

MACRO- AND MICROMORPHOLOGY OF *LYCOPERSICON HIRSUTUM*, HUMB. AND BENPL., F. TYPICA, CULTIVATED IN EGYPT. THE LEAF AND STEM

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نبات "ليكوپيرسيكون هيرسوتم" ، همب وبنبل" ، هو أحد أنواع جنس الطماطم السامة التي تنمو برية في أمريكا ، ونظرا لشدة مقاومته للطفيليات والبكتيريا والآفات الزراعية ، فقد أدخلت زراعته حديثا بمحطة التجارب الزراعية بجامعة أسيوط.
وفي نشرة سابقة تم عمل مسح ودراسة كيميائية على أجزاء هذا النبات لاستجلاء مواده الفعالة. وفي هذا البحث ، أجريت دراسة تفصيلية لابرار الصفات العيانية والمجهريية لأوراق وسوق هذا النبات وذلك للتعرف على صفاته المميزة سواء كانت كاملة أو على هيئة مسحوق.

The detailed macro- and micromorphological characters of the leaf and stem of Lycopersicon hirsutum, Humb. and Benpl., F. typica, cultivated in Egypt, have been studied in order to find out the diagnostic features which can help in the identification of these parts in both entire and powdered forms.

INTRODUCTION

Lycopersicon hirsutum, Humb. and Benpl. is a poisonous small shrub belonging to Family Solanaceae¹. It is originally a wild American plant, which has been, recently, introduced to Egypt, i.e. acclimatized*. This species has 2 botanical forms: One form is hairy, *L. hirsutum*, *F. typica*, and another form is less hairy or nearly glabrous, i.e. *L. hirsutum*, *F. glabratum*². Bailey³ reported that the Genus *Lycopersicum* or *Lycopersicon* includes both the familiar cultivated tomato, and the poisonous one. Muller¹ and Luckwill², divided the Genus *Lycopersicon* into two subgenera:

1. Cultivated species of tomato including *Lycopersicon esculentum*, Mill. which are red-fruited.
2. Wild species of tomato, e.g. *Lycopersicon hirsutum*, Humb. and Benpl. which are green-fruited.

Muschler⁴, mentioned that *Lycopersicum esculentum*, Mill., was formerly known as

Solanum lycopersicum, L., with the local names: Khûta, tòmaten and bendûra. In "Index Kewensis"⁵ both *Lycopersicum esculentum*, Mill. and *Lycopersicum hirsutum*, H.B., were mentioned as separate species. Alexander⁶ confirmed that *L. hirsutum* provided high resistance to many parasites. In a cytogenic study, Sawant⁷, confirmed the separation of *L. esculentum*, Mill. and *L. hirsutum*, Humb. & Benpl., as distinct species. William's *et al.*⁸ have ascertained that the sesquiterpenoid, 2-tridecanone in the glandular trichome exudate of the leaves of *L. hirsutum*, is the toxic factor which resists attack of a wide range of parasites. Glanfagna *et al.*⁹, reported that the resistance to Colorado potato beetle in a clone of *L. Hirsutum*, is attributed to the presence of the sesquiterpene, zingiberene in the glandular trichomes of the leaf. Metcalfe *et al.*¹⁰ mentioned that, hair characters for the identification of different species of *Lycopersicum* have been recorded by Luckwill 1943². A survey of literature revealed the

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* Prof. Dr. Farouk Abdel Kawi, and Prof. Dr. Tahani Hassan, Faculty of Agriculture, Assiut University, have introduced the plant to Egypt.

absence of any previous botanical or complete phytochemical studies on the plant under investigation; *L. hirsutum*, Humb., and Benpl. *F. typica*.

The preliminary phytochemical screening revealed the presence of volatile oil, steroidal alkaloids, flavonoids, sterols and/or triterpenes¹¹.

EXPERIMENTAL

Habitat

The typical form of *Lycopersicon hirsutum*, Humb. and Benpl. (Fig. 1) is an annual or biennial, hairy shrub with branched, green, slender stems of monopodial growth. The branches are cylindrical, smooth, minutely ridged, and showing long internodes & swollen nodes. The stem carries alternate, irregularly or interruptedly, imparipinnate compound leaves.

Flowers are arranged in short branched racemes. Flowering period is during summer, and extends from May to September. The plant yields green fruits which are fleshy, many-seeded berries.

The plant prefers a rich, light soil, but a well-drained, clayey loam is suitable with a temperate climate and moderate humidity.

Material

Fresh samples of the plant were collected by the author in the period from March to September, 1993 and 1994. The samples were gathered before and during flowering and fruiting stages from the plant cultivated in the Experimental station of faculty of Agriculture, Assiut University, Assiut. Dried and preserved samples were also, used. Identification of the plant was confirmed by Prof. Dr. Farouk Abdel Kawi & Prof. Dr. Tahani Hassan, Faculty of Agriculture, Assiut University.

I- THE LEAF

Macromorphology (Fig. 1, A&B):

The leaf of *L. hirsutum*, Humb. and Benpl., *F. typica* is compound, imparipinnate, with pubescent, heterogenous leaflets. It is petiolate, stipulate and measures about 12 to 40 cms. long. The rachis of the leaf is subcylindrical, densely

hairy, slightly grooved on the upper surface, and carries from 11 to about 23 leaflets. The leaflet is dark green to grayish-green in colour and usually, asymmetric at the base. They are mainly alternate rarely opposite especially towards the apex of the rachis. These leaflets are of two types. One type consists of petiolulate, large leaflets, which are ovate-lanceolate to oblong-lanceolate and vary in size from 5 to 10 cms. long, and from 2 to 5 cms. wide at the middle portion. The leaflet possesses an irregularly dentate to serrate margin and an acute to acuminate apex. The second type consists of sessile, smaller leaflets which are oval to cordate-ovate in shape and varying in size from 4 to 20 mms. long, and from 2 to 10 mms. wide at the middle portion. The margin is minutely dentate and the apex is rounded to acute.

The leaf has at its base 2 small, unequal sessile stipules. The stipule is dark green in colour, cordate to semicircular in shape and possesses a dentate margin and a rounded apex. It measures about 8 to 25 mms. across.

The petiole of the leaf is subcylindrical, with a shallow groove on its upper surface, and measures from 2 to 5 cms. in length and 1.5 to 4 mms. in diameter. The leaf has a characteristic nauseous odour (rank-smelling) and a slight bitter, astringent taste.

Micromorphology (Fig. 2):

A transverse section in the leaflet appears more or less biconvex in outline, with the midrib prominent on both the upper and lower surfaces, being broader and more prominent on the lower one. It shows a dorsiventral structure (i.e. bifacial) with an upper palisade layer formed of one row below the upper epidermis. The palisade is not continuous in the midrib region, being interrupted or replaced by a mass of collenchyma. Another broader mass of collenchyma is situated on the lower part of the midrib. The spongy zone consists of parenchymatous cells, some of which contain sandy crystals of calcium oxalate.

The vascular bundle of the midrib is broad, curved or crescent-shaped, and consists of an

upper arc of xylem and a lower arc of phloem. Small patches of perimedullary phloem are situated above the xylem. The pericycle is represented by a large lower arc of parenchyma. The bundle is enclosed in an endodermis of one layer thick and the whole bundle is suspended in a wide zone of cortical parenchyma showing scattered idioblasts of sandy crystals of calcium oxalate.

The epidermis (Fig. 1, C & D and Fig. 2, B&C)

The upper epidermis is formed of one layer of square to rectangular cells as seen in transverse section. In surface view the cells are polygonal, usually isodiametric, sometimes elongated, subrectangular. The cells have thin, usually straight, frequently curved anticlinal walls, and covered by thin, smooth cuticle. They measure from 32 to 60 U in length, 28 to 48 U in width and 22 to 33 U in height. Stomata are numerous being mainly of anisocytic type. They are oval in shape and each is surrounded by 3 to 5, commonly 4 subsidiary cells one of which is markedly smaller than the others. They measure from 15 to 20 U in diameter and 18 to 32 μ in length.

Abundant glandular and very rare nonglandular trichomes are present. Both types of trichomes are uniseriate, multicellular and their stalks consisting of about 3 to 12, or even more, cells some of which are collapsed. In the glandular type, the glandular head is unicellular and the cells of the stalk decrease gradually in size towards the apex until they become very short & narrow just below the gland. The hairs are covered with thin, smooth cuticle and measuring from 100 to about 1000 μ in length.

The lower Epidermis appears in transection to be formed of square, subrectangular cells. In surface view, the cells are polygonal, mainly isodiametric, frequently elongated but their anticlinal walls are wavy and sinuated. They are much more wavy than those of the upper epidermis. The cells are covered with smooth, thin cuticle. being slight smaller in size than those of the upper epidermis & measuring from 28 to 46 μ in length, 25 to 42 μ in width and 18 to 30 μ in height.

Stomata and trichomes of both types are present. They are much more numerous than

those of the upper epidermis. They are exactly identical to those of the upper epidermis in type, size shape and distribution.

The neural epidermal cells of the upper and lower epidermis are polygonal axially elongated, subrectangular & usually with thin, rarely beaded, straight to slightly curved anticlinal walls. The cells of the upper epidermis are slightly larger in size than those of the lower one and measuring about 60 to 120 length and 28 to 45 μ in width. The hairs are, particularly, abundant on the midrib and veins.

The mesophyll (Fig. 2)

The mesophyll is heterogeneous showing an upper palisade consisting of one row of columnar cells and occupying half the region of mesophyll.

The spongy mesophyll consists of 4 to 6 rows of irregular somewhat collapsed parenchymatous cells with wide intercellular spaces. The cells abutting on the palisade, (i.e. collecting cells) are radially elongated. Certain of the cells of the spongy mesophyll are filled with sandy crystals of calcium oxalate, but prisms and clusters are not observed.

The cortical tissue (Fig. 2)

This tissue shows an upper and a lower subepidermal collenchymatous cells. These cells are small, rounded to oval with cellulosic thickened corners. Each mass of collenchyma is represented by 3 to 5 rows of cells.

The remaining cortical tissue is represented by wide rounded or polygonal parenchymatous cells surrounding the vascular bundle and forming a larger zone below the bundle.

The vascular system (Fig. 2 & Fig. 4, B)

The midrib bundle is enclosed in an endodermis which takes the form of a starch sheath.

The pericycle is represented by few layers of a small lower arc of parenchymatous cells situated below the phloem. Few small groups of perimedullary phloem of soft elements are present above the xylem within the endodermis. The xylem consists of radial groups of vessels and few tracheids accompanied by wood parenchyma and separated from each other by

narrow medullary rays. The vessels are lignified, possessing mainly pitted and spiral thickening & measuring 14 to 35 μ in diameter. Few scalariform and annular vessels as well as pitted tracheids are, also, present.

The petiole of the leaf (Fig. 3 & Fig. 4)

A transverse section in the petiole appears concavo-convex in outline with a groove or depression on the upper side enclosed between two slight ridges.

The epidermis is much hairy and surrounds a narrow cortex which becomes comparatively wide on the adaxial surface above the vascular strand, and showing widely distributed sandy crystals of calcium oxalate. The petiole is provided with a large median, deeply crescentic, horseshoe-shaped or U-shaped vascular strand within the cortex, consisting of numerous radial bundles separated by narrow medullary rays. The vascular strand shows an upper arc of xylem and a lower arc of phloem. There are numerous groups of intraxylary phloem (perimedullary), scattered above the xylem and accompanied with isolated or small groups of fibres. The pericyclic arc is well developed below the phloem & the endodermal ring is indistinct above the strand.

The epidermis (Fig. 3 and Fig. 4)

Both upper and lower epidermi are more or less identical. The cells appear polygonal in surface view, being mainly axially elongated subrectangular, frequently isodiametric. Their anticlinal walls are usually thin, minutely beaded, mainly straight to slightly curved. The cells of the lower epidermis are covered with smooth, thin cuticle & measure 50 to 130 μ in length, 30 to 70 μ in width & 30 to 55 μ in height. Those of the upper epidermis are slightly larger than those of the lower one and of more straight anticlinal walls. Stomata of anisocytic type are occasional on both surfaces, but glandular hairs are very numerous. These hairs are exactly identical to those of the leaflet in all aspects.

The cortical tissue: (Fig. 3 & 4)

The cortical tissue consists of an outer zone of 3 to 4 rows of subepidermal collenchyma increasing to about 6 rows above and below the vascular strand and in the 2 ridges. The inner zone of the cortex consists of about 4 to 6 layers of parenchymatous cells many of which contain sandy crystals of calcium oxalate. The cortex above the vascular strand becomes wide and consists of several layers of polygonal or subrectangular parenchyma with wide intercellular spaces & showing idioblasts of sandy crystals of calcium oxalate. In old stage, the cells of the upper cortex become collapsed & ruptured. The endodermis is formed of one layer of subrectangular cells taking the form of a starch sheath, being hardly distinct above the strand.

The vascular system (Figs. 3&4)

The pericycle is represented by an arc extending below the vascular strand & is formed of 2 to 3, sometimes 4, layers of parenchyma interrupted by isolated or small groups of lignified fibres. The pericyclic fibre possesses a thick lignified pitted wall, a moderately wide, rarely narrow, lumen and an acute to blunt apex; measuring 400 to 800 μ in length and 20 to 40 μ in diameter.

The phloem is formed of soft elements of sieve tubes, companion cells & phloem parenchyma. The xylem constitutes the upper arc of the vascular strand. The vessels are lignified, radially arranged, and showing scalariform, spiral and pitted thickening. Occasional reticulate and annular vessels can be observed. The vessel measures about 20 to 60 μ in diameter. Few tracheids are present and showing lignified, thick and pitted walls. Wood parenchyma as well as lignified fibres are scattered among the vessels. The wood fibre has a thick, pitted, almost straight wall, narrow lumen and blunt to rounded apex, & measuring about 350 to 650 μ in length and 18 to 35 μ in diameter. The groups of the perimedullary phloem are accompanied by lignified fibres. The fibre has a lignified wall, usually wide lumen and acute to round apex and measures about 400 to 750 μ in length and 20 to

50 μ in diameter.

The powder (Fig. 4,b)

The powdered leaf is dark green to brownish green in colour with a characteristic, nauseous odour, and a slight bitter taste. It is characterised microscopically by the following:

- 1- Fragments of the upper epidermis of the leaflet showing polygonal, usually isodiametric, slightly elongated cells with straight, sometimes curved anticlinal walls. Anisocytic stomata are present as well as numerous glandular and occasional non glandular hairs. The hairs are uniseriate, multicellular with stalks of 3 to 12 cells. The head of the glandular hair consists of one cell.
- 2- Fragments of the lower epidermis of isodiametric cells with much wavy anticlinal walls and showing more numerous stomata and more numerous hairs than those of the upper epidermis.
- 3- Fragments of the upper and lower epidermis of the rachis showing polygonal, usually elongated cells with more or less straight anticlinal walls. The cells are covered with abundant hairs which are exactly identical to those of the leaflet, but stomata are rare.
- 4- Fragments of the mesophyll of the leaflet showing palisade cells and spongy parenchyma containing sandy crystals of calcium oxalate.
- 5- Fragments of the xylem showing spiral, pitted scalariform, sometimes reticulate and annular vessels with lignified walls.
- 6- Fragments of the cortical tissue of leaflet and rachis with wide polygonal parenchyma containing idioblasts of sandy crystals.
- 7- Fragments of the xylem and pericyclic fibres of the rachis with fairly wide lumen, pitted lignified wall and acute to blunt apex.

II- THE STEM

Macromorphology (Fig. 1, A & B)

The stem attains a length of about 2 to 4 meters. The branches are erect, slender, cylindrical, with smooth, finely ribbed, dark green to greenish brown hairy surface. The branches carry clear nodes and long internodes

of about 3 to 10 cms in length and about 6 to 12 mms. in diameter in the basal part. The stem has a characteristic nauseous odour and a slight bitter taste.

Micromorphology

A transverse section in the stem (Figs, 5 & 6) appears more or less rounded in outline with, usually, three broad slight prominent ridges. It shows an epidermis covered with abundant hairs. The cortex is comparatively narrow with outer few layers of collenchyma and the remaining cells are parenchyma showing idioblasts of sandy crystals of calcium oxalate. The endodermis is almost distinct. The pericycle is parenchymatous in young stem, but in old stage, it becomes interrupted by several groups of lignified fibres.

The vascular tissue is represented by a narrow ring of phloem elements and a wide zone of radiating xylem, separated by a cambial layer and crossed by numerous medullary rays. Perimedullary phloem of supernumerary strands is present within the primary xylem at the periphery of the pith, and usually accompanied by fibres.

The pith is wide and parenchymatous showing idioblasts of sandy crystals and becoming hollow in old stage.

The epidermis (Fig. 5)

It consists of one layer of cells which appear square to subrectangular in side view. In surface view the epidermal cells are polygonal, usually isodiametric, sometimes elongated, subrectangular with straight to slightly curved, and finely beaded anticlinal walls. The cells are covered with thin, smooth cuticle, and measuring 36 to 76 μ in length, 30 to 70 μ in width and 25 to 55 μ in height. Stomata of anisocytic type are of common occurrence. They are exactly similar to those of the leaf, but being slightly larger measuring 18 to 24 μ in diameter & 22 to 38 μ in length. Occasional clothing and numerous glandular hairs are found. These hairs are closely identical to those present on the leaf in all aspects.

The cortex (Fig. 5 & 6)

The outer region of the cortex is formed of 2 to 3 rows of rounded collenchymatous cells.

The inner region consists of about 5 to 6 rows of thin-walled rounded to polygonal parenchymatous cells showing intercellular spaces, and many of which contain sandy crystals of calcium oxalate. The endodermis is formed of one layer of subrectangular cells.

The vascular system (Figs. 5 & 6)

The pericycle, consists of a complete ring of thin-walled parenchyma which is almost accompanied by small groups of fibres. The pericyclic fibre is straight, sometimes, slightly tortuous in outline and possesses moderately thick, lignified wall, fairly wide, rarely, narrow lumen and an acute to acuminate apex. It measures about 20 to 45 μ diameter & 450 to 950 μ in length.

The phloem, is comparatively a narrow ring of sieve tubes, companion cells and thin-walled parenchyma, some of which contain sandy crystals of calcium oxalate.

The cambium, is situated between the phloem and xylem and forms a cambial zone of about 3 to 6 rows of cellulosic, thin-walled, cambiform cells which are subrectangular, tangentially and radially arranged.

The xylem, forms a comparatively wide, continuous ring of lignified radiating elements. Fibres are the main constituent of the xylem. The vessels are lignified, mainly possessing pitted, spiral and scalariform thickening. Some vessels show reticulated and annular thickening. The pits of the vessel are both bordered and simple. The vessels measure about 20 to 90 μ in diameter. They are usually accompanied by lignified pitted wood parenchyma and few tracheids measuring about 18 to 30 μ in diameter, and 40 to 120 μ in length. The wood fibre is more or less straight in outline & shows a lignified, thick, pitted wall, usually narrow lumen and an acute to rounded apex & measuring about 400 to 750 μ in length and 15 to 35 μ in diameter. Both phloem and xylem are radially traversed by numerous medullary rays of 1 to 3 cells wide. The cells of the medullary rays are rectangular to subrectangular, being, non lignified in the phloem region, but in the xylem region they are radially elongated and with lignified, pitted walls.

The perimedullary phloem, is represented below the primary xylem and at the periphery of the pith by numerous strands of thin-walled, cellulosic phloem elements. These strands are accompanied by isolated or small groups of almost wide-lumen sclerenchymatous fibres. The fibre is lignified & generally possesses lignified thick wall, wide lumen and acute to rounded apex & measuring 25 to 70 μ in diameter & 350 to 750 μ in length.

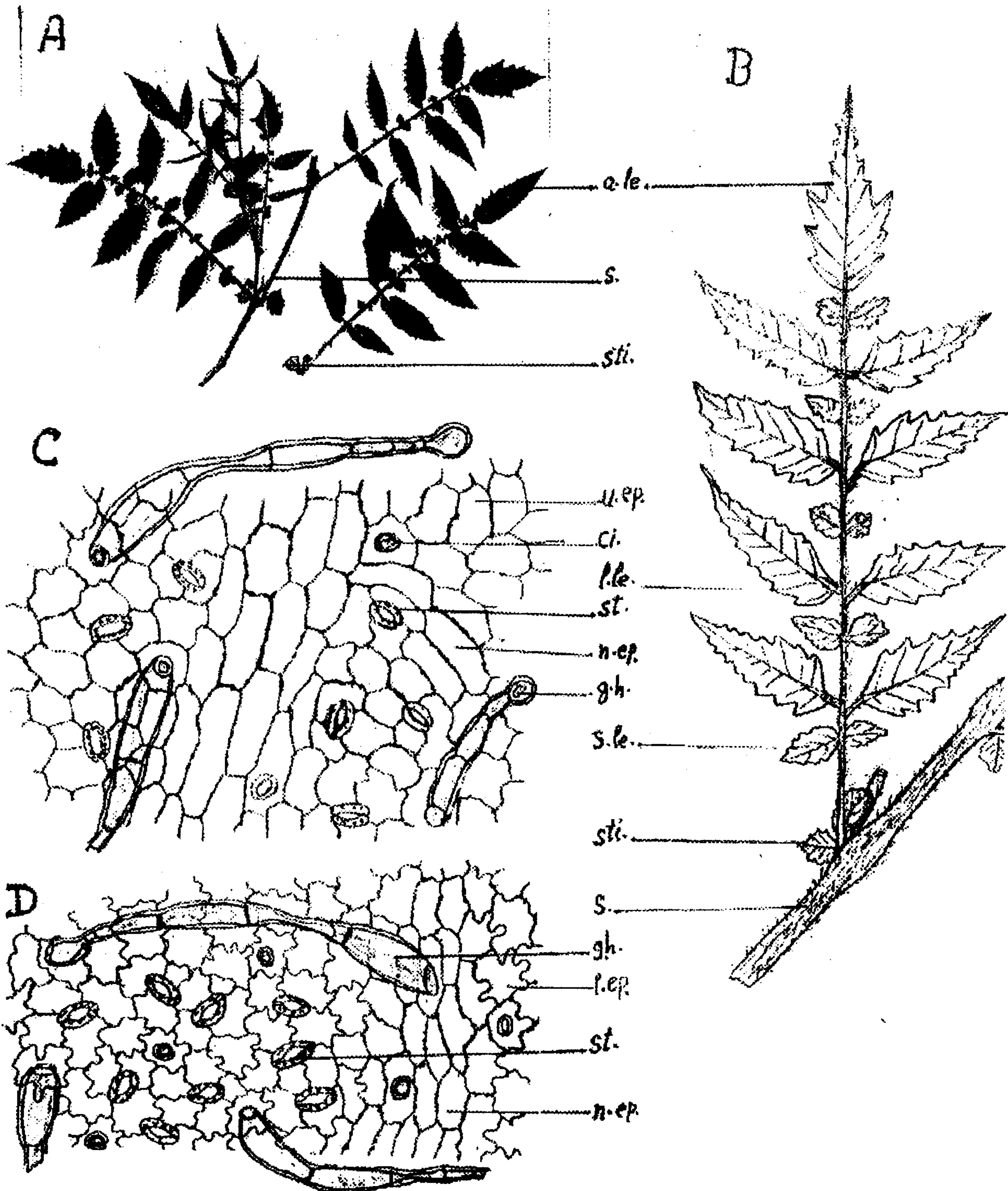
The pith (Figs. 5 & 6)

It is comparatively wide, and becomes partially hollow in old stem. It is formed of rounded to polygonal parenchymatous cells with wide intercellular spaces, & many of which contain idioblasts of sandy crystals of calcium oxalate.

The powder (Fig. 6, D)

The powdered stem is brownish green in colour and having a characteristic nauseous odour and a slight bitter taste. Under microscope it shows the following features:

- 1- Fragments of the epidermis with polygonal, usually, isodiametric cells with finely beaded, straight to slightly curved anticlinal walls and covered with smooth cuticle. Numerous anisocytic stomata are of common occurrence. Abundant glandular and occasional nonglandular hairs are uniseriate, multicellular with a stalk of 3 to 12 cells some of which are collapsed, and the head of the glandular hair is unicellular.
- 2- Fragments of fibres from pericycle, xylem and perimedullary phloem with straight to slightly tortuous outline, fairly wide lumen, lignified pitted wall and acute to acuminate, sometimes rounded apex.
- 3- Fragments of lignified vessels with mainly pitted spiral and scalariform, sometimes, reticulated thickening.
- 4- Fragments of thin-walled parenchymatous cells from cortex, phloem and pith showing idioblasts of sandy crystals.
- 5- Fragments of parenchyma from wood & medullary rays of xylem region with lignified pitted walls.



Lycopersicon hirsutum, Humb. and Benpl., F. Typica:

Fig. 1: The Leaf

A- Photo of a branch. x 1/3

B- Sketch of the leaf. x 2/3

C- Surface preparation of upper epidermis. x 170

D- Surface preparation of lower epidermis. X 170

a.le., apical leaflet; ci., cicatex; g.h., glandular hair; l.ep., lower epidermis; l.le., large leaflet; n.ep., neural epidermis; s.le., small leaflet; sti., stipule; s., stem; st., stomata.

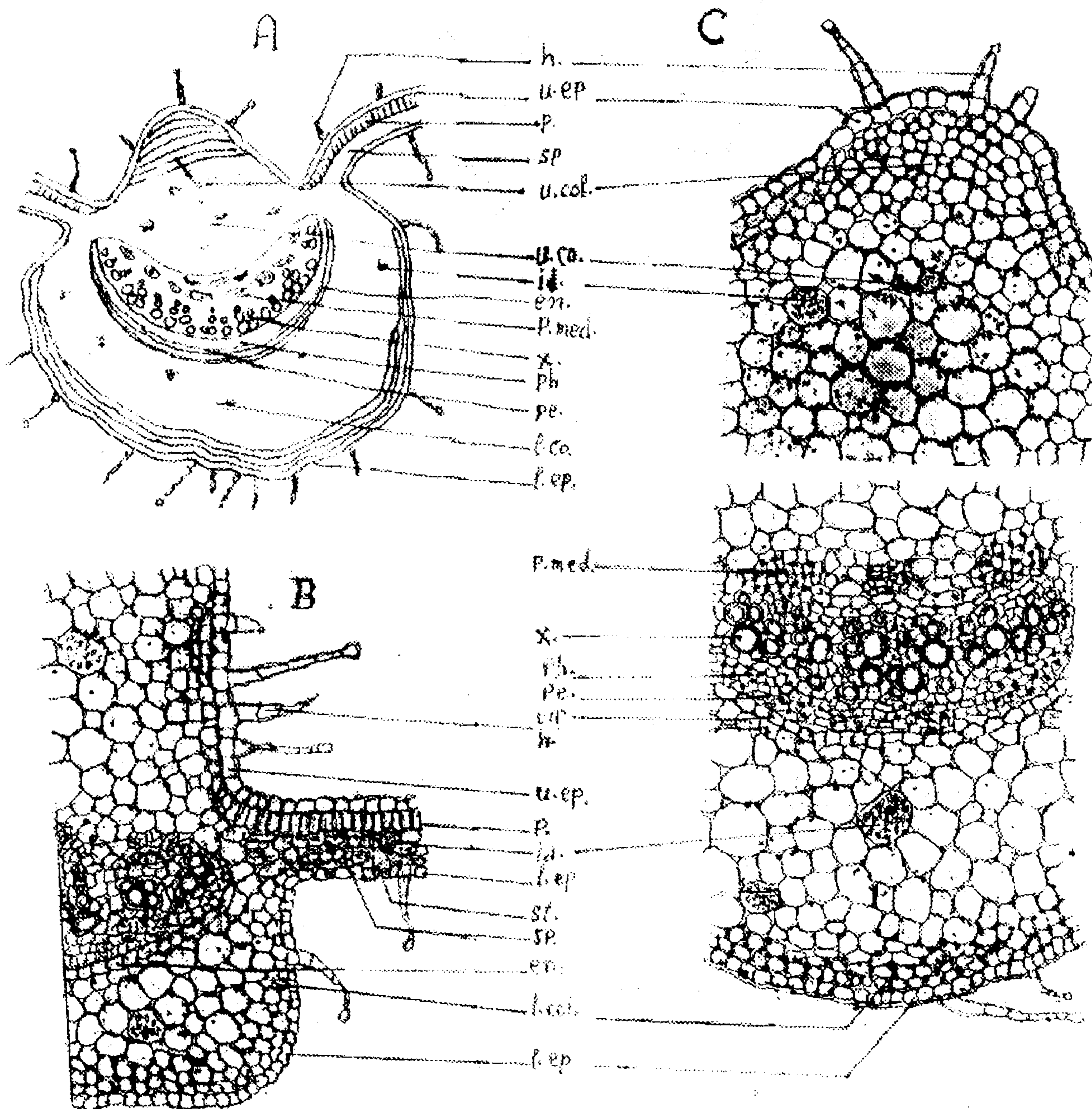


Fig. 2: The Leaf

A- Diagramatic T.S. of the leaflet. x 48

B- Detailed T.S. of the leaflet (mesophyll region). x 150

C- Detailed T.S. of the leaflet (midrib region). x 150

en., endodermis; h., hair; id., idioblast; l.col., lower collenchyma; l.co., lower cortical region; l.ep., lower epidermis; p., palisade; pe., pericylce; p. med., perimedullary phloem; ph., phloem; sp., spongy layer; st., stomata; u.col., upper collenchyma; u.co., upper cortical region; u.ep., upper epidermis; x., xylem.

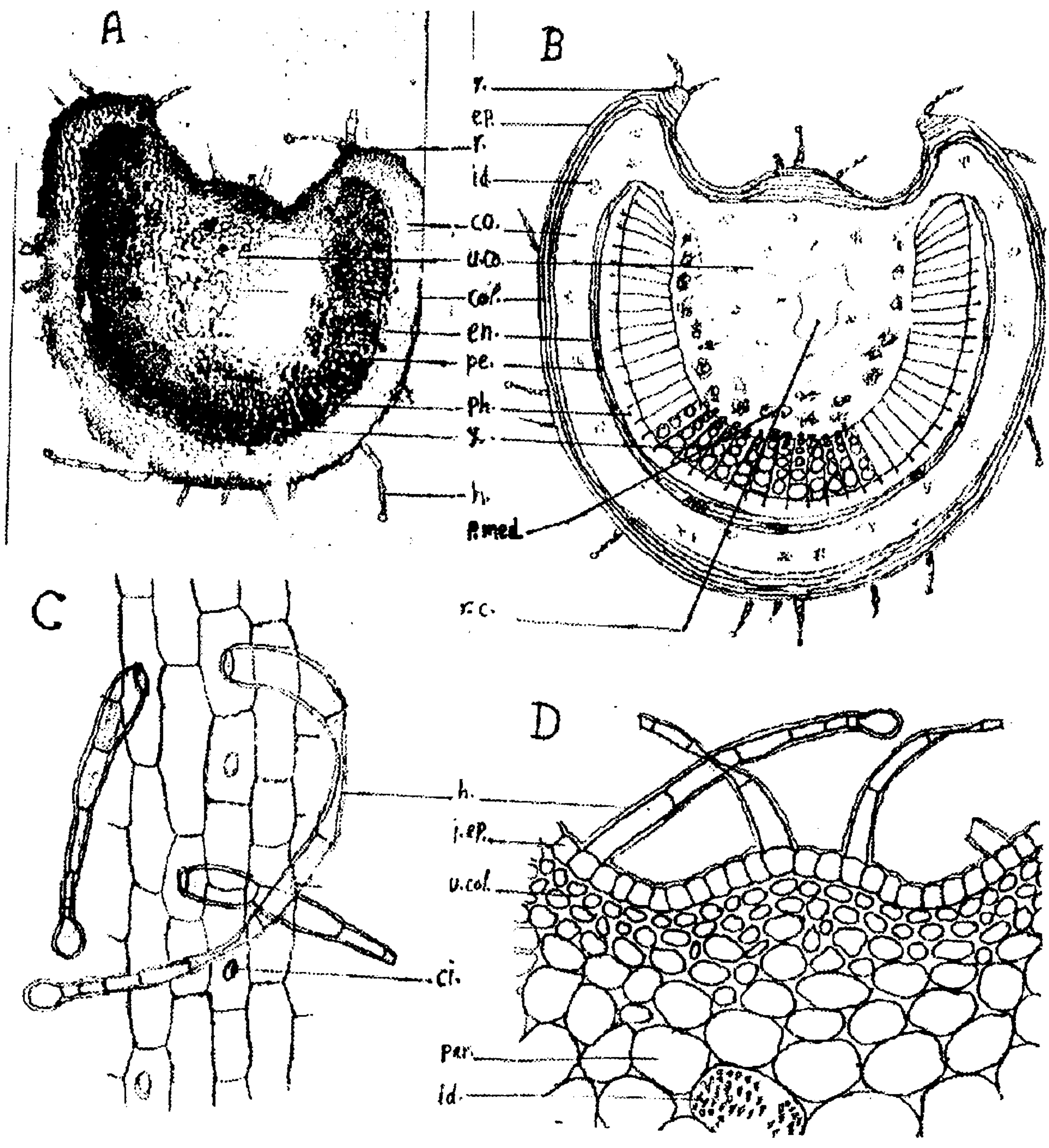


Fig.3: The leaf (Petiole)

A- Photo of diagrammatic T.S. of the petiole. x 24

B- Sketch of diagrammatic T.S. of the petiole. x 34

C- Surface preparation of epidermis. x 200

D- Detailed T.S. of upper cortical region of petiole. x 200

col., collenchyma; ci., ciatres; co., cortex; en., endodermis; ep., epidermis; h., hair; id., idioblast; par., parenchyma; pe., pericycle; p.med., perimedullary phloem; r.c., ruptured cells; u.col., upper collenchyma.

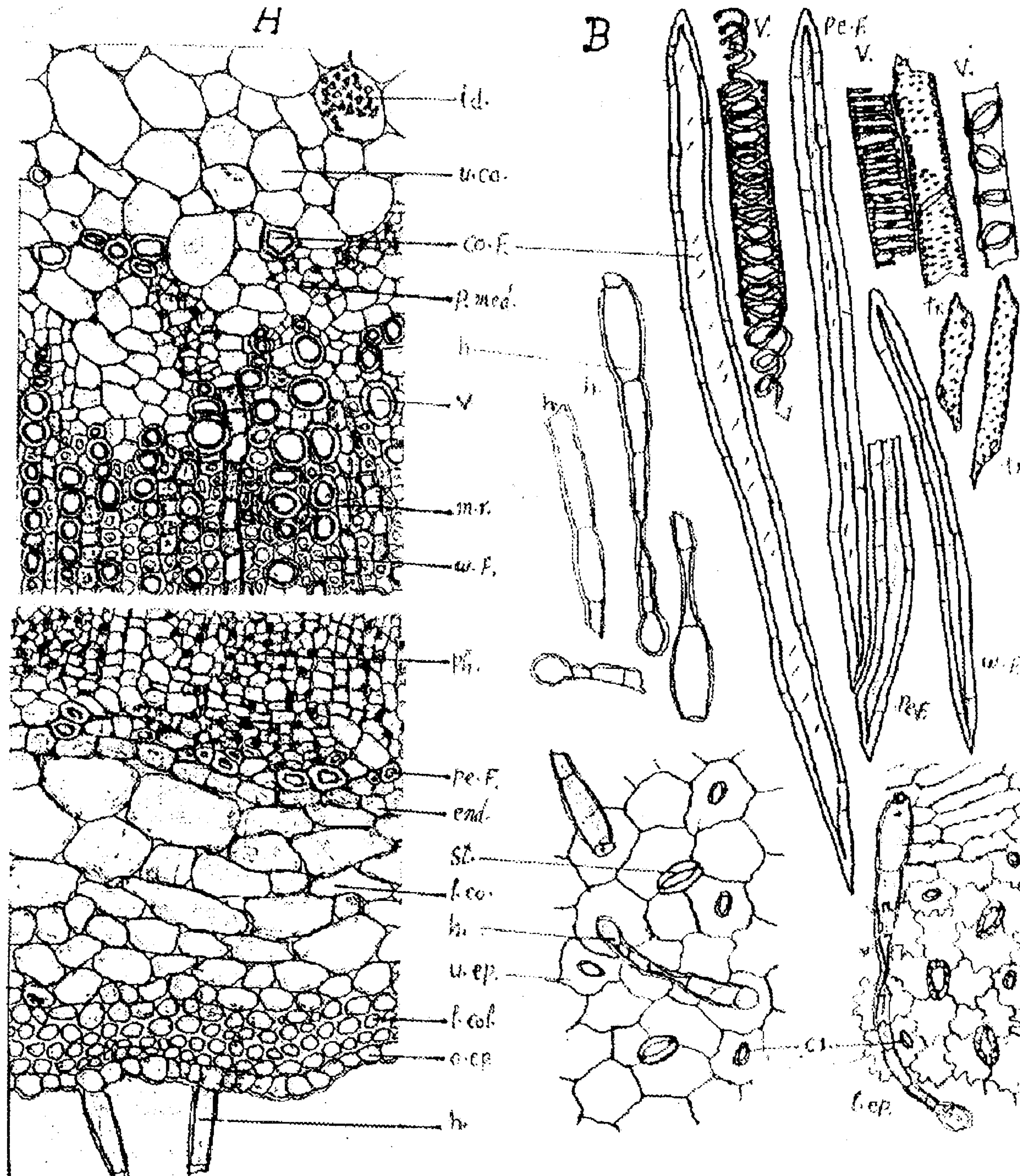


Fig. 4: The leaf (Petiole)

A- Detailed T.S. of middle and lower cortical region (petiole). x 150

B- Isolated elements of leaflet and petiole. x 200

co.f., cortex fibre; h., hair; id., idioblast; l.col., lower collenchyma; l.co., lower cortical region; l.ep., lower epidermis of leaflet; m.r., medullary ray; end., endoderm; o.ep., outer epidermis of petiole; p.med., perimedullary phloem; pe.f., pericyclic fibre; st., stomata; tr., tracheid; u.ep., upper epidermis; u.co., upper cortex; v., vessel; x., xylem; w.f., wood fibre.

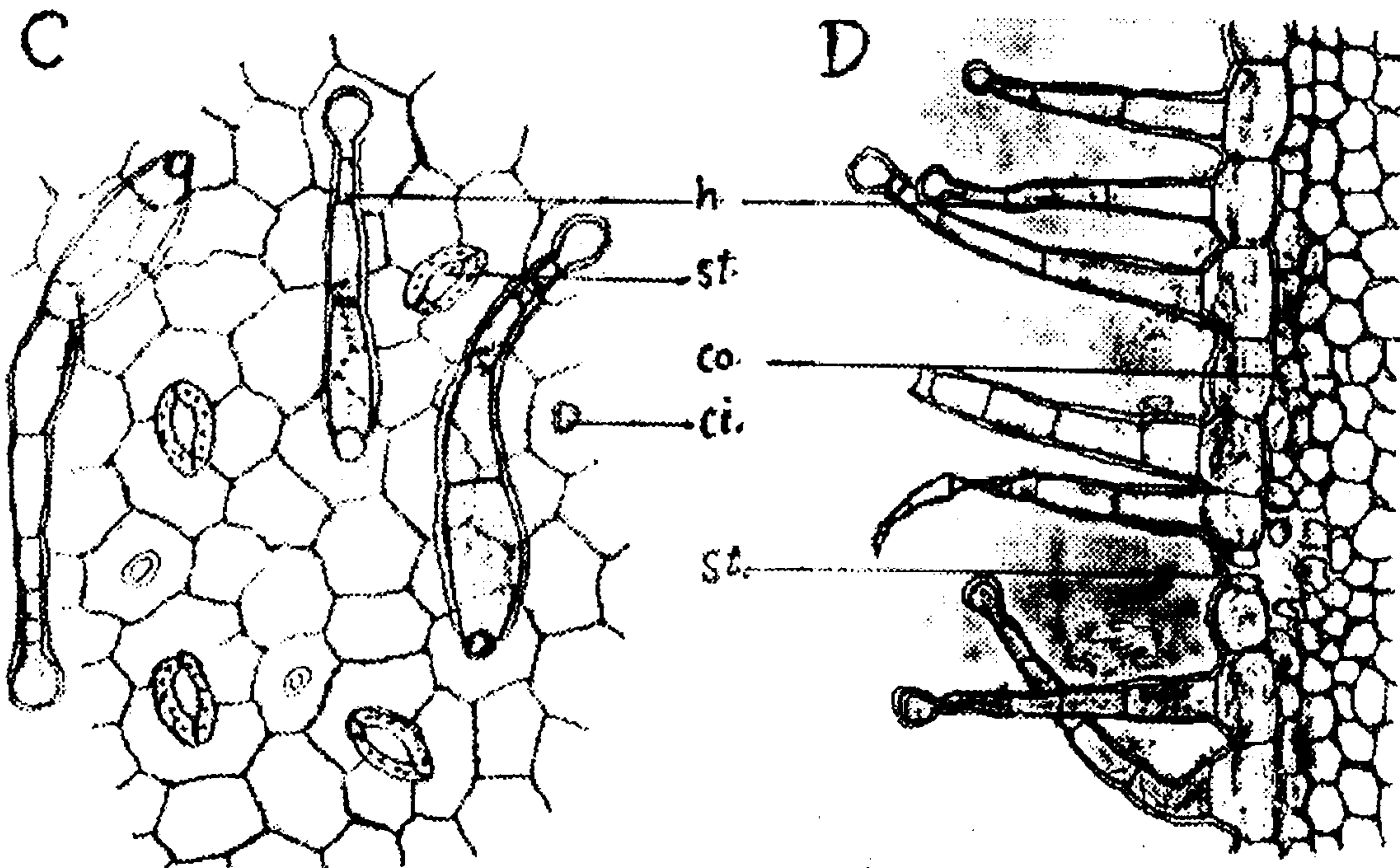
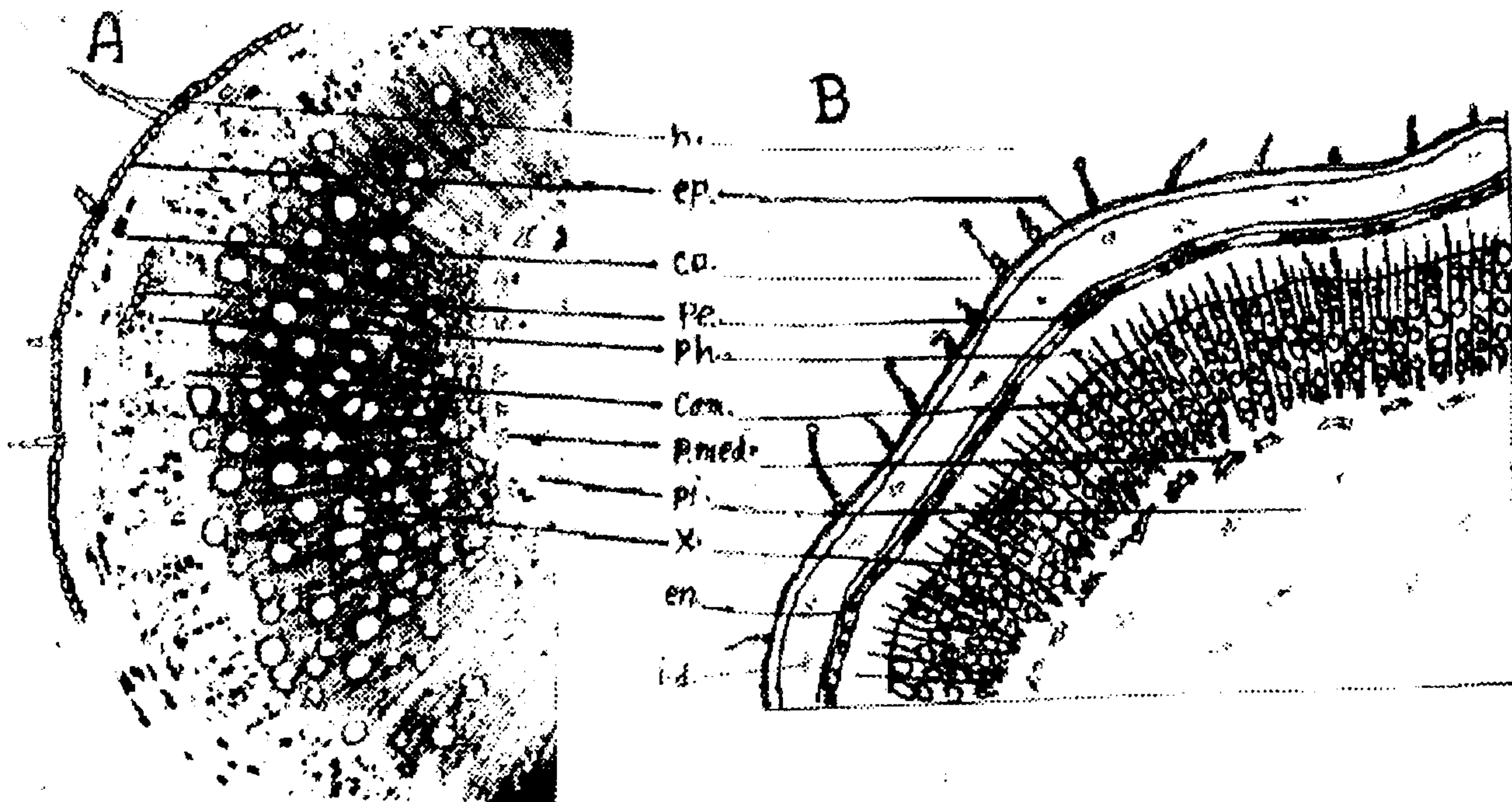


Fig. 5: The Stem

A- Photo of diagrammatic T.S. of old stem. x 20

B- Photo of diagrammatic T.S. of moderate stem. x 12

C- Surface preparation of stem. x 200

D- Detailed T.S. of the epidermis and outer part of the cortex. x 200

cam., cambium; ci., cicatrix; co., cortex; ep., epidermis; h., hairs; pe., pericycle; pi., pith; p.med., perimedullary phloem; ph., phloem; st., stomata; x., xylem; en., endodermis; id., idioblast of calcium oxalate.

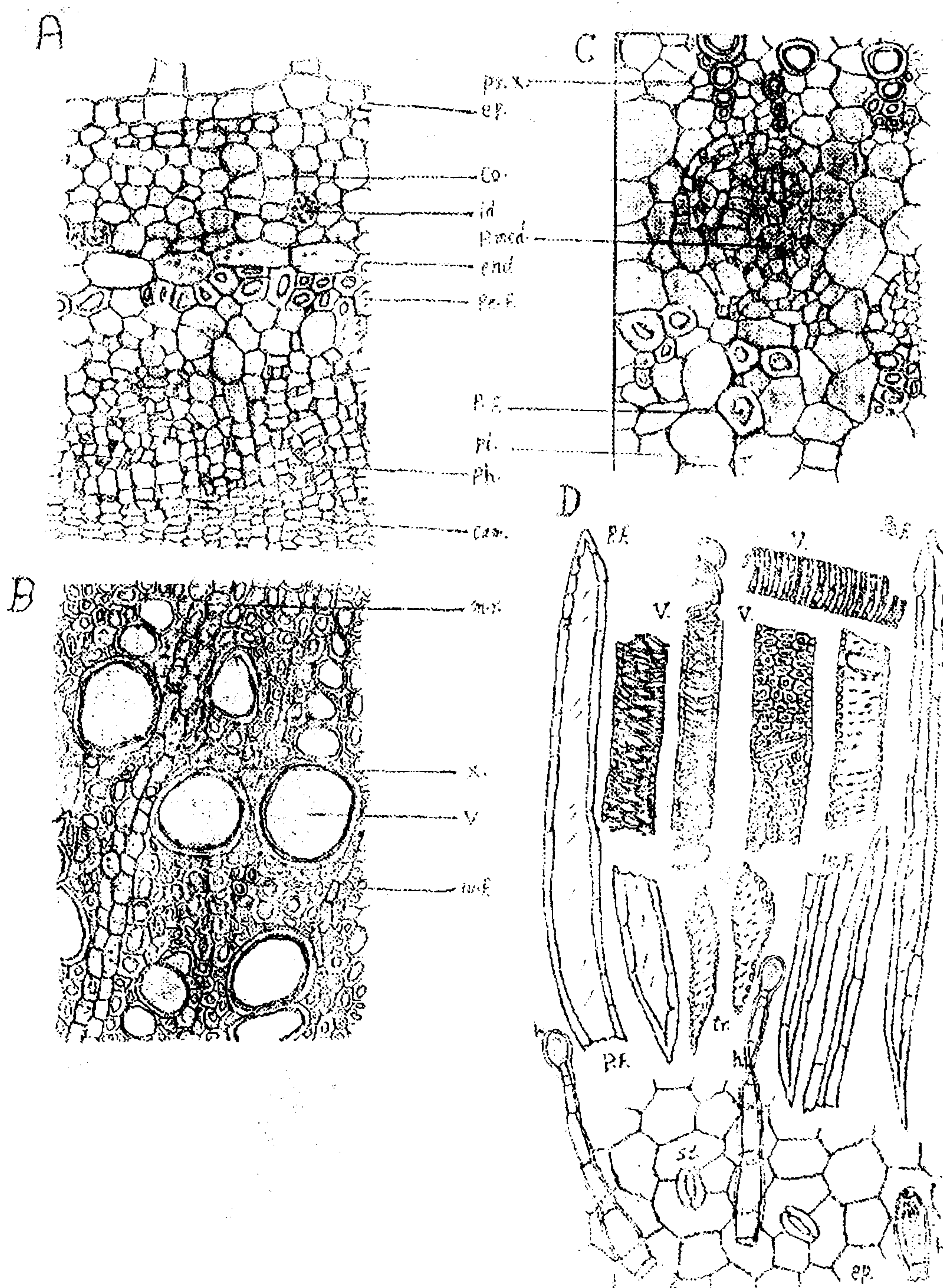


Fig. 6: The Stem

- A- Detailed T.S. of the bark. x 200
- B- Detailed T.S. of secondary xylem. x 200
- C- Detailed T.S. of perimedullary phloem. x 200
- D- Isolated elements. x 200

cam., cambium; co., cortex; ep., epidermis; end., endodermis; h., hair; id., idioblast; m.r., medullary ray; p.med., perimedullary phloem; pe.f., pericyclic fibre; ph., phloem; pr.x., primary xylem; p.f., perimed phloem fibre; pi., pith; st., stomata; tr., tracheid; w.f., wood fibre; v., vessel; x., xylem.

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