, idioblasts in the form of dots or druses⁸ and starch grains simple or compound (2-4 components) which stain blue with iodine. The pericycle consists of groups of lignified fibres alternating with parenchyma cells. The

vascular tissue is formed of a number of collateral continuous radiating bundles. Each bundle consists of an outer phloem in the form of phloem parenchyma and groups of phloem fibres and inner radiating xylem which traversed by uni, bi- and triseriate medullary rays. Intraxylary phloem in the form of separate patches present at the periphery of the parenchymatous pith and surrounding a number of sub-spherical or ovoid (schizo-lysigenous) secretory cavities (1-3 in number) filled with mucilaginous contents which stains red with ruthenium red⁹.

The epidermis (Fig 3A, B)

In transverse section appears as one row of subrectangular cells covered with thick smooth cuticle. In surface view (Fig 2B), the cells are polygonal with straight anticlinal walls, covered with smooth cuticle and measure 43-50-53 μ in length, 30-38-40 μ in height and 38-42-45 μ in width, stomata are not observed. Simple non glandular unicellular trichomes, often bulbous at the base, more or less conically or convexly arched outwards towards the filamentous distal end are observed⁹. They measure 300-325-350 μ in length and 23-28-30 μ in width.

The cortical tissue (Fig 3A, B)

The outer collenchymatous region is formed of 4-6 rows of nearly rounded cells. The inner one is parenchymatous and consists of 7-10 rows of thin-walled rounded cells. They contain cluster crystals of calcium oxalate measuring 23-28-33 μ in diameter and 30-38-50 μ in length; starch grains are simple and compound (2-4 components) and idioblasts of calcium oxalate in the form of dots or druses. The endodermis is indistinct.

The pericycle (Fig 4)

The fibres are elongated, straight and have thick lignified walls, moderately wide lumina and blunt to rounded apices with small simple pits. They measure from 25-30-35 μ in diameter and 600-650-700 μ in length.

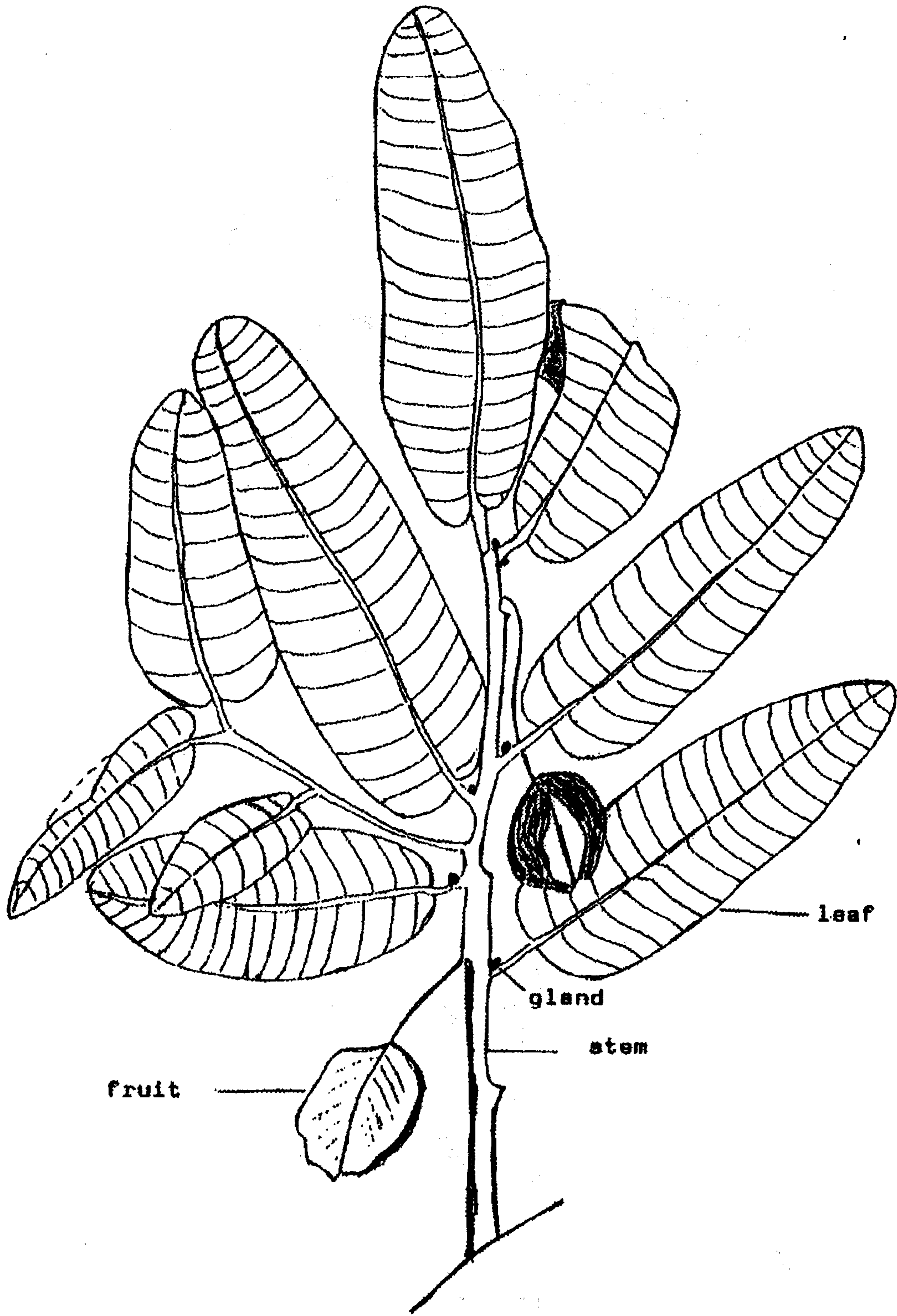


Fig 1: Sketch of a branch

x 0.52

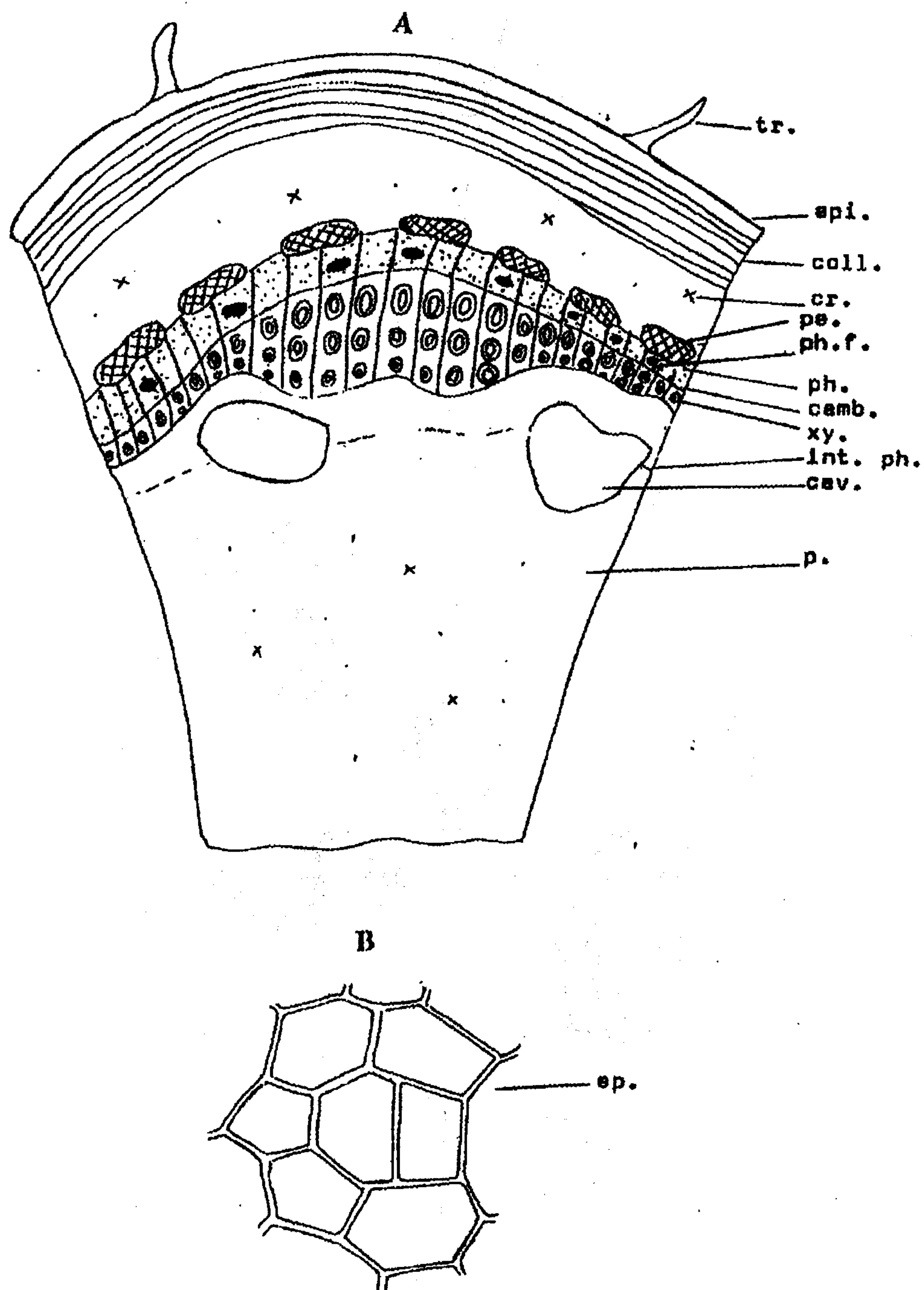


Fig 2: A- Diagrammatic T. S. of young stem x 27
 B- Surface preparation of young stem x 281

camb., cambium; cav., cavity; coll., collenchyma; cor., cortex; cr., crystal; epi., epidermis; int. ph., intraxylary phloem; p., pith; pe., pericycle; ph., phloem; ph. f., phloem fibre; tr., trichome; xy., xylem.

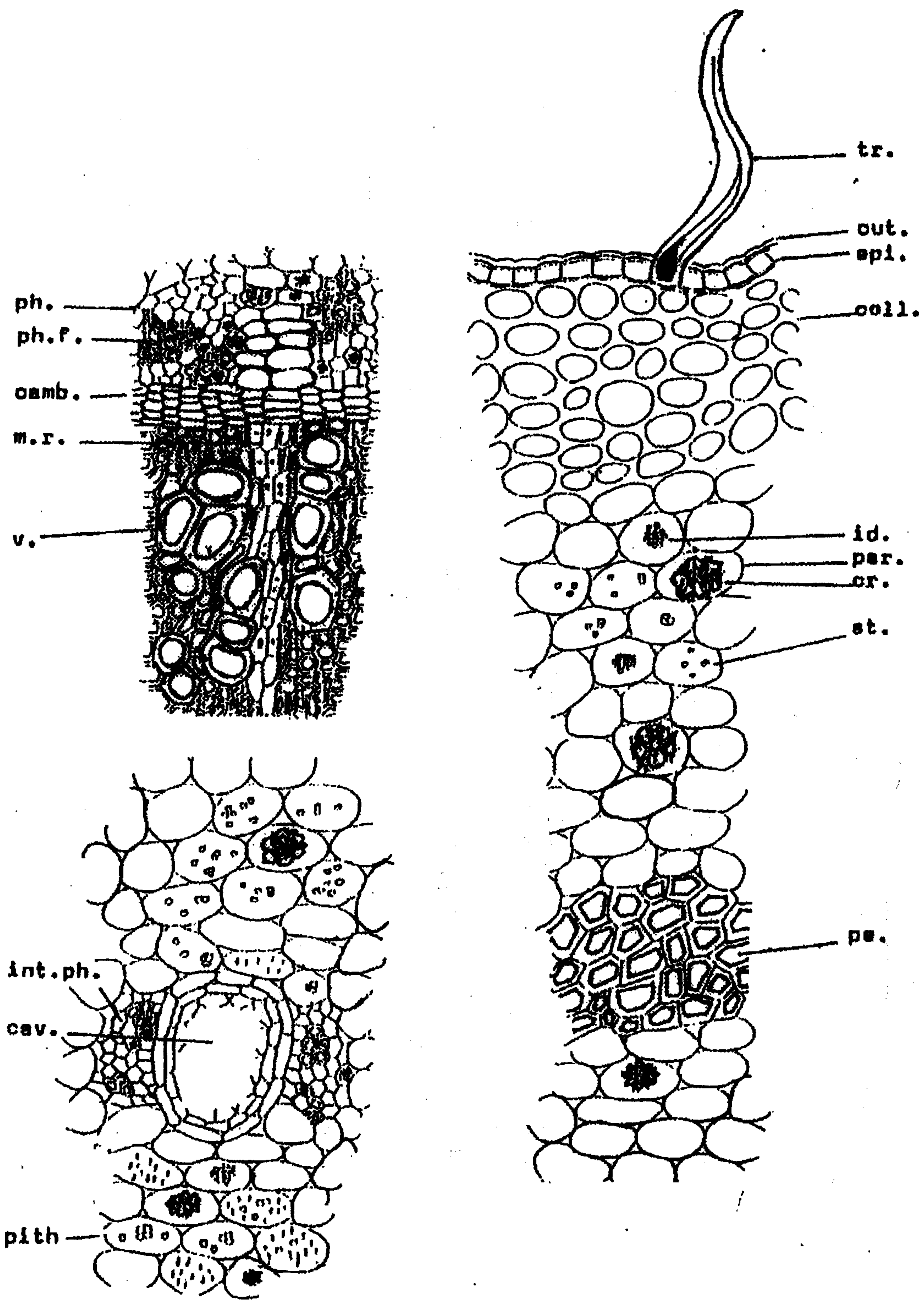


Fig 3: Detailed T. S. of young stem

x 157

camb., cambium; cav., cavity; coll. collenchyma; cr., crystal; cut., cuticle; epi., epidermis; m.r., medullary ray; par., parenchyma; id., idioblast; int. ph., intraxylary phloem; pe., pericycle; ph., phloem; ph. f., phloem fibre; st., starch; tr., trichome; v., vessel.

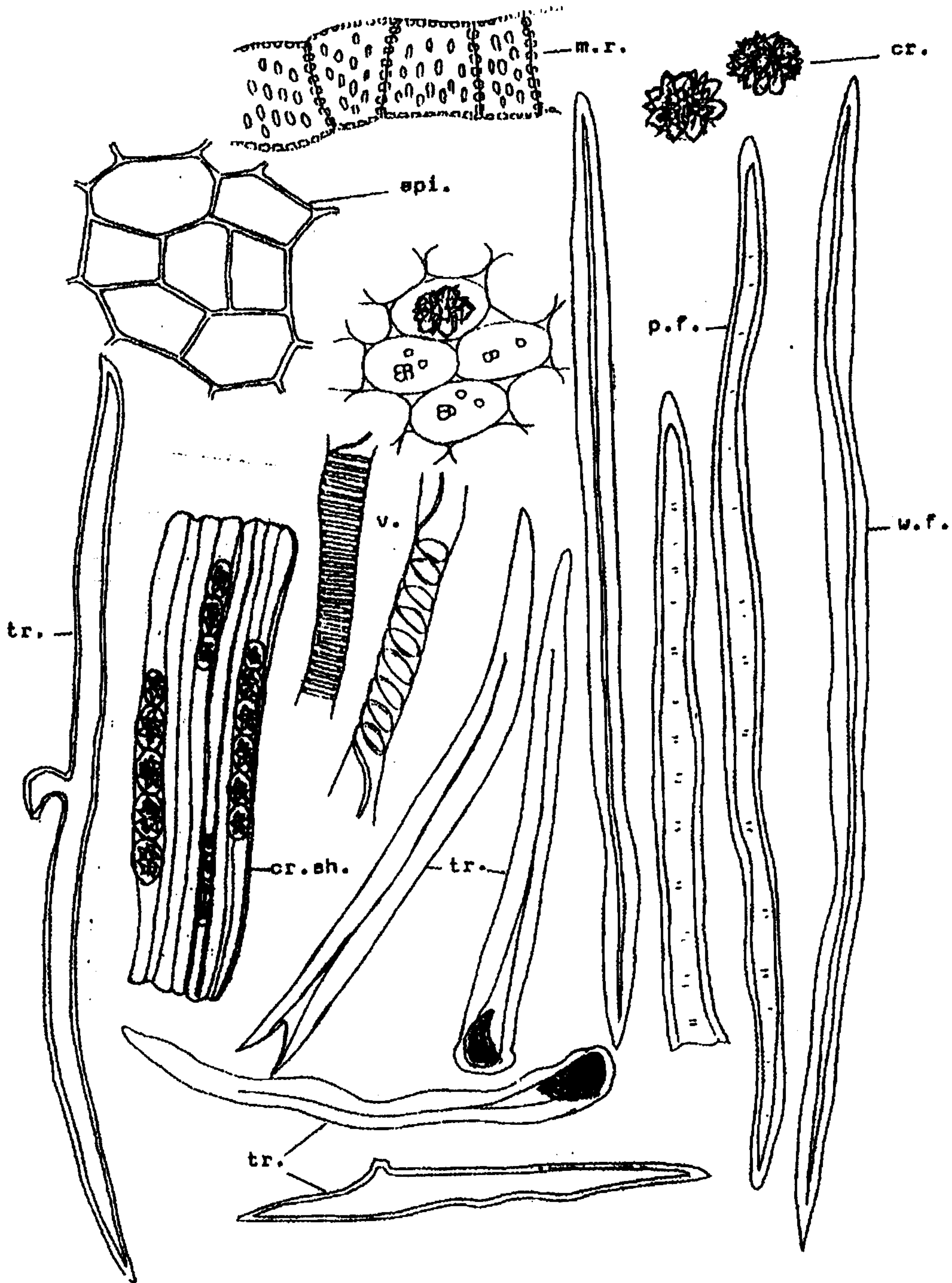


Fig 4: Isolated elements of the stem
x 239
cr., crystal; cr. sh., crystal sheath; epi., epidermis; m. r., medullary ray; p. f., pericyclic fibre;
tr., trichome; v., vessel; w. f., wood fibre.

The vascular system (Fig 3A, B)

The phloem is formed of phloem parenchyma and groups of lignified phloem fibres with moderately narrow lumina and acute apices, alternating with parenchyma cells containing cluster crystals of calcium oxalate forming a crystal sheath with cluster. The cluster measures 13-20-25 μ in length and 10-15-18 μ in diameter and fibres measure 490-530-600 μ in length and 22-27-30 μ in width. Phloem is separated from xylem by a narrow cambial ring. Xylem consists of lignified spiral and reticulate vessels, measure 23-25-28 μ in diameter and accompanied by lignified subrectangular wood parenchyma. Wood fibres have lignified walls, moderately narrow lumina, acute apices and measuring 425-500-550 μ in length and 15-18-23 μ in diameter. Medullary rays are uni-, bi- and triseriate parenchyma cells, sometimes contain minute starch grains.

The pith

The pith is formed of rounded to oval parenchymatous cells with intercellular spaces, sometimes pitted, lignified and contain minute starch grains and cluster crystals of calcium oxalate.

The powder (Fig 4)

Powdered stem of *Terminalia arjuna* (Bedd.) is brownish-green in colour with a faint odour, acrid and astringent taste. It is characteristic microscopically by the following features:

- 1- Fragments of polygonal epidermal cells with straight walls covered with smooth cuticle, showing unicellular non glandular trichomes often bulbous at the base and stomata are not observed.
- 2- Fragments of parenchyma cells of cortex with thin non lignified walls, containing cluster crystals of calcium oxalate and minute starch granules.
- 3- Groups of lignified pericyclic fibres with moderately wide lumina, small pits and blunt apices.
- 4- Fragments of lignified reticulate and spiral xylem vessels.
- 5- Fragments of lignified phloem fibres with narrow lumina and filled with small cluster

crystals of calcium oxalate in the form of crystal sheath with cluster.

- 6- Groups of elongated thick-walled lignified wood fibres with moderately narrow lumina and acute apices.
- 7- Fragments showing lignified and pitted parenchyma cells of the pith. In addition, fragments of medullary ray cells.
- 8- Unicellular non glandular two-armed trichomes, sometimes with an imperfectly developed second arm⁹.

II- The leaves

A- The lamina

A transverse section through the lamina (Fig 5A, B) is somewhat biconvex prominent on the lower side in outline. It shows a dorsiventral structure which containing two rows of columnar palisade cells. The palisade is interrupted by one or two secretory cavities (schizo-lysigenous) filled with mucilaginous contents which stains red with ruthenium red. In the midrib region, the palisade is interrupted by mass of hypodermal collenchyma. The main vascular system is represented by a ring of vascular bundles enclosing central parenchyma. The latter contains patches of intraxylary phloem surrounding secretory cavities filled with mucilaginous contents. All the system is surrounded by a pericycle formed of groups of fibres interrupted by parenchyma cells.

The epidermis

The upper epidermal cells (Fig 5C) are polygonal, isodiametric or sometimes slightly elongated with straight to slightly curved anticlinal walls, covered with thick smooth cuticle measuring 55-63-75 μ in length, 45-47-50 μ in width and 23-25-28 μ in height showing unicellular non glandular trichomes, often bulbous at the base and measure 263-300-325 μ in length and 20-23-25 μ in width. Stomata are not observed.

The lower epidermis (Fig 5D) is composed of polygonal nearly isodiametric cells with slightly wavy anticlinal walls, covered with thick smooth cuticle and measuring 43-50-63 μ in length, 28-38-40 μ in height and 30-40-45 μ in width. Stomata of anomocytic type surrounded by 4-5 cells are noticed and measure 37-45-50 μ

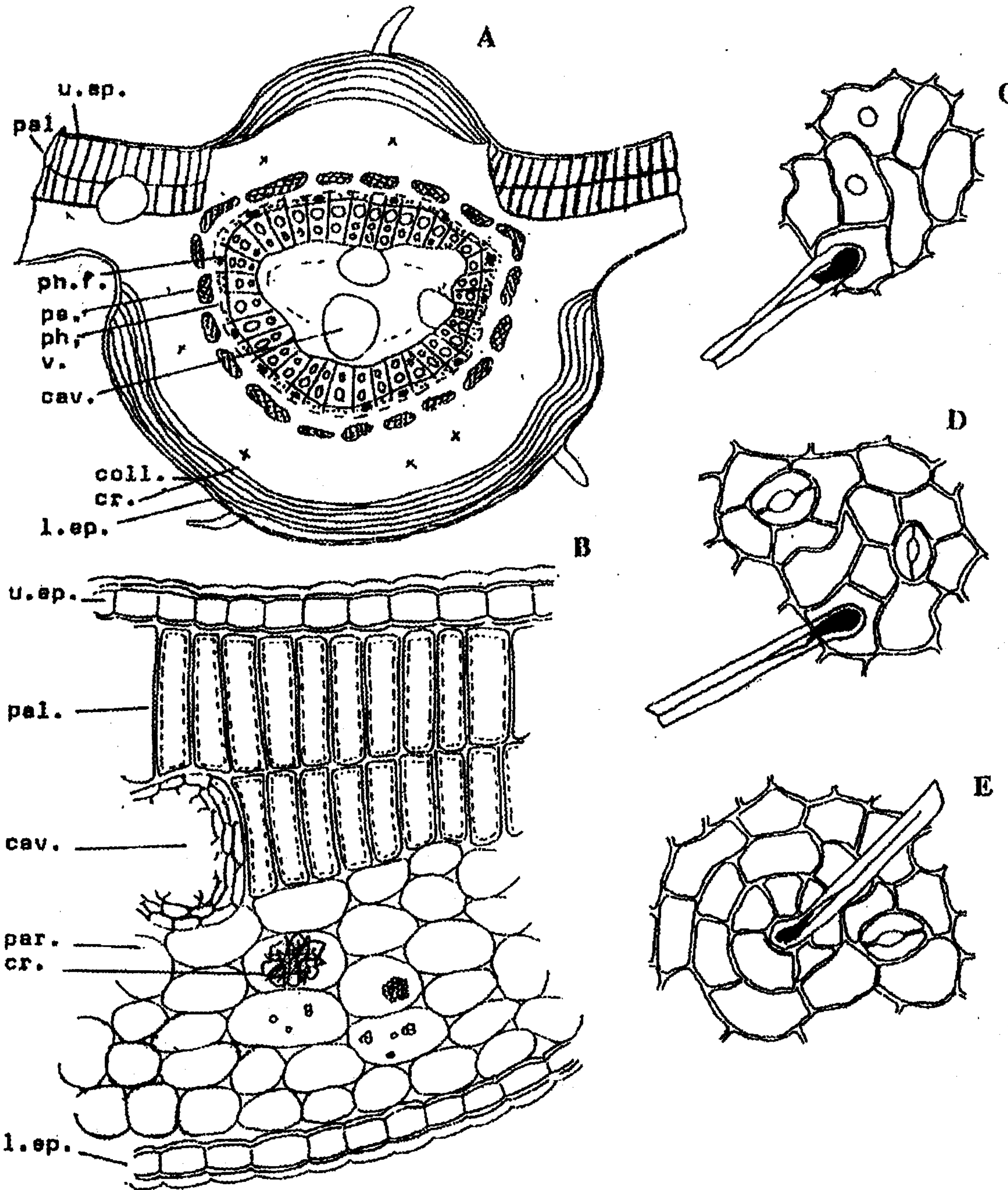


Fig 5: A- Diagrammatic T. S. of the leaf x 22
 B- Detailed T. S. of the lamina x 210
 C- Surface preparation of the upper epidermis x 210
 D- Surface preparation of the lower epidermis x 210
 E- Lower epidermis with radiating cells x 210

cav., cavity; coll., collenchyma; cr., crystal; int. ph., intraxylary phloem; l. ep., lower epidermis; par., parenchyma; pal., palisade; pe., pericycle; ph., phloem; ph. f., phloem fibre; st., stomata; u. ep., upper epidermis; v., vessel.

in length and 25-40-43 μ in width. Non glandular trichomes are noticed on the lower epidermis, some of them show at their bulb base 5-7 radiating epidermal cells (Fig 5E).

The cortical tissue (Fig 6A, B)

The upper and lower collenchyma are formed of 4-6 rows of rounded collenchyma cells. The parenchyma is rounded (8-10 rows) containing minute starch granules, cluster crystals of calcium oxalate measuring 25-38-50 μ in length and 18-28-35 μ in diameter and idioblasts of calcium oxalate in the form of dots or druses⁹.

The mesophyll (Fig 5B)

The palisade consists of two rows of columnar cells measuring 87-100-150 μ in length and 23-25-30 μ in width.

The vascular system (Fig 6A, B)

The pericycle fibres are straight, elongated and have lignified thick walls, moderately wide lumina, blunt to rounded apices with small pits and measure 500-750-900 μ in length and 23-25-28 μ in diameter. The phloem is formed of phloem parenchyma and groups of lignified fibres with a moderately narrow lumina, acute to acuminate apices and measure 500-550-613 μ in length and 20-26-29 μ in diameter. The fibres are alternating with parenchyma cells containing cluster crystals of calcium oxalate, forming a crystal sheath with cluster. The cluster measures 9-10-13 μ in diameter and 13-15-18 μ in length. The xylem shows lignified spiral and reticulate vessels measuring 25-27-30 μ in diameter. Medullary rays are uni- bi- and triseriate parenchyma cells, containing minute starch grains.

B- The petiole

A transverse section through the petiole (Fig 7A) is nearly similar to that of the stem.

The epidermis (Fig 7B)

It consists of polygonal mostly isodiametric cells with straight anticlinal walls and covered with smooth cuticle, they measure 43-45-50 μ in length, 30-37-40 μ in width and 20-23-25 μ in height.

The cortex (Fig 8)

It consists of 3-6 rows of nearly rounded outer collenchymatous cells and 4-7 rows of thin walled rounded inner parenchymatous cells containing cluster crystals of calcium oxalate measuring 35-37-43 μ in length and 20-30-40 μ in diameter, starch grains are simple and compound (2-4 components) and idioblasts in the form of dots or druses. The endodermis is indistinct.

The pericycle (Fig 8)

The fibres are similar to those of the stem and measure 590-630-650 μ in length and 24-27-30 μ in diameter.

The vascular system (Fig 8)

There is no difference in vascular system from that of the stem. The xylem vessels measure 22-26-27 μ in diameter. The pith is formed of somewhat rounded thin walled sometimes pitted parenchyma with intercellular spaces. The cells contain cluster crystals of calcium oxalate, measuring 15-28-30 μ in length and 13-18-25 μ in diameter and starch grains.

The powder (Fig 9)

The powdered leaves are green in colour with faint characteristic odour and acrid taste. It is characterised microscopically by the following:

- 1- Fragments of the upper epidermis of the leaves showing polygonal, isodiametric or slightly elongated cells with straight to slightly curved anticlinal walls and covered with thick smooth cuticle.
- 2- Fragments of lower epidermis of the leaves showing polygonal nearly isodiametric cells with slightly wavy anticlinal walls and covered with thick smooth cuticle bearing ranunculaceous stomata.
- 3- Fragments of lower epidermis with radiating cells (5-7 cells) surrounding the bulb of non glandular trichomes.
- 4- Fragments of epidermal cells of the petiole consisting of polygonal isodiametric cells with straight anticlinal walls and covered with smooth cuticle.

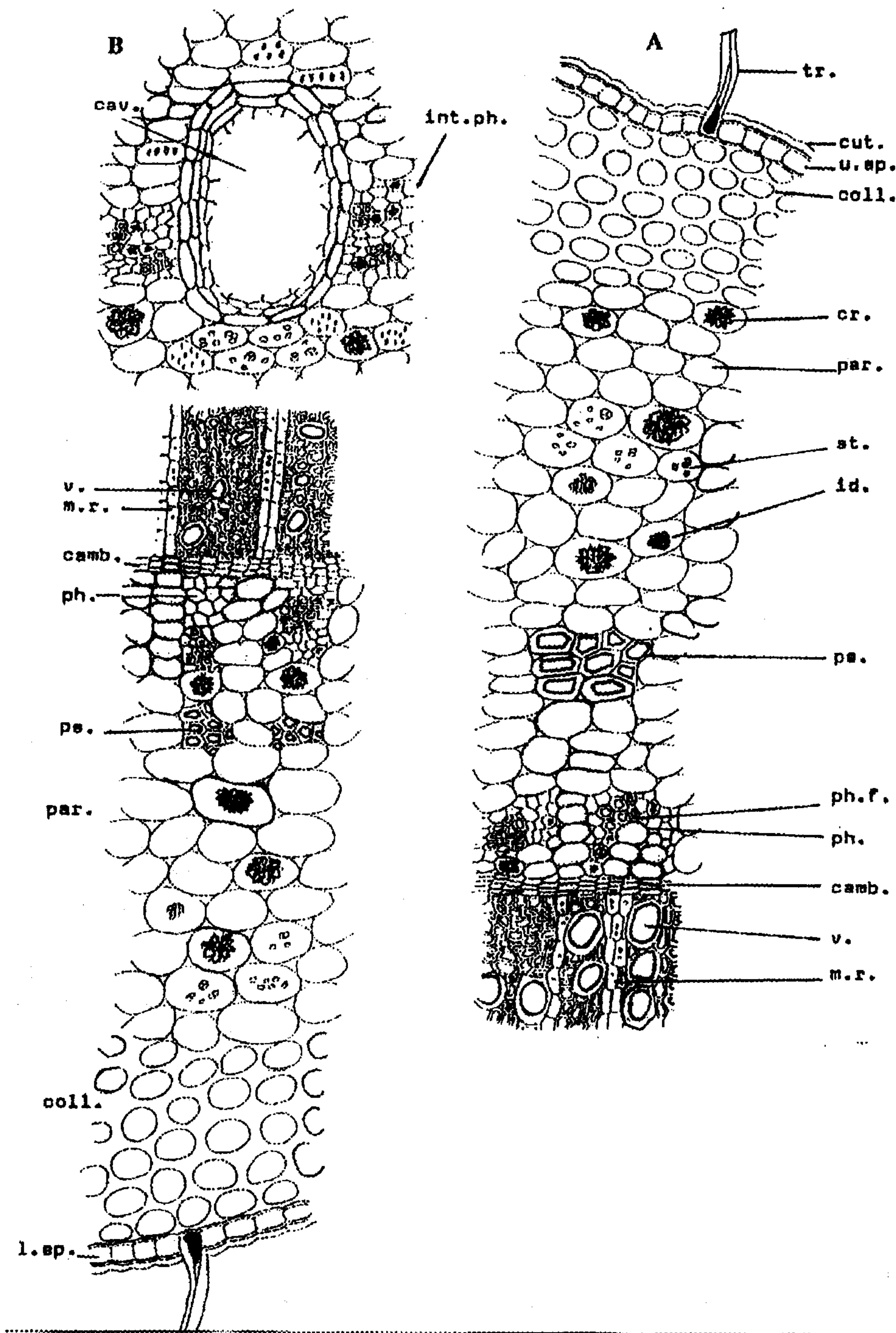


Fig 6: A and B Detailed T. S. of the leaf

x 141

camb., cambium; cav., cavity; coll., collenchyma; cr., crystal; cut., cuticle; m. r., medullary ray; par., parenchyma; id., idioblast; int. ph., intraxylary phloem; ph. f., phloem fibre; per., pericycle; ph., phloem; l. ep., lower epidermis; st., starch; tr., trichome; u. ep., upper epidermis; v., vessel.

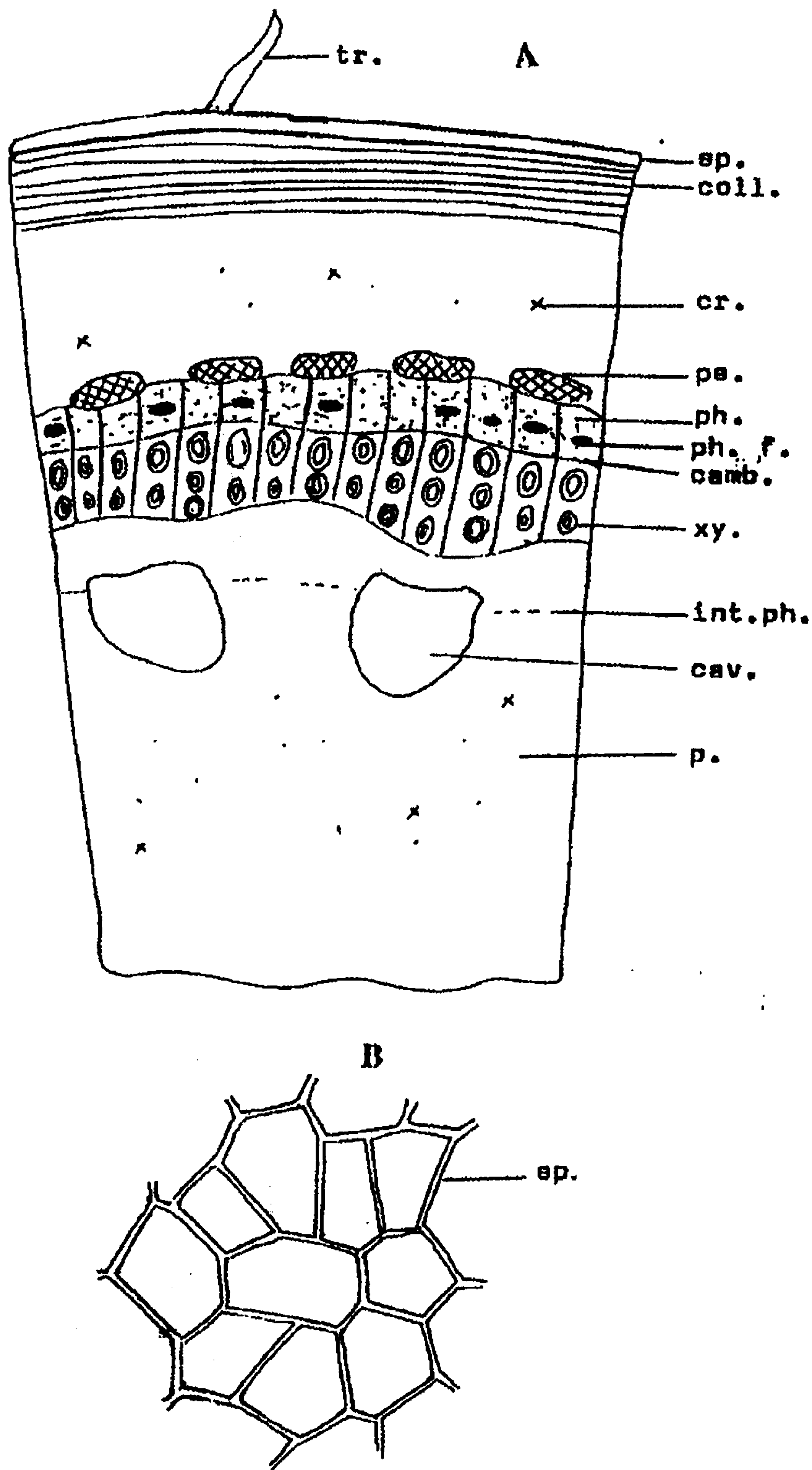


Fig 7: A- Diagrammatic T. S. of the petiole x 33
 B- Surface preparation of the petiole x 342

camb., cambium; cav., cavity; coll., collenchyma; cr., crystal; ep., epidermis; int. ph., intraxylary phloem; p., pith; pe., pericycle; ph., phloem; ph. f., phloem fibre; tr., trichome; xy., xylem.

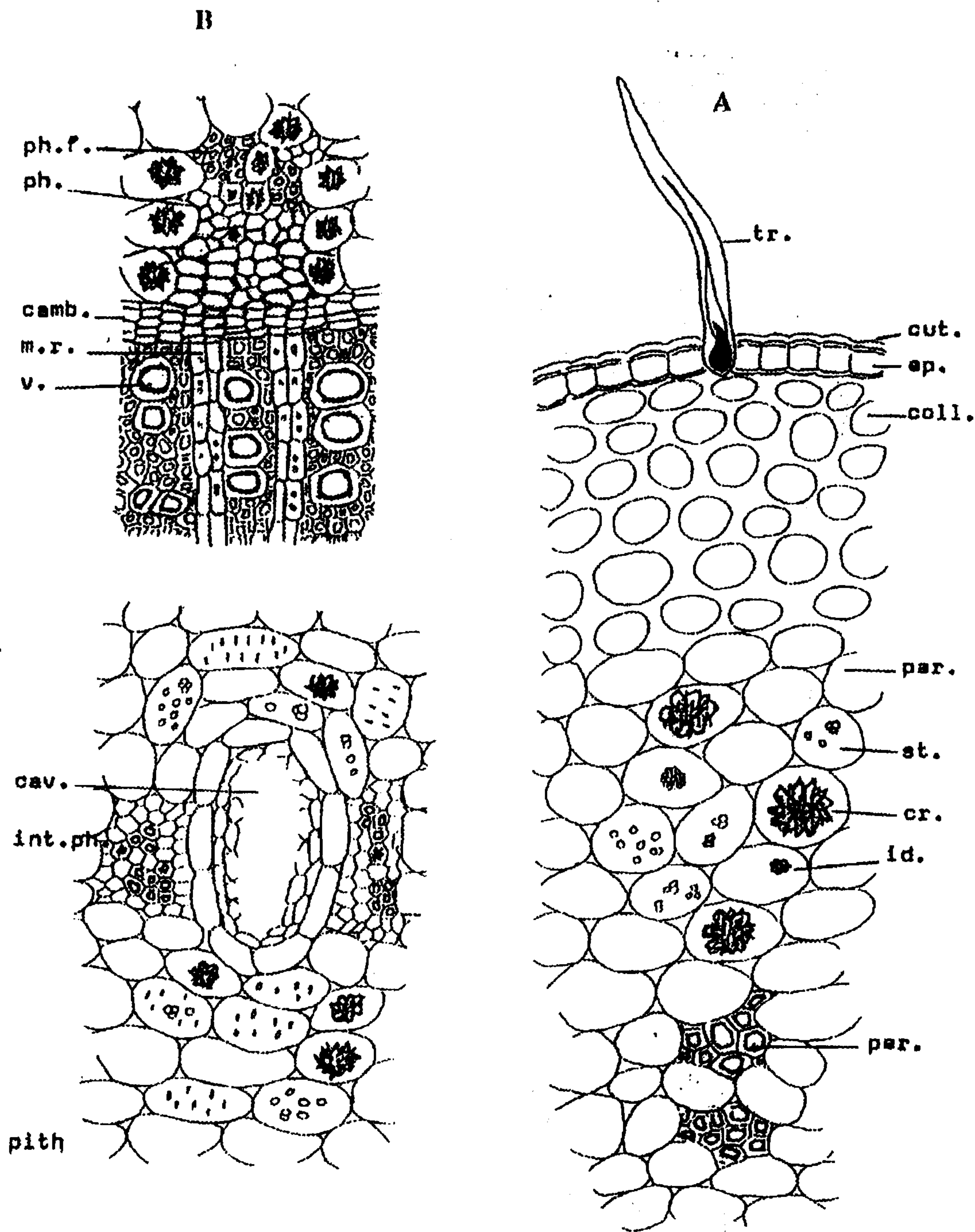


Fig 8: A and B- Detailed T. S. of the petiole x 215
 camb., cambium; cav., cavity; coll., collenchyma; cr., crystal; cut., cuticle; ep., epidermis;
 m. r., medullary ray; par., parenchyma; id., idioblast; int. ph., intraxylary phloem; per.,
 pericycle; ph., phloem; ph. f., phloem fibre; st., starch; tr., trichome; v., vessel.

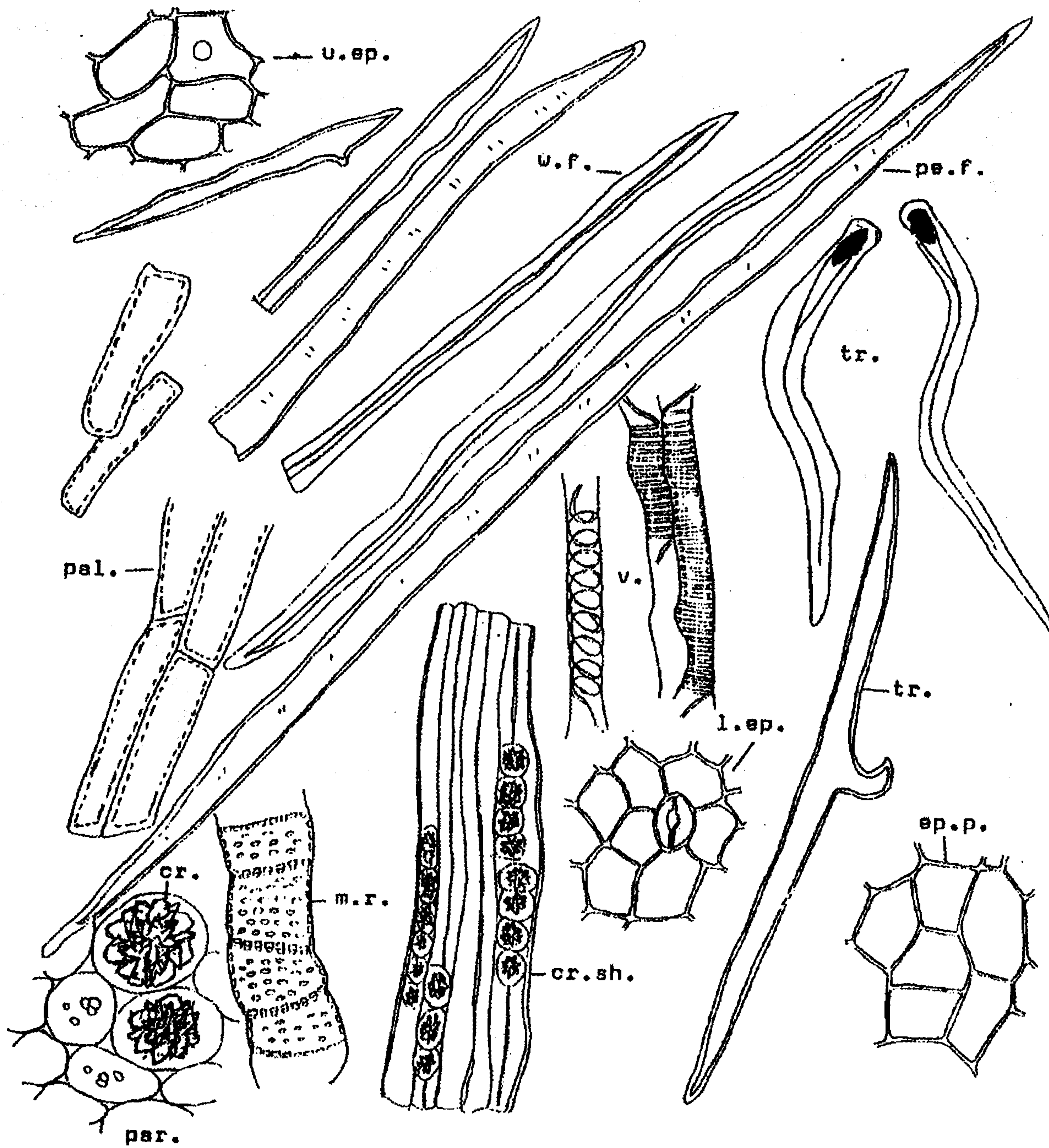


Fig 9: Isolated elements of the leaf

x 230

cr., crystal; cr. sh., crystal sheath; ep. p., epidermis of petiole; l. ep., lower epidermis; m. r., medullary ray; par., parenchyma; pal., palisade; pe. f., pericyclic fiber; tr., trichome; u. ep., upper epidermis; v., vessel; w. f., wood fiber.

- 5- Fragments of cortical parenchyma cells containing cluster crystals of calcium oxalate, minute starch grains and idioblasts.
- 6- Fragments of pericyclic fibres with straight, thick lignified walls with moderately wide lumina and blunt to rounded apices.
- 7- Fragments of phloem fibres with straight, thick, lignified walls with moderately narrow lumina, acute to acuminate apices and filled with small cluster crystals of calcium oxalate in the form of crystal sheath with clusters.
- 8- Fragments of lignified spiral and reticulated vessels.
- 9- Fragments of wood fibres with straight, thick, lignified walls with narrow lumina and acute apices.
- 10- Fragments of palisade cells.
- 11- Scattered cluster crystals of calcium oxalate and starch grains.
- 12- Unicellular non glandular trichomes with bulbous at the base.
- 13- Unicellular non glandular two armed trichomes, sometimes with an imperfectly developed second arm.

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