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# MACRO- AND MICROMORPHOLOGICAL STUDY OF *BOUGAINVILLEA* 'SCARLETT O'HARA' CULTIVATED IN EGYPT

**May A. El-Sayed[1]*, Fawkeya A. Abbas[1], Sara Refaat[1], Azza M. El-Shafae[1] and Eman Fikry[1]**

Department of Pharmacognosy, Faculty of Pharmacy, Zagazig University, 44519 Zagazig, Egypt.

***Corresponding Author: May A. El-Sayed**
Department of Pharmacognosy, Faculty of Pharmacy, Zagazig University, 44519 Zagazig, Egypt.
**Email id:** mayalsayed@gmail.com, Mayalsayed@zu.edu.eg

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**ABSTRACT**
The macro-and micromorphological characters of the leaf, stem, root and inflorescence of *Bougainvillea* 'Scarlett O'Hara' are presented with the aim of finding their diagnostic characters by which the plant can be easily identified in both the entire and powdered forms. The fascinating thing during the current research is the presence of bulbous trichomres, raphide crystals of calcium oxalate and pink-purple trichomes containing betalains content protrude from the tubular perianth, from the epidermal cells of leaves and from the bracts.

**KEYWORDS:** *Bougainvillea*, Nyctaginaceae; leaf, stem, root, inflorescence.

## INTRODUCTION

Family Nyctaginaceae (Known as the Four-O'Clock family) is a moderately little group of dicotyledonous blooming plants including around 33 genera with approximately bout 400 species. It dispersed chiefly in tropical and subtropical areas of the New World with a few species in the Mascarene and Pacific Islands, India and Africa.[1-4] In Mexico, Brazil and Asia, plants of the family Nyctaginaceae have been utilized to treat diarrhea, dysentery, gastrointestinal colic, muscle discomfort and as abscess, boil and scab poultices. Roots of some indigenous species are eaten as vegetables in southern Africa, the family is best known to South Africans by the genus of *Bougainvillea* that is frequently cultivated in gardens.[3]

*Bougainvillea* is a genus of a very widespread flowering plants native to South America from Peru to West Brazil and South to Southern Argentina.[5] In 1768, at Rio-de-Janeiro, Brazil, *Bougainvillea* was discovered by French military commander *Louis Antoine de Bougainville*, who introduced the plant to Europe.[6] Plants of this genus are reported to have a broad range of medicinal properties such as antidiarrheal, anti-ulcer, antiviral, antibacterial, antioxidant, anti- inflammatory, antidiabetic, antifertility, hepatoprotective, for ttreatment of hypotension and also considered to be larvicidal and insecticide.[7,8]

Only four species of *Bougainvillea* (*B. buttiana, B. glabra, B. spectabilis and B. peruviana*) have been well studied and used economically. However, there are even more than 100 cultivars and three hybrids that have not yet been identified.[9] Due to their commercialisation, *Bougainvillea* plants have been regularly hybridised, leading to the development of more than 400 new varieties with a complex genetic background.[10]

Beautiful attractive bracts and the growth habit of *Bougainvillea* make it a common plant for landscaping either for agronomy, prettification, medicinal, or environmental industries.[11] In addition to its ornamental value in landscaping, it can reduce the air pollution (greenhouse effect).[12]

Plants of this genus are spread in swift growing ornamental shrubs or small trees, sometimes climbers. They are commonly used in tropical or subtropical gardens due to the presence of marvellous colorful foliage bracts and large compliance with various soil and climatic environments. They bloom throughout the year.[13,14]

One of the best and most hardy *Bougainvillea* cultivars is 'Scarlett O'Hara' which is the plant of concern for this genus.

As there is no report in the available literature about the pharmacognostical study of this plant, it is deemed of interest to carry out our study on this plant. Therefore, the main objective of the present work was covering macro- and micromorphological study of *Bougainvillea* 'Scarlett O'Hara' leaves, stem, root and inflorescence with the aim of finding out the diagnostic features by which the plant and these organs can be easily identified in both entire and powdered forms.

## MATERIAL AND METHODS

### Plant material

The fresh leaves, stems, roots and inflorescences of *Bougainvillea* 'Scarlett O'Hara' were collected from

Zagazig- Benha road, Sharkia province, Egypt on June 2016. Eng. Therese Labib, Consultant of plant taxonomy at Ministry of Agriculture and the former director of El-Orman Botanical Garden, Giza, Egypt had taxonomically authenticated the plant sample. In the herbarium of Pharmacognosy Department, Faculty of Pharmacy, Zagazig University, Egypt, a voucher specimen for plant (#BSO-2016) was kept. Samples of different organs were well- preserved in a mixture of ethanol/ glycerin (1:1, v/v) and stored in a firmly sealed container for botanical study.

## RESULTS AND DISSCUSSION

### I. Macro-morphology

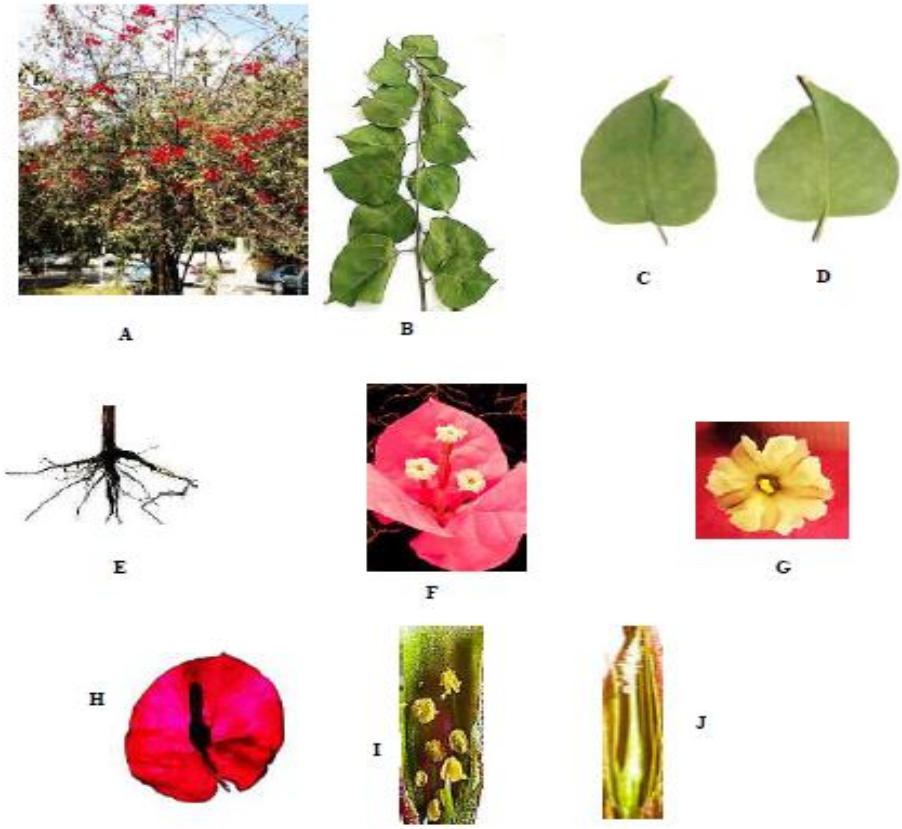
*Bougainvillea* 'Scarlett O'Hara'. "Fig. 1A" is a tropical and subtropical woody, shrubby, thorny ornamental vine, evergreen where rainfall occurs all year, or deciduous if there is a dry season. The growth habit is dense, and the colorful bracts appear up and down the branches, essentially scrambling shrubs that bloom most vigorously in hot, full sun. Typically multi-trunked or with clumping stems, it has a spreading, round plant habit with a height and spread of up to 12 meter. It climbs by sending out slender arching canes armed with stiff curved thorns. *Bougainvillea* 'Scarlett O'Hara' is one of the best and most hardy cultivars. Large deep green leaves contrast well with the deep red bracts. When the bracts are fully open the color changes to hot magenta. It can be trained to tree form by staking and pruning. It grows anywhere from 1 to 12 m tall, scrambling over other plants with their spiky thorns. The thorns are tipped with a black, waxy substance.

The main trunk of the plant "Fig. 1A" is rigid, cylindrical and monopodially branched. It measures from 1 to 12 m in height and 30 to 50 cm in diameter. Typically multi-trunked or with clumping stems. Just as they age, the stems turn from mid-green to dull green-brown in colour. The terminal and lateral branches are thinner, erect and having short internodes; they are dull brown in colour, rough and measure 0.5 to 3.5 cm in length and 0.2 to 0.4 cm in diameter. The old stem is rigid, solid, monopodially branched and cylindrical with brownish rough surface. The internodes measure 2.5 to 5.0 cm in length and 1.0 to 2.5 mm in diameter. The young stem and small branches "Fig. 1B" have green coloured hairy surface. The stem is flexible when fresh, hard and rigid when dry, broken with fibrous fracture exposing greenish- white interior. The stem has slight odour and slightly salty taste.

The leaves "Fig. 1B, C & D" are simple, alternate, petiolate, ovate with acuminate apices, undulate margins and symmetric bases. The leaves have hairy surfaces; the upper surface "Fig. 1C" is dark green, while the lower one "Fig. 1D" is pale green in colour. The leaves are pinnately veined with large central vein that is prominent on both sides but more prominent on the lower surface and joining with secondary veins, almost at 45º angles, that running parallel up to the margin with distinct reticulate venation in between. The leaf measures 2.0 to 7.5 cm in length and 2.0 to 6.5 cm in breadth. The petiole of the leaf is solid, cylindrical, with yellowish green hairy surface (0.5 to 1.5 cm in length and 1.0 to 1.5 mm in diameter). The leaves have faint characteristic odour and a slightly salty taste.

The root "Fig. 1E" is cylindrical, terete and gives few wiry secondary roots and numerous rootlets. The main root measures 10 to 25 cm in length and 0.3 to 0.5 cm in diameter, while the secondary root measures 10 to 15 cm in length and 1 to 1.5 mm in diameter. The root and its branches have rough, reddish-brown outer surface and break with a fibrous fracture exposing a reddish bark and a yellowish wood. The root has a characteristic salty taste.

The inflorescence "Fig. 1A & F" is terminal or axiallary, in panicles, cymes or umbels, characterized by units of three small flowers. Each flower being situated epiphyllouslly on the upper surface of red showy bract. The flowers "Fig. 1G" are perfect and apetalous, small and generally white to creamy white, hermaphrodite, tubular in shape with a constriction in the middle and borne in clusters of three flowers, each cluster is surrounded by three brightly red coloured heart-shaped petaloid bracts. The tip of the flower is conspicuous with a star. There is a solitary carpel at the base surrounded by ring shaped nectar. Each flower has stamens and pistil surrounded by a long five-lobed green to yellowish green perianth tube measuring 1 to 2.5 mm in diameter and in its width and 17 to 19 mm in length. The lower broadened part of the perianth tube will form the anthocarp. The upper part is twisted. There are thorns on the stem underlie inflorescences as part of the flower structure. The bract "Fig. 1H" is heart shaped, modified magenta red colored leaf. The vein that runs from the base to the tip of this bract is the attachment for the tubular flower. It has a rounded apex, entire margin and hairy surfaces. It measures 2.0 to 3.0 cm in length and 1.3 to 1.5 cm in breadth. Bracts may retain their color for several months after the flowers have finished, gradually fading to resemble the color and texture of paper. The androecium "Fig. 1I" consists of 8 stamens with nearly unequal lengths filament joining at their bases forming a short staminal tube. Each stamen is formed of a long flattened yellowish brown filament and bilobed anther. The filament is elongated slender with hairy base and fused with the bract at base. The longest filament is 17 mm long and protoudes over the perianth, the shortest is 12 mm long and the rest measure 13 to 16 mm and they measure 40 to 60 µ in diameter. The anther (30 to 35µ in length and 34 to 45 µ in diameter) is yellow in colour, bilobed and dehisce through lateral slits. The gynoecium "Fig. 1J" consists of monocarpellary, uilocular and superior ovary with a campylotropous ovule with solitary carpel at the base surrounded by a ring shaped nectar. The style is 3 mm long and emerge laterally form the upper part of the ovary. The stigma is ellipsoid, 2 mm long located on one side of the style.




**"Fig. 1" Macro-morphology of *Bougainvillea* 'Scarlett O'Hara':** A Photograph for aerial parts (A, x 0.02), branch bearing leaves (B, x 0.6), leaf with upper surface (C, x 0.8), leaf with lower surface (D, x 0.8), root (E, x 0.95), inflorescence (F, x 0.95), flower (G, x 0.95), bract (H, x 0.95), androecium (I, x 23) and gynoecium (J, x 23).

**II. Micromorphology 1- The leaf**

A transverse section of the leaf "Fig. 2A- 2C" shows a dorsiventral structure with two rows of palisade under the upper epidermis, being interrupted in the midrib region by collenchyma. The midrib is prominent on both sides but more prominent on the lower surface and shows a parenchymatous cortex with subepidermal collenchyma. It is traversed by large vascular system formed of an interrupted ring formed of 6 to 8 separate collateral vascular bundles with arc- shaped towards lower surface enclosing central parenchyma. Each vascular bundle is surrounded by ring of 1 to 2 rows of thick-walled non lignified pericycle fibres. There is an extensive layer of parenchyma tissue between the lower epidermis and the vascular bundles.

**The epidermis**

**The upper epidermis of lamina**

The upper epidermal cells of lamina "Fig. 2C & D" are polygonal, isodiametric cells with straight anticlinal walls, covered with thin smooth cuticle and containing trichomes (uniseriate, multicellular and bulbous).

**The lower epidermis of lamina**

The lower epidermal cells of lamina "Fig. 2C & E" are similar for upper epidermis but it contains anomocytic and actinocytic stomata.

**The upper neural epidermis**

The upper neural epidermal cells "Fig. 2B & F" are polygonal, slightly axially elongated cells with straight anticlinal walls, covered with smooth cuticle and containing trichomes (uniseriate, multicellular and bulbous).

**The lower neural epidermis**

The lower epidermal cells of the midrib "Fig. 2B & G" are similar for upper neural epidermis but it contains more trichomes (uniseriate, multicellular and bulbous).

**Table (1): Dimensions of epidermal cells of the leaf of *Bougainvillea* 'Scarlett O'Hara' (in micron).**

| Epidermis | Length | Breadth | Height |
|---|---|---|---|
| Upper lamina | 16- 35 | 10- 41 | 8- 12 |
| Lower | 17- 40 | 16- 43 | 10- 16 |
| Upper neural | 33- 62 | 10- 23 | 10- 14 |
| Lower neural | 27- 58 | 10- 21 | 14- 16 |

**The stomata**

The stomata "Fig. 2E" are present only in the lower epidermal surface of lamina and absent from the neural regions. They are of anomocytic or actinocytic (meaning *star-celled*) type. They are sunken, surrounded by 4 to 6 epidermal cells and measure 22 to 43 µ in length and 19 to 45µ in breadth.

**Trichomes**

Upper and lower epidermises bear few non-glandular and numerous glandular trichomes. Different types of trichomes are classified into:

**Glandular trichomes**

a. **Bulbous glandular trichomes** "Fig. 2H" formed of long uniseriate multicellular (7-9 cells) stalk (90-110 µ in length and 15- 20 µ in width) and single elongated globular or oval head. The head is formed of single elongated oval or globose cell measuring 18 to 24 in diameter.
b. **Glandular trichomes** "Fig. 2I" having a short tricellular stalk and small globular head. The stalk measuring 65 to 90 µ in length and 13 to 20 µ in width. The head is formed of a small single cell measuring 14 to 22 in diameter.

Glandular trichomes contain greenish black content which gave positive results with Sudan III.

**Non-glandular trichomes**

Non-glandular trichomes "Fig. 2J" are multicellular, uniseriate formed of 8 to 10 cells with thin walls and smooth cuticle with some collapsed cells. They measures 89 to 122 µ in length and 15 to 18 µ in width. Non-glandular trichomes contain red betalains content that can be detected by the destruction of pink colour by the action of the hot aqueous HCl or can be detected by the conversion of the pink coloured pigment to a dull yellow colour the action of a few drops of NaOH.[15,16]

**The mesophyll**

The mesophyll "Fig. 2A & C" is dorsiventral with an upper palisade discontinuous in the midrib region and a moderately wide spongy tissue. The palisade "Fig. 2C" consists of two rows of cylindrical columnar and radially elongated cells with straight anticlinal walls. The length of the cells in the lower row nearly equal the half of that of the upper one. The cells in the upper row measure 46 to 70 µ in length and 12 to 16 µ in width, while the cells in the lower row measure 24 to 38 µ in length and 10 to 14 µ in width. The palisade tissue occupies about one - half of the whole thickness of the mesophyll.

The spongy tissue "Fig. 2C" consists of 4 to 6 rows of thin-walled irregular chlorenchymatous cells showing wide intercellular spaces. They measure 29 to 35 µ in length and 19 to 41 µ in breadth, sometimes traversed by vascular bundle surrounded with bundle sheath. Bundles of raphide crystals of calcium oxalate (in large amount) are observed scattered throughout the mesophyll. They measure 45 to 52 µ in length. Parenchymatous bundle sheath "Fig. 2C" are also observed surrounding the vascular bundle. They are large, oval, begins below the upper epidermis deep in the mesophyll. They measure 25 to 28 µ in length and 19 to 31 µ in breadth.

**The midrib**

**The cortical tissue**

The cortical tissue of the midrib "Fig. 2A & B" is parenchymatous showing an upper band of collenchyma of 3 to 5 rows and a lower arc of 1 to 3 rows of collenchyma. Cells of the upper layers are small but cells of lower are comparatively big. They are oval to rounded with thick cellulosic walls and measure 8 to 17 µ in diameter. The parenchymatous cells are thin-walled, cellulosic, rounded to polyhedral cells with narrow intercellular spaces and measure 8 to 33 µ in diameter. The lower 2 to 4 rows of parenchyma cells are larger in size having large intercellular spaces .The parenchyma cells contain idioblast "Fig. 2K" of raphide crystals of calcium oxalate "Fig. 2N" measuring 45 to 52 µ in length.

The endodermis "Fig. 2A & B" is differentiated around the vascular system. It is formed of tangentially elongated rectangular parenchymatous cells, which measure 15 to 28 µ in length, 12 to 20 µ in breadth.

**The pericycle**

The pericycle "Fig. 2A & B" is formed of a ring of 1 to 2 rows of thick-walled non-lignified fibres surrounding each vascular bundle. The pericyclic fibres "Fig. 2M" are spindle-shaped, with acute apices and moderately thick non lignified walls showing few projections (dentate-like). They measure 432 to 800 µ in length and 10 to 15 µ in diameter.

**The vascular tissue**

The vascular bundles "Fig. 2A & B" is represented by a lower large dissected crescent-shaped arc of 3 to 5 vascular bundles accompanied towards the upper side by 1 to 3 inverted smaller ones which oriented to form a dissected ring of collateral vascular bundles composed of xylem towards ventral side and phloem towards dorsal sides. Each vascular bundle is surrounded by ring of 1 to 2 rows of thick-walled non-lignified pericyclic fibres.

**The phloem** "Fig. 2A & 2B" is composed of polygonal thin-walled cellulosic elements.

**The xylem** "Fig. 2A, 2B & 2L" is formed of moderately thick-walled lignified spiral vessels measuring 23 to 35 µ in diameter.

**The central parenchyma** "Fig. 2A & 2B" consists of thick-walled cellulosic parenchyma cells with narrow intercellular spaces and measure 28 to 47 in diameter.

**The microscopical numerical values of the leaf**

Stomatal index, vein-islet number, veinlet termination number and palisade ratio were summarized in Table (**2**).

**Table (2): The microscopical numerical values of the leaves of *Bougainvillea* 'Scarlett O'Hara'**

| The numerical value | Recorded value |
|---|---|
| 1-Stomatal index of the lower epidermis | 7.1 – 10.8 |
| 2-Vein-islet number | 3 – 5 |
| 3-Veinlet-termination number | 4 – 8 |
| 4-Palisade ratio | 3.2 – 6.5 |

**The petiole**
A transverse section in the petiole "Fig. 3A & B" is nearly circular in outline. It shows an epidermis surrounding a collenchymatous hypodermis and parenchymatous cortex. Three to five inverted vascular bundles appear scattered in the center of the cortex and are enclosed by a peripheral ring formed of 7 to 9 separate vascular bundles. Each vascular bundle is formed of outer xylem and inner phloem and surrounded by 1 to 2 rows of non-lignified thick-walled pericyclic fibres and the peripheral vascular bundles are surrounded by endodermis.

**Epidermis**
The epidermal cells "Fig. 3A, B & C" are polygonal, isodiametric cells with straight anticlinal walls and covered with thin smooth cuticle and containing uniseriate, multicellular non glandular trichomes. The cells measure 21 to 32 µ in length, 12 to 21µ in breadth and 10 to 18 µ in height.

**Stomata**
The stomata are absent on the epidermis of the petiole.

**Trichomes**
The epidermal cells bear few non-glandular trichomes "Fig. 3A, B, D & E". They are multicellular, uniseriate, formed of 4 to 6 cells with some collapsed cells, contain red betalains and covered with smooth cuticle. They measures 85 to 93 µ in length and 17 to 21 µ in width.

**Cortical tissue**
The cortical tissue "Fig. 3A & B" is parenchymatous with a continuous layer of 1 to 3 rows of collenchyma below the epidermis. The collenchymatous cells are more or less rounded with moderately thick cellulosic walls and measure 11 to 25 µ in diameter. The rest of the cortex is parenchymatous consisting of 5 to 7 rows of more or less rounded parenchyma cells with large intercellular spaces. They measure 15 to 45 µ in diameter. The parenchymatous cells contain raphide crystals of calcium oxalate "Fig. 3F" measuring 50 to 55 µ in length.

The endodermis "Fig. 3A & B" is differentiated around the peripheral vascular bundles. It is formed of tangentially elongated rectangular parenchymatous cells, which measure 15 to 28 µ in length, 12 to 20 µ in breadth.

**The pericycle**
The pericycle "Fig. 3A, B & G" is formed of 1 to 2 rows of non-lignified thick walled fibres. The fibres are spindle-shaped, with acute apices and moderately thick non-lignified walls showing few projections (dentate-like). They measure 430 to 1000 µ in length and 12 to 20 µ in diameter.

**The vascular tissue**
The vascular tissue "Fig. 3A & B" is represented by 3 to 5 inner vascular bundles enclosed by a peripheral ring formed of 7 to 9 dissected vascular bundles embded in the cortex and being inverted towards the upper side. The inverted vascular bundles is formed of outer phloem and inner xylem. Each vascular bundle is surrounded by 1 to 2 rows of non-lignified thick-walled pericyclic fibres. The peripheral vascular bundles is surrounded by endodermis and enclosing a central parenchyma.

**The phloem** "Fig. 3B" is formed of polygonal thin-walled cellulosic elements.

**The xylem** "Fig. 3B & H" is formed of moderately thick-walled lignified spiral vessels measuring 20 to 35 µ in diameter.

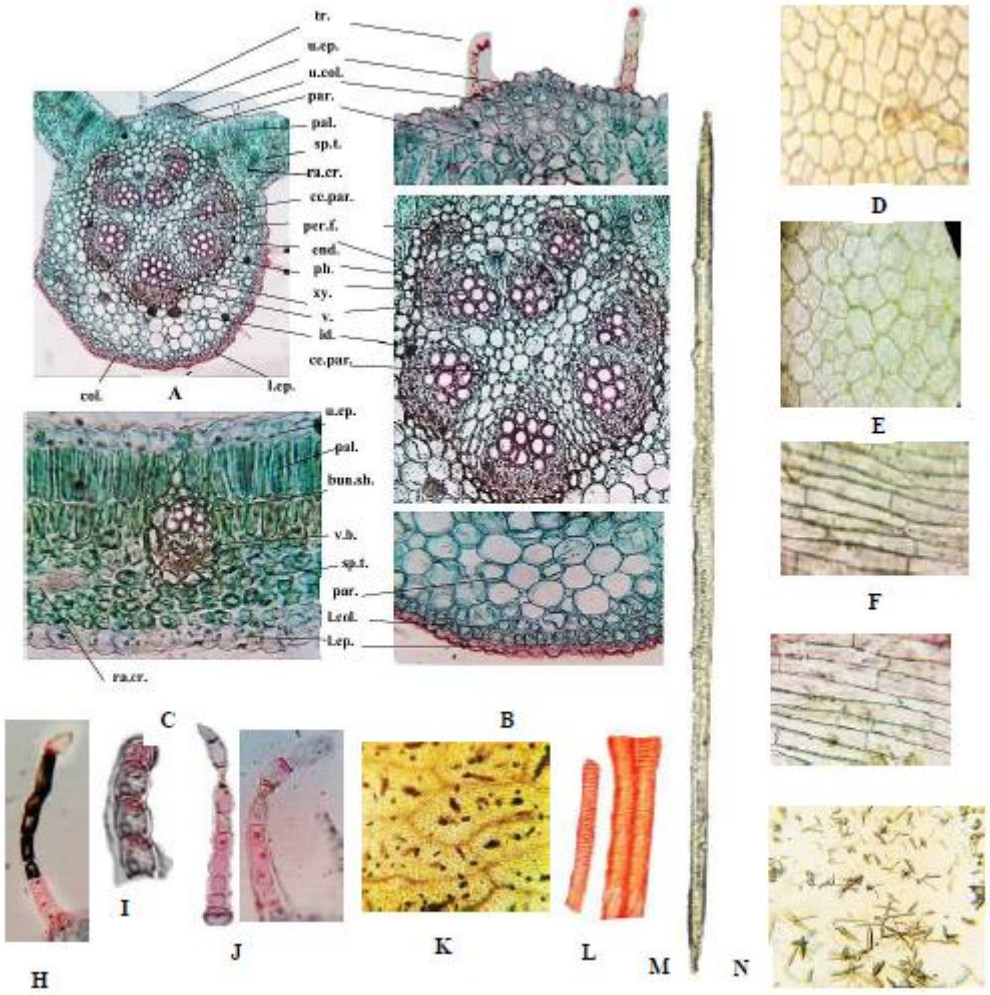
**The central parenchyma** "Fig. 3A" consists of thick-walled cellulosic parenchyma cells with narrow intercellular spaces and measures 16 to 42 µ in diameter.

**The powdered leaf**
The powdered leaves are dark green in colour with faint characteristic odour and slightly salty taste. It is characterized microscopically by the following:

1. Fragments of the upper and lower epidermises of the lamina; they are polygonal, nearly isodiametric, cells having straight anticlinal walls, covered with thin smooth cuticle and showing anomocytic and actinocytic stomata on the lower one.
2. Fragments of the lamina showing dorsiventral structure with two rows of palisade.
3. Fragments of the upper and lower neural epidermal cells which are polygonal axially elongated cells with straight anticlinal walls and covered with smooth cuticle.
4. Fragments of the epidermal cells of the petiole; they are polygonal, with straight anticlinal walls and covered with thin smooth cuticle.
5. Fragments of non-lignified pericyclic fibres of the leaf and the petiole. They have acute apices and moderately thick walls showing few projections (dentate-like).
6. Fragments of idioblast of calcium oxalate needle-like crystal.
7. Fragments of lignified spiral vessels.
8. Calcium oxalate; raphide crystals are present either

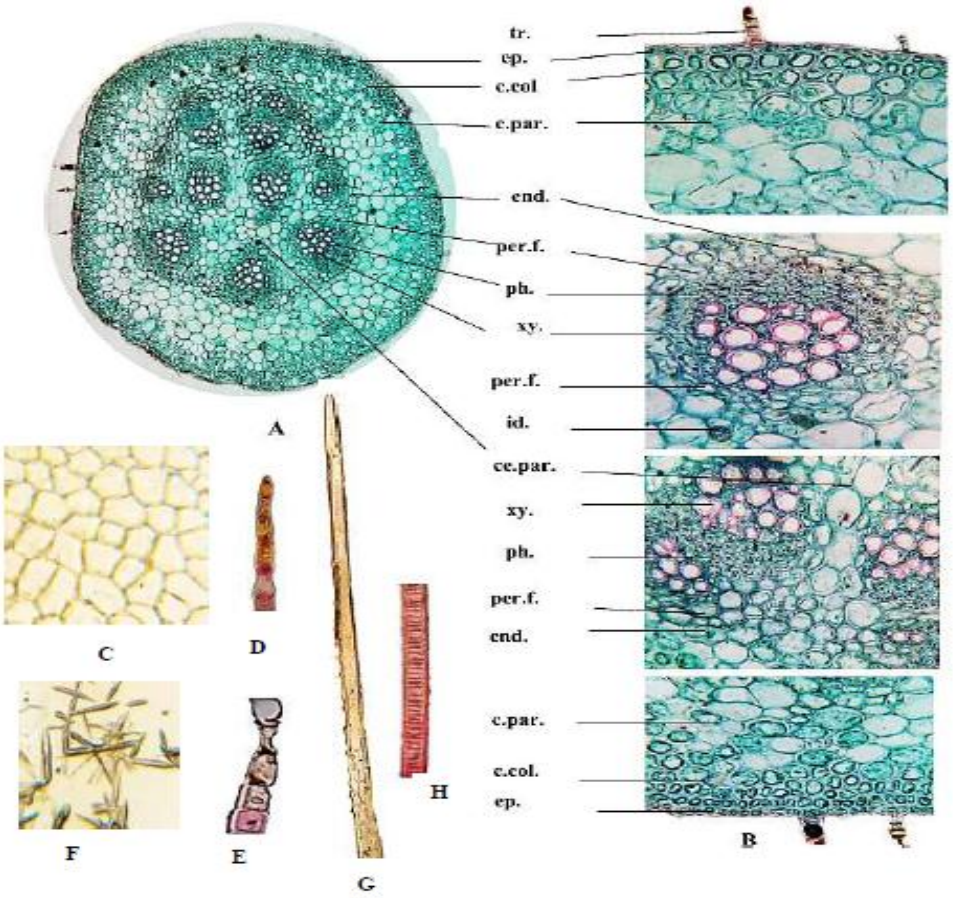
free or in parenchymatous cells.

9. Bulbous glandular trichomes are present which are formed of long uniseriate, multicellular stalk (7- 9) cells and elongated globular or oval head.
10. Glandular trichomes having a short tri-cellular stalk and small globular head are present. They contain greenish black content that gave positive results with Sudan III.
11. Non-glandular trichomes are present which are multicellular, uniseriate formed of (8 to 10) cells with thin walls and smooth cuticle with some collapsed cells and contain red betalains content.




**"Fig. 2" The leaf :** Detailed transverse section of the leaf (A, x40), detailed transverse section of the midrib (B, x162), detailed transverse section of the lamina (C, x512), upper epidermal cells of the lamina (D, x400), lower epidermal cells of the lamina (E, x400), upper neural epidermal cells (F, x 400) and lower neural epidermal cells (G, x400), bulbous glandular trichomes (H, x500), glandular trichomes (I, x500), non-glandular collapsed trichome (J, x500), idioblast (K, x247), spiral vessels (L, x135), non-lignified pericyclic fibres (M, x134), raphide crystals of calcium oxalate (N, x427).

bun.sh., bundle sheath; col., collenchyma; ce.par., central parenchyma; end., endodermis; id., idioblast; l.ep., lower epidermis; pal., palisade; per.f., pericyclic fibres; ph., phloem; ra.cr., raphide crystals of calcium oxalate; sp.t., spongy tissue; tr., trichome; u.ep., upper epidermis; v., vessels; v.b., vascular bundles; xy., xylem.




**"Fig. 3" The petiole:** Diagrammatic transverse section of the petiole (A, x 37), detailed transverse section of the petiole (B, x 100), the epidermal cells of the petiole (C, x 300), non-glandular trichomes (D, x 500), Collapsed non-glandular trichome (E, x 500), raphide crystals of calcium oxalate (F, x 427), non-lignified pericyclic fibre (G, x 220), spiral vessel (H, x 135).
c.col., cortical collenchyma; c.par., cortical parenchyma; ce.par., central parenchyma; end., endodermis; ep., epidermis; id., idioblast; per.f., pericyclic fibres; ph., phloem; ra.cr., raphide crystals of calcium oxalate; tr., trichomes; xy., xylem.

**2. The stem**

A transverse section of the young stem "Fig. 4A & B" is more or less circular in outline. It shows an epidermis surrounding a cortex consisting of an outer collenchyma followed by parenchyma and lined internally by an endodermis. The stele is formed of 30 to 35 collateral bundles each with non-lignified pericycle fibres. The vascular bundles are arranged in 3 to 4 whorles enclosing a parenchymatous pith.

A transverse section of the old stem "Fig. 5A & B" is circular in outline and formed of an outer brownish cork followed by a wide phelloderm with a phellogen in-between, cortex is parenchymatous. The endodermis is indistinct. The pericycle consists a ring of thin layer of groups of lignified fibres separated by parenchyma towards the periphery of the stem with a thicker layer of fibres capping the phloem. Xylem tracheary elements are also surrounded by fibres and sclerified parenchyma. The vascular tissue is formed of a continuous ring of an outer phloem and inner radiating xylem (which occupy two-third of the diameter). The xylem surrounds a narrow lignified parenchymatous pith. Anomalous secondary growth of vascular bundles composed of xylem and phloem are embded in the pith. A close examination of individual vacular bundles reveals fibres.

**The epidermis**

The epidermal cells of the young stem "Fig. 4A, B & C" are single layer, polygonal, axially elongated with straight anticlinal walls and covered with thin smooth cuticle. They measure 18 to 33 µ in length, 9 to 24 µ in breadth and 8 to 13 µ in height.

**Stomata**

The stomata are absent on the epidermis of the young stem.

**Trichomes**

Numerous multicellular non-glandular trichomes "Fig. 4A, B & D" are observed on the epidermis of the young stem. They are covered with thin smooth cuticle and measure 90 to 130 µ in length and 13 to 18 µ in width.

**The cortex**

The cortex of young stem "Fig. 4A & B" is formed mainly of an outer collenchyma (3 to 4 rows) formed of rounded isodiametric cells with thick cellulosic walls,

measuring 15 to 24 µ in diameter and an inner parenchyma (1 to 3 rows) formed of rounded cells with thin cellulosic walls, measuring 25 to 38 µ in diameter.

Numerous raphide crystals of calcium oxalate "Fig. 4E" are scattered in the cortical cells. They measure 55 to 59 µ in length. Some cells contain microsphenoidal crystals of calcium oxalate.

The endodermis "Fig. 4A & B" is differentiated around the vascular system. It is formed of tangentially elongated rectangular parenchymatous cells, which measure 12 to 20 µ in length, 15 to 27 µ in breadth.

**The cork**

The cork "Fig. 5A, B & C" consists of 3 to 5 rows of brownish polygonal tabular cells arranged in radial rows. They have moderately thick suberized walls with brownish contents. They measure 26 to 45 µ in length, 18 to 30 µ in breadth and 7 to 15 µ in height.

**The phellogen**

The phellogen "Fig. 5A & B" arises in the outer rows of cortex and consists of 1 to 2 rows of rectangular thin-walled meristematic cells.

**The phelloderm**

In old stem, the phelloderm "Fig. 5A & B" consists of 3 to 5 rows of thin-walled cellulosic, oval to rounded cells with narrow intercellular spaces. They measure 35 to 50 µ in diameter. Some cells contain idioblast of raphide crystals of calcium oxalate "Fig. 5A & D**"** measuring 58 to 75 µ in length. The endodermis is indistinct.

**The pericycle**

In young stem, the pericycle "Fig. 4A & B" is formed of interrupted patches of non-lignified thick-walled fibres. The pericyclic fibres "Fig. 4F" are spindle-shaped, with acute apices and moderately thick non-lignified walls showing few projections (dentate-like). They measure 650 to 1250 µ in length and 16 to 30 µ in diameter.

In old stem, the pericycle "Fig. 5A & B" is formed of ring of groups of slightly lignified fibres, separated by parenchyma towards the periphery of the stem with thicker layer capping the phloem and surrounding also the xylem tracheary elements. The pericyclic fibres "Fig. 5E" are spindle-shaped, with acute apices and thin lignified walls showing few projections (dentate-like). They measure 576 to 1650 µ in length and 8 to 35 µ in diameter.

**The vascular tissue**

In young stem "Fig. 4A & B", the vascular tissue is formed of a 30 to 35 vascular bundles arranged in 3 to 4 whorles embded in the pith, each with an outer phloem formed of cellulosic elements and an inner xylem showing lignified spiral vessels "Fig. 4G" measuring 25 to 38 µ in diameter.

In old stem "Fig. 5A & B", in the center, there are 20 to 25 primary vascular bundles embedded in lignified parenchymatous pith. Each vascular bundle is formed of an outer phloem and an inner xylem and surrounded with fibres at intervals. At the periphery, extensive secondary vascular tissue are formed of secondary phloem capped with thicker pericycle fibres and secondary xylem and transversed by uniseriate to multiseriate medullary rays. The secondary xylem is composed of tracheids, fibres, wood parenchyma and narrow-diameter vessels. The xylem tracheary elements are also surrounded by pericyclic fibres and sclerified parenchyma. Interspersed with the secondary xylem, small pockets of phloem are observed as well as large- diameter metaxylem vessels. These are reminiscent of the primary bundles towards the centre of the stem.

**The phloem** "Fig**.** 4B & 5B" is formed of polygonal thin-walled cellulosic elements.

**The xylem** "Fig. 5A & B" consists of alternative bands of wood parenchyma and wood fibres in which xylem vessels are scattered with few tracheids. The vessels "Fig. 5F" are lignified, being spiral; they measure 27 to 58 µ in diameter.

The wood fibres "Fig. 5G" are spindle-shaped with moderately thick lignified walls, relatively narrow lumens and acute apices. They measure 461 to 606 µ in length and 10 to 22 µ in diameter.

Few tracheides "Fig. 5H" are present showing blunt apices and moderately thick lignified walls showing rounded bordered pits. They measure 245 to 360 µ in length and 35 to 48 µ in breadth.

The wood parenchyma "Fig. 5B & I" are meta-tracheal and consists of polygonal to subrectangular cells with thick, pitted, slightly lignified walls showing simple pits and measuring 50 to 74 µ in length and 10 to 24 µ in breadth.

**The medullary rays**

The medullary rays "Fig. 5B & J" are uniseriate to multiseriate and formed of rectangular, radially elongated cells with thick, pitted and lignified walls in the xylem region. The cells measure 12 to 68 µ in length and 8 to 35 µ in breadth.

**The pith**

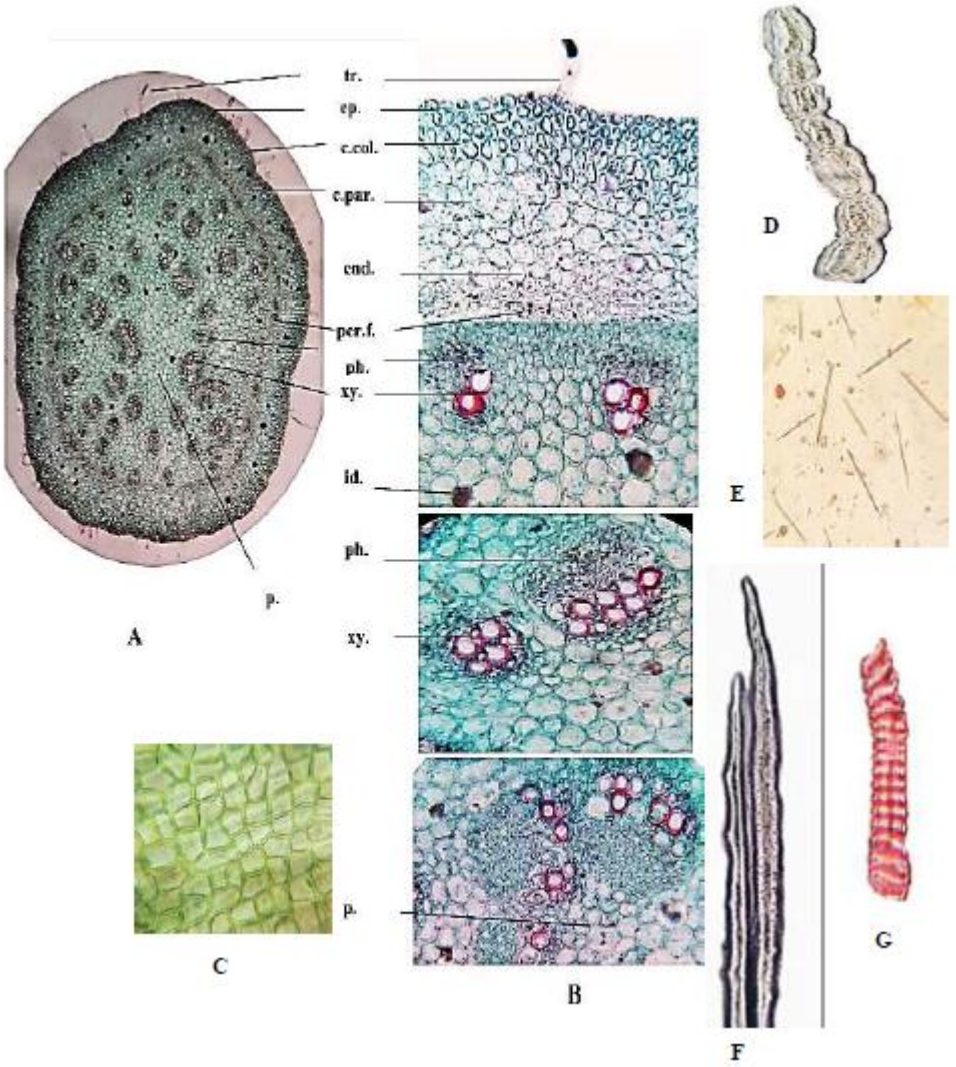
In the young stem**,** the pith "Fig. 4A & B" is thick-walled cellulosic parenchyma with narrow intercellular spaces. They measure 25 to 60 µ in diameter.

In the old stem, the pith "Fig. 5B" is narrow and composed of somewhat rounded cells with moderately thick, pitted, lignified walls and with narrow intercellular spaces. They measure 26 to 75 µ in diameter.

**The powdered stem**

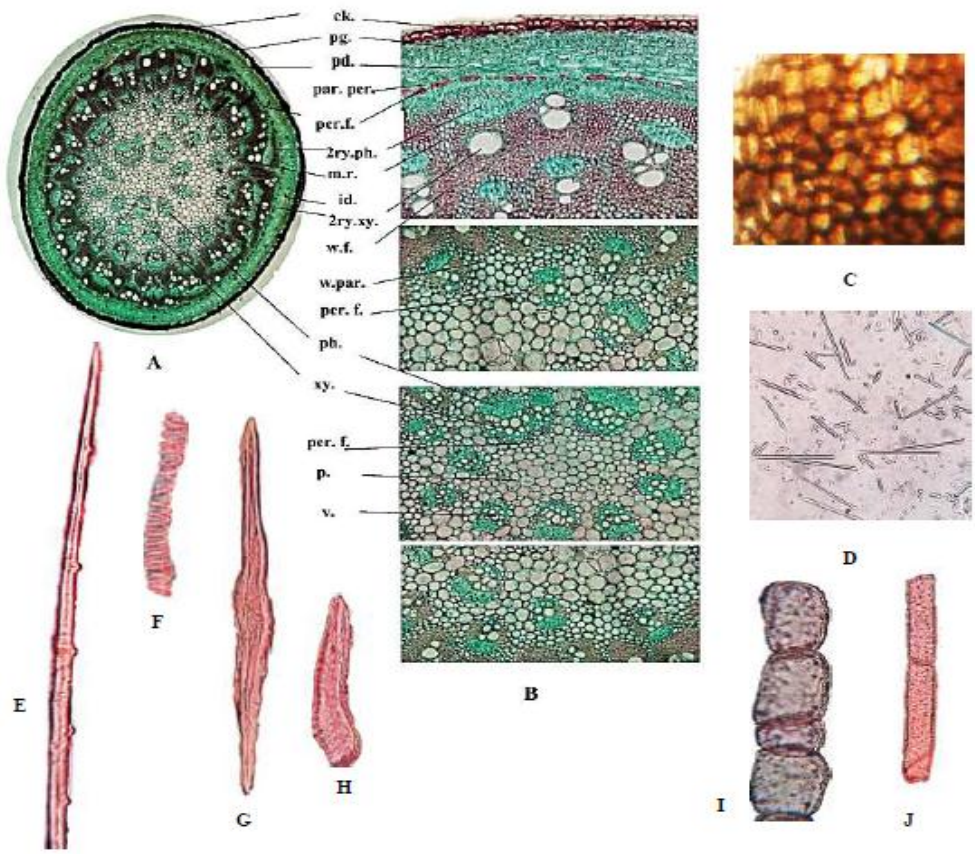
The powdered stem is greenish brown in colour with faint characteristic odour and slightly salty taste. It is characterized microscopically by the following:

1. Fragments of brownish suberized polygonal, thick walled cork cells.
2. Fragments of epidermis consisting of polygonal elongated cells with straight anticlinal walls and covered with thin smooth cuticle.
3. Fragments of lignified and non-lignified pericyclic fibres. They have acute apices and moderately thick walls showing few projections (dentate-like).
4. Fragments of lignified spiral vessels.
5. Fragments of tracheides showing blunt apices and moderately thick lignified walls with rounded bordered pits.
6. Fragments of moderately thick-walled, pitted lignified parenchymatous cells of wood parenchyma, medullary rays and pith.
7. Fragments of spindle-shaped wood fibres with moderately thick lignified walls and acute apices.
8. Raphide crystals of calcium oxalate are frequently observed.
9. Numerous multicellular non-glandular trichomes are present which covered with smooth cuticle.




**"Fig. 4" The young stem:** Diagrammatic transverse section (A, x 30), detailed transverse section (B, x 220), epidermal cells (C, x 300), non-glandular trichome (D, x 500), raphide crystals of calcium oxalate (E, x 195), pericyclic fibres (F, x 246), spiral vessel (G, x 315).

c.col; cortical collenchyma., c.par., cortical parenchyma; end., endodermis; ep., epidermis; id., idioblast; p., pith; per.f., pericyclic fibres; ph., phloem; tr., trichome; xy., xylem.




**"Fig. 5" The old stem:** Diagrammatic transverse section (A, x 20.5), detailed transverse section (B, x 140), cork (C, x 410), raphide crystals of calcium oxalate (D, x 195), pericyclic fibre (E, x 115), spiral vessel (F, x 190), wood fibre (G, x 95), tracheid (H, x 215), wood parenchyma (I, x 328), medullary ray (J, x 485).
ck., cork; id., idioblast; m.r., medullary rays; p., pith; par.per., parenchymatous pericycle; pd., phelloderm; per.f., pericyclic fibres; pg., phellogen; ph., phloem; v., vessel; w.f., wood fibres; w.p., wood parenchyma; xy., xylem.

**3. The spine**
The transverse section of the spine "Fig. 6A" is almost circular in outline. It is formed of thick periderm surrounding a parenchymatous cortex, followed by a ring of fibres, overlaying a ring of sclerified parenchyma. Within this ring, parenchymatous pith contains few small vascular bundles.

**The periderm**
The periderm layer "Fig. 6A, B & C" shows an outer and inner phllem.

**The phellem**
The phellem layer "Fig. 6A & B" is composed of two suberized layers with brownish thickening. The outer layer is composed of radially elongated cells, measuring 11 to 15 µ in length, 7 to 14µ in breadth, while the inner suberized layer is composed of elongated hexagonal cells distributed in 2 to 3 rows. The cells measure 15 to 28 µ in length, 8 to 23 µ in breadth and 7 to 12 µ in height.

**The phelloderm**
The phelloderm layer "Fig. 6B" is formed of (2 to 3) rows of more or less rounded collenchyma with moderately thick cellulosic walls. The cells measure 13 to 26 µ in diameter and contain some prismatic crystals of calcium oxalate "Fig. 6D" that measure 8 to 14 µ in length and 6 to 12 µ in breadth.

**The cortex**
The cortex "Fig. 6A & B" is formed of 3 to 4 rows of rounded isodiametric parenchyma cells with thin cellulosic walls and small intercellular spaces. They measure 23 to 38 µ in diameter. Many prisms of calcium oxalate are present scatterly in cortex, measuring 8 to 14 µ in length and 6 to 12 µ in breadth. Some of parenchymatous cells contain idioblast with raphide crystals of calcium oxalate "Fig. 6E" measuring 45 to 54 µ in length. Few fibrosclerides "Fig. 6F" are scattered in the cortex; they are elongated with thick lignified walls, wide lumen and measure 30 to 37 µ in length and 12 to 15 µ in breadth.

The endodermis "Fig. 6A & B" is formed of small tabular cells surrounding a thick sclerenchymatous layer composed of fibres and sclerified parenchyma. They measure 13 to 22 µ in length, 11 to 21 µ in breadth.

**The sclerenchymatous layer**
The Sclerenchymatous layer "Fig. 6A & B" is formed of an outer narrow fibrous layer formed of 3 to 5 rows of fibres "Fig. 6G" having thick lignified walls, wide lumen

and subacute apices. They measure 435 to 550 µ in length and 10 to 22 µ in diameter.

The inner sclerenchymatous layer is much wider than the outer layer and consists mainly of sclerified parenchyma "Fig. 6B& H". They are formed of polygonal cells with very thick lignified walls showing simple pits. They measure 42 to 55µ in length and 10 to 26 µ in breadth.

Occasional tracheides "Fig. 6I" are present showing moderately thick lignified walls with numerous rounded or oval bordered pits, wide lumen and oblique end walls and measure 250 to 350 µ in length and 25 to 42 µ in breadth.

**The vascular tissue**

The vascular tissue "Fig. 6A & B" is formed of 7 to 9 vascular bundles scattered in a lignified parenchymatous pith. Each vascular tissue is formed of an outer and inner phloem with xylem inbetween.

The phloem "Fig. 6B" consists of moderatey thick-walled polygonal cellulosic elements.

The xylem "Fig. 6B& J" is much fewer than the phloem, consists of small xylem vessels, they are lignified, being spiral and measure 27 – 51 µ in diameter.

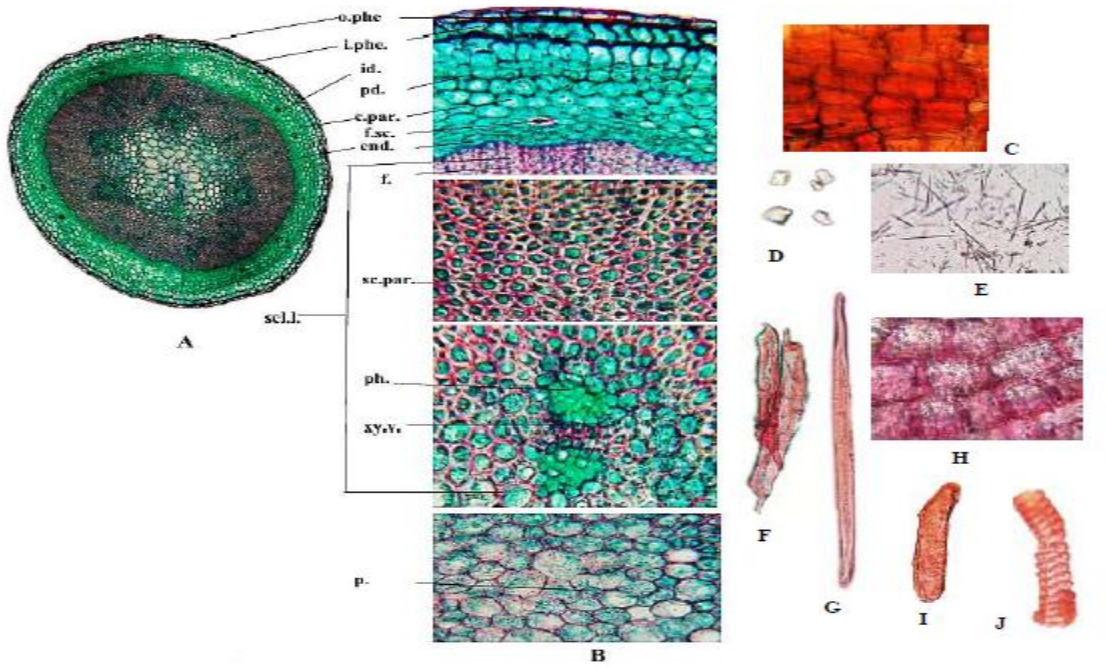
**The pith**

The pith "Fig. 6A & 6B" is comparatively narrow, composed of large polyhedral moderately thick-walled lignified parenchyma cells with narrow intercellular spaces and measure 27– 65 µ in diameter.

**The powdered spine**

The powdered spine is greenish-brown in colour with a salty taste. It is characterized microscopically by the following fragments:

1. Fragments of polygonal thick-walled suberized cells of periderm.
2. Fragments of lignified spiral xylem vessels.
3. Fragments of lignified fibres with moderately thick, lignified walls with slit-like pits, wide lumen and subacute apices.
4. Fragments of lignified fibrosclerides with moderately thick, lignified walls with wide lumen and blunt apices.
5. Prisms and raphide crystals of calcium oxalate are present.




**"Fig. 6" The spine:** Diagrammatic transverse section (A, x 30), detailed transverse section (B, x 220), periderm (C, x 369), prismatic crystal of calcium oxalate (D, x 195), raphide crystals of calcium oxalate (E, x 195), fibrosclerides (F, x 284), fibres (G, x 148), sclerified parenchyma (H, x 248), tracheid (I, x 215), spiral vessel (J, x 190).
c.par., cortical parenchyma; end., endodermis; f., fibres; f.sc., fibroscleride; i.phe., inner phellem; id., idioblast; o.phe., outer phellem; p., pith; pd., phelloderm; ph., phloem; sc.par., sclerified parenchyma; scl.l., sclerenchymatous layer; xy.v., xylem vessel.

**4. The root**

The transverse section of the old root "Fig. 7A & B" appears circular in outline. It shows an outer periderm surrounding narrow cortical region (phelloderm) followed by a narrow outer secondary phloem and a wide inner secondary xylem with cambium in between. Anomalous secondary thickening, characterized by concentric zones of collateral vascular bundles are distributed in secondary xylem which is responsible for expansion of secondary xylem around the region of metaxylem. Centrally a diarch vascular arrangement with xylem having two protoxylem poles with metaxylem

between. Some cells containing cluster of calcium oxalate and idioblasts with raphide crystals is observed in cortex and phloem.

**The periderm**
The periderm "Fig. 7A, B& C" consists polygonal, subrectangular cells with thick walls. They measure 22 to 45µ in length 15 to 33µ in breadth and 9 to 15µ in height in old root.

**The phelloderm**
The Phelloderm "Fig. 7A& B", is formed of 5 to 7 rows of thick-walled polygonal cellulosic cells with narrow intercellular spaces. The cells measure 17 to 40 µ in length and 40 to 75 µ in breadth.

Many of these cells contain numerous idioblast "Fig. 7D" of raphide crystals of calcium oxalate measuring 45 to 70 µ in length.

**The vascular tissue**
In the center of the old root "Fig. 7A& B" there is a diarch vascular arrangement with xylem having two protoxlyem poles with metaxylem between. The developing phloem formed two arches surrounding the xylem. As secondary growth began "Fig. 7A & B" secondary tracheary elements were added outwards from the metaxylem and phloem began to surround the secondary xylem. The vascular tissue is formed of a cylinder consists of an outer narrow secondary phloem and a wide inner secondary xylem with cambium in between. Anomalous secondary thickening characterized by concentric zones of collateral vascular bundles are distributed in the secondary xylem.

**The phloem** "Fig. 7B" consists of polygonal, thin-walled cellulosic elements .The phloem shows no fibres.

**The cambium** "Fig. **7**B" is represented by 1 to 2 rows of thin-walled cells between the xylem and the phloem.

**The xylem** "Fig. 7B" is wide, lignified and consists mainly of wood fibres, xylem vessels with few tracheides and wood parenchyma. It is transversed radially by moderately thick-walled lignified medullary rays.

Xylem vessels are diffused and occur either isolated or in radial rows of (2 to 8) vessels. The vessels "Fig. 7E" are lignified, being spiral; they measure 26 to 60 µ in diameter.

Wood fibres "Fig. 7F" are spindle-shaped with moderately thick lignified walls with slit-like pits, wide lumen and acute apices. They measure 350 to 540 µ in length and 10 to 22 µ in diameter.

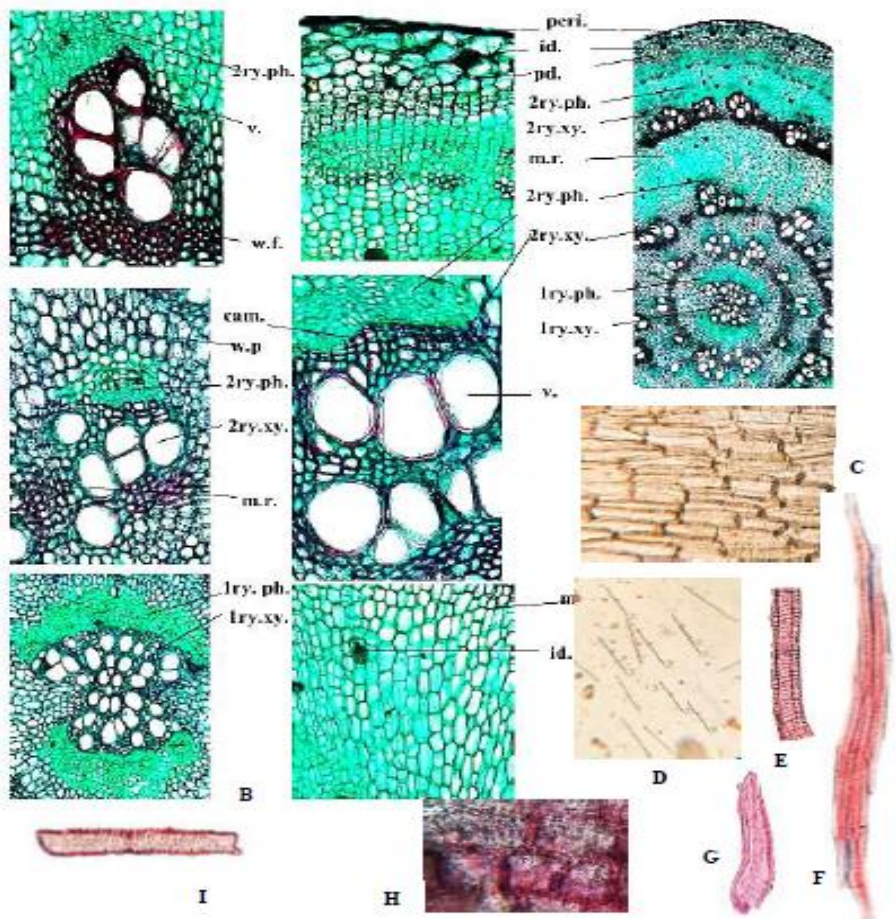
Few tracheides "Fig. 7G" are present showing blunt apices and moderately thick lignified walls showing rounded bordered pits. They measure 245 to 360 µ in length and 35 to 48 µ in breadth.

The wood parenchyma "Fig. 7H" is metatracheal and formed of polygonal, axially elongated cells. They have thick lignified walls showing simple pits and measure 39 to 64 µ in length and 17 to 31µ in breadth.

**The medullary rays**
The medullary rays "Fig. 7B & I" are usually multiseriate and formed of radially elongated rectangular cells with moderately thick-lignified walls in the xylem region and of subrectangular parenchymatous cells with cellulosic walls in the phloem region.

**Powdered root**
The powdered root is reddish-brown in colour with a salty taste. It is characterized microscopically by the following fragments:

1. Fragments of polygonal thick-walled suberized periderm cells which are polygonal subrectangular cells with thick walls.
3. Fragments of wood showing either lignified spiral vessels and pitted tracheides showing rounded or oval bordered pits.
4. Fragments of lignified wood fibres with moderately thick, lignified walls showing slit-like pits, wide lumen and acute apices.
5. Fragments of lignified pitted wood parenchyma.
6. Fragments of idioblast containing needle like crystal of calcium oxalate.
7. Raphide crystals of calcium oxalate are present.




**"Fig. 7" The old root:** Diagrammatic transverse section (A, x 30), detailed transverse section (B, x 220), periderm (C, x 410), raphide crystals of calcium oxalate (D, x 195), spiral vessel (E, x 190), wood fibre (F, x 95), tracheid (G, x 215), wood parenchyma (H, x 328), medullary ray (I, x 485).
cam., cambium; id., idioblast; m.r., medullary rays; peri., periderm; pd., phelloderm; ph., phloem; w.f., wood fibres; v., vessel; w.p., wood parenchyma; xy., xylem.

**5. The inflorescence**

**a. The bract**

A transverse section of the bract "Fig. 8A & B" shows a specialized leaf, a planoconvex midrib and a narrow lamina with heterogenous parenchymatous mesophyll. The midrib is strongly prominent on the lower surface. It shows a collenchymatous hypodermis, a parenchymatous cortex and is transversed by a single crescent-shaped collateral vascular bundle, crowned by an arc of non-lignified thick-walled pericyclic fibres. Each vascular bundle "Fig. 8B" consists of delicate xylem with phloem beneath.

**Epidermis**

Both the upper and lower epidermises of lamina "Fig. 8A, C, D& E" are polygonal cells with wavy anticlinal walls and covered with smooth cuticle. The upper epidermis measure 11 to 23µ in length and 9 to 17 µ in breadth, while the lower epidermis measure 17 to 34 µ in length and 10 to 25 µ in breadth.

The upper and lower neural epidermal cells "Fig. 8A, B, F& G" are polygonal, axially elongated with straight anticlinal walls and covered with thin, smooth cuticle. The upper neural epidermis measure 43 to 66 µ in length and 13 to 19 µ in breadth, while the lower neural epidermis measure 25 to 43 µ in length and 12 to 19 µ in breadth.

**Stomata**

The stomata is completely absent in both sides of the bract.

**Trichomes**

Both the upper and lower epidermises bear few non-glandular and bulbous glandular trichomes. **1-** Non-glandular trichomes "Fig. 8A& I" are multicellular, uniseriate formed of 3 to 4 cells with thin walls and smooth cuticle. They measures 65 to 79 µ in length and 15 to 18 µ in width.

**2-** Bulbous glandular trichomes "Fig. 8A& H" formed of long stalk (4 to 5) cells and elongated oval head. The stalk is uniseriate, multicellular and measuring measure 75 to 91 µ in length and 15 to 20 µ in width. The head is formed of single elongated oval cell measuring 18 to 24 in diameter.

**Mesophyll**

The mesophyll "Fig. 8A& C" is heterogenous and consists of few rows of rounded thin walled cellulosic parenchymatous cells with wide spaces forming areoles. They measure 12 to 23 µ in diameter.

**Midrib**

**The cortical tissue**

The cortical tissue of the midrib "Fig. 8A& B" is parenchymatous showing an upper bands of (1 to 3) rows and a lower arc of one row of collenchyma. They are polyhedral cells with thick cellulosic walls and measure 6 to 10 µ in diameter. The parenchymatous cells are thin-walled, cellulosic, polyhedral with wide intercellular spaces forming areoles. They measure 12 to 23 µ in diameter. The cells contain few raphide crystals of calcium oxalate "Fig. 10C" measuring 40 to 51 µ in length and prisms of calcium oxalate "Fig. 8K" measuring 8 to 14 µ in length and 6 to 12 µ in breadth.

The endodermis "Fig. 8A& B" is differentiated around vascular system. It is formed of tangentially elongated rectangular parenchymatous cells, which measure 9 to 11 µ in length, 12 to 15 µ in breadth.

**Pericycle**

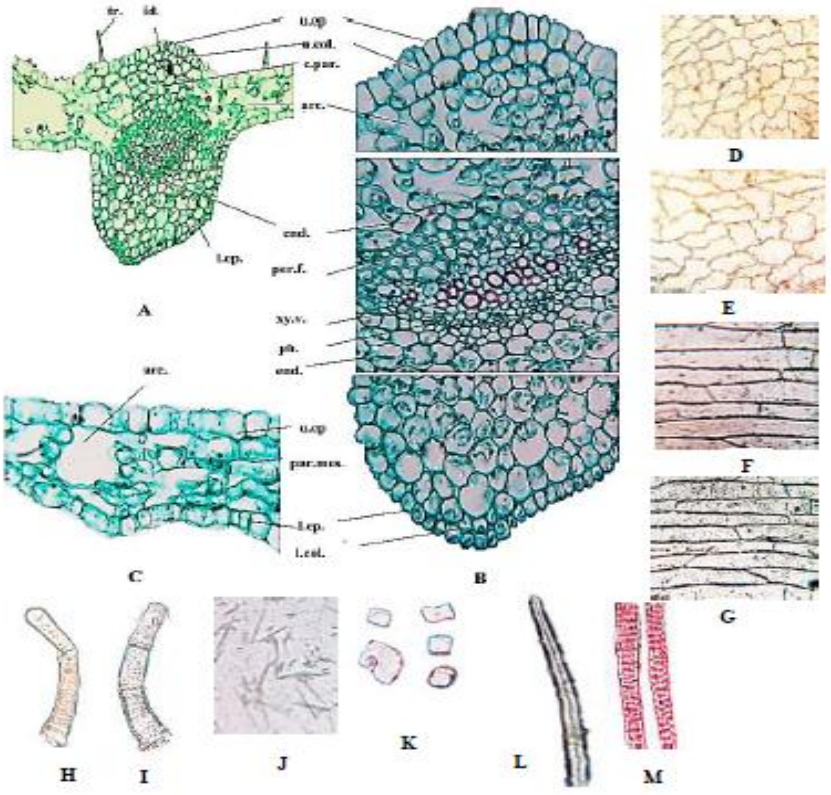
The pericycle "Fig. 8A& B" is formed of arc of (3 to 4) rows of thick-walled non-lignified fibres above the vascular bundle. The pericyclic fibres "Fig. 8L" are spindle-shaped, with acute apices and moderately thick non-lignified walls showing few projections (dentate-like). They measure 432 to 800 µ in length and 10 to 15 µ in diameter.

**Vascular tissue**

The vascular bundle is formed of single central crescent shaped collateral vascular bundle formed of radiate xylem and a band of phloem underneath.

**The xylem** "Fig. 8B& M" is radiated and formed of lignified spiral vessels measuring 10 to 18 µ in diameter.

**The phloem** "Fig. 8B" is comparatively narrow, formed of small thin-walled cellulosic elements.




**"Fig. 8" The bract:** Diagrammatic transverse section (A, x 70), detailed transverse section of the midrib (B, x 512), detailed transverse section of the lamina (C, x 364), upper epidermal cells of the lamina (D, x 445), lower epidermal cells of the lamina (E, x 440), upper neural epidermal cells (F, x 428), lower neural epidermal cells (G, x 415), bulbous glandular trichomes (H, x 500), non-glandular trichomes (I, x 500), raphide crystals of calcium oxalate (J, x 427), prismatic crystals of calcium oxalate (K, x 440), non- lignified pericycle fibres (L, x 375), spiral vessels (M, x 392).
are., areoles; c.par., cortical parenchyma; end., endodermis; id., idioblast; l.col., lower collenchyma., l.ep., lower epidermis; par.mes., parenchmatous mesopyll; per.f., pericyclic fibres; ph., phloem;; tr., trichome; u.col., upper collenchymas; u.ep., upper epidermis; xy.v., xylem vessels.

**b. The perianth**

Transverse section of the perianth "Fig. 9A & B" is ridged in outline. It shows an outer and an inner epidermises enclosing a parenchymatous mesophyll with raphide crystals of calcium oxalate and traversed longitudinally by many vascular bundles.

**Outer and inner epidermises**

Both the outer and inner epidermises "Fig. 9C & D" are sudrectangular polygonal and axially elongated with straight anticlinal walls and are covered by smooth cuticle. The outer epidermis measure 18 to 35 µ in length, 14 to 25 µ in breadth and 9 to 12 µ in height, while the inner epidermis measure 17 to 32 µ in length, 15 to 27 µ in breadth and 9 to 11µ in height.

**Stomata**

Stomata are completely absent in both epidermises.

**Trichomes**

The outer epidermis bears numerous pink-purple trichomes "Fig. 9E". These hair are referred to as betalains containing stylar brush which might responsible for inhibiting contact between the flower's pollen mass and stigma between the cluster of flowers found on each bract, reducing the sterility of the plant.[15]

1- Covering trichomes "Fig. 9F" are uniseriate, multicellular (4 to 8 cells), with thin cellulosic walls and smooth cuticle, with occasional collapsed cells and having obtuse apices. They measure 86 to 190 µ in length, 9 to 33 µ in width.
2- Few branched glandular trichomes "Fig. 9G" are present, showing two branches, each branch cosists of 1 to 3 cells, measures 55 to 93 µ in length and 12 to 22 µ in width and a terminal globular head measures 18 to 24 µ in diameter. The stalk cosists of 5 to 8 cells, measure 73 to 184 µ in length and 19 to 27 µ in width.
3- Bulbous glandular trichomes "Fig. 9H" are formed of long stalk (4 to 6) cells and elongated globular or oval head. The stalk is uniseriate, multicellular and measuring 54 to 58 µ in length and 17 to 19 µ in width. The head is formed of single elongated oval or globose cell measuring 34 to 39 in diameter.

**The mesophyll**

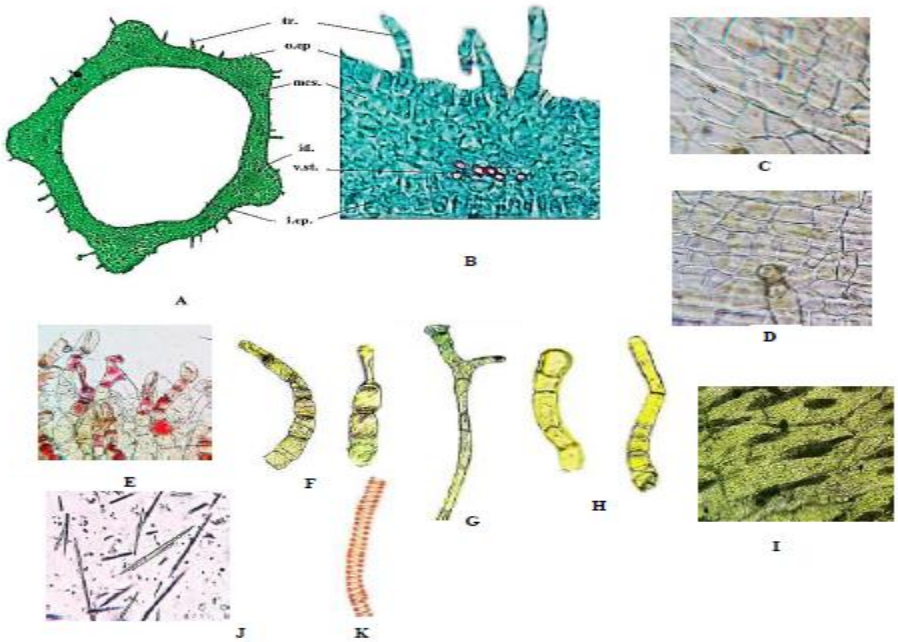
The mesophyll "Fig. 9B" is undifferentiated and consists of (5 to 7) rows of rounded thin-walled cellulosic cells with narrow intercellular spaces. It is transverse by (23 to 25) vascular strands. They measure 16 to 25 µ in diameter. Many of the parenchyma cells contain idioblast "Fig. 9I" formed of raphide crystals of calcium oxalate "Fig. 9J" which measure 42 to 51 µ in length.

**The Vascular system**

The vascular tissue "Fig. 9B" consists of (23 to 25) vascular strands; each consists of an outer xylem and an inner phloem.

**The xylem** "Fig. 9K" consists of lignified spiral vessels measuring 8 to 11 µ in diameter.

**The phloem** formed of moderately thick-walled cellulosic elements.




**"Fig. 9" The perianth:** Diagrammatic transverse section (A, x 70), detailed transverse section (B, x 364), outer epidermal cells (C, x 445), inner epidermal Cells (D, x 440), numerous pink-purple trichomes (E, x 445), covering non-glandular trichomes (F, x 500), branched glandular trichomes (G, x 500), bulbous glandular trichomes (H, x 500), idioblast. (I, x 328), raphide crystals of calcium oxalate (J, x 427), spiral vessel (K, x 392).
i.ep., inner epidermis; id., idioblast; o.ep., outer epidermis; mes., mesophyll; v.st., vascular strand.

**c. The androecium 1- Filament**

The transverse section of the filament "Fig. 10A" shows an epidermis surrounding a parenchymatous ground tissue which is traversed longitudinally by a small vascular strand.

**Epidermis**

The epidermal cells "Fig. 10A & B" are rectangular axially elongated cells with straight anticlinal walls. They are covered with thin smooth cuticle. The cells measure 35 to 50 µ in length, 15 to 19 µ in breadth and 12 to 16 µ in height. Numerous unicellular non-glandular trichomes covered with thin smooth cuticle "Fig. 10C" are present on the epidermal cells of the basal region of the filament. They measure 160 to 450 µ in length and 8 to 15 µ in diameter.

**Ground tissue**

The ground tissue "Fig. 10A" consists of (3 to 5) rows of thin-walled rounded cellulosic loosely arranged parenchymatous cells and traversed longitudinally by a small vascular strand. They measure 13 to 26 µ in diameter. The vascular strand showing few delicate spiral vessel, measuring 9 to 11 µ in diameter and cellulosic thin-walled phloem elements.

**2- Anther**

The transverse section of the anther "Fig. 10D" consists of two anther-lobes each enclosing two pollen sac and separated by the connective. The anther-wall "Fig. 10E" is formed of an epidermis underlined by a fibrous layer then a collapsed tapetum.

**Epidermis**

The epidermis "Fig. 10D & E" is composed of rectangular or polygonal cells with straight anticlinal walls and covered with thin smooth cuticle. They measure 25 to 38 µ in length and 11 to 21µ in breadth. The epidermis of the anther is devoid of stomata and trichomes but containing red betalains content.[15]

**Fibrous layer**

The fibrous layer "Fig. 10D, E, F & G" is formed of one row of polygonal, axially elongated cells having straight anticlinal walls with lignified spiral bands of thickening which appear as bar in the anticlinal plane and as beads in surface view. They measure 25 to 41 µ in length, 22 to 38 µ in breadth and 33 to 45 µ in height.

**Tapetum**

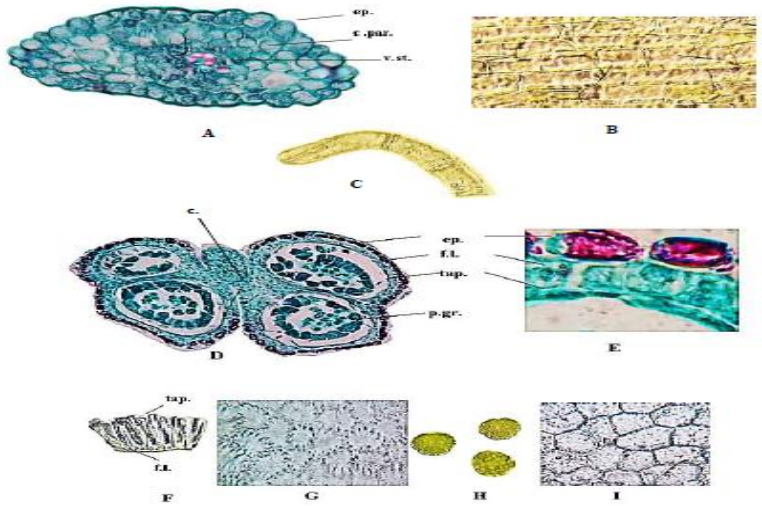
Tapetum "Fig. 10D, E & F" is formed of collapsed cells.

**Pollen grains**

The pollen grains "Fig. 10H" are spherical with a rough-surfaced reticulate exine. They measure 10 to 30 µ in diameter.

**3- Connective**

The Connective "Fig. 10D & I" projects beyond the anther lobes in the form of abcordate appendage having pointed apex. The epidermal cells of the connective "Fig. 10I' are rectangular or polygonal, axially elongated with straight anticlinal walls and are covered with thin smooth cuticle. The terminal projection shows elongated epidermal cells with beaded anticlinal walls. They measure 20 to 35 µ in length and 10 to 18 µ in breadth 9 to 10 µ in height. The ground tissue of the connective and its vascular bundles are continous with those of the filament.




**"Fig. 10" The Androecium:** Diagrammatic transverse section of the filament (A, x 357), epidermal cells of the filament (B, x 357),trichome (C, x 410),diagrammatic transverse section of the anther lobe (D, x 130),detailed transverse section of anther wall (E, x 480), diagrammatic transverse section of the anther wall showing fiberous layer and tapetum (F, x 480), fibrous layer in surface view (G, x 238), pollen grains (H, x 565), epidermal cells of the connective (I, x 400).

c., connective; c.par., cortical parenchyma; ep., epidermis; f.l., fibrous layer; p.gr., pollen grain; tap., tapetum; v.st., vascular strand.

**d. The gynoecium**

**1. The stigma**

A transverse section of the stigma "Fig. 11A" is nearly polygonal in shape. It is formed of an epidermis enclosing a parenchymatous ground tissue and transversed longitudinally by three vascular strands.

The epidermal cells of stigma "Fig. 11A & D" consists of thin-walled axially elongated polygonal cells, with straight anticlinal walls and covered with thin smooth cuticle, the outer periclinal walls of the cells "Fig. 11E" are prolonged into long cylindrical or conical-shaped papillae at the apex and short ones on the sides, they have rounded apices which measured 11 to 15µ in length and 7 to 12µ in breadth. Stomata and trichomes are completely absent. The ground tissue "Fig. 11A" is parenchymatous formed of thin-walled, cellulosic cells having narrow intercellular spaces and traversed longitudinally by 3 vascular strands.

**2. The style**

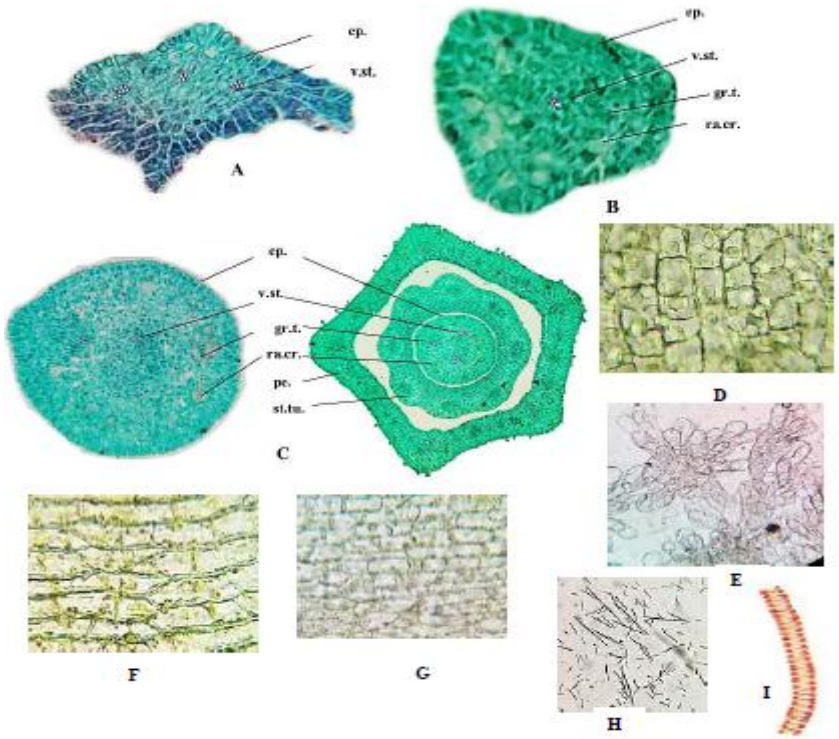
The transverse section of the style "Fig. 11B" is composed of an epidermis surrounding a parenchymatous ground tissue traversed longitudinally by one vascular strand.

The epidermal cells of the style "Fig. 11F" are polygonal, axially elongated cells with beaded anticlinal moderately thick walls and covered with thin smooth cuticle. They measure 30 to 38 µ in length, 10 to 19 µ in breadth and 7 to 14 µ in height. Stomata and trichomes are completely absent.

The ground tissue "Fig. 11B" is formed of rounded, moderately thin walled parenchyma with small intercellular spaces, measuring 19 to 26 µ in diameter and contain few raphide crystals of calcium oxalate "Fig. 11H" which measure 40 to 52 µ in length. The vascular strand shows (1 to 3) lignified spiral vessels of the xylem "Fig. 11I" and thin walled cellulosic elements of the phloem.

**3. The ovary**

A transverse section of the monocarpellary ovary "Fig.11C" is rounded in outline. It is formed of glabrous epidermis enclosing a parenchymatous mesophyll. The ovary traversed longitudinally by (3 to 5) vascular strands. Each vascular strand is composed of xylem showing few delicate, lignified spiral vessels and phloem formed of thin-walled cellulosic elements. Many raphide crystals of calcium oxalate "Fig. 11H" are scattered in the mesophyll cells.




**"Fig. 11" The gynoecium:** Diagrammatic transverse section of the stigma (A, x 47), diagrammatic transverse section of the style (B, x 42), diagrammatic transverse section of the ovary (C, x 34), outer epidermis of the stigma at the side (D, x 304), epidermis of the stigma at the apex (E, x 369), epidermis of the style (F, x 319), epidermis of the ovary wall (G, x 283), raphide crystals of calcium oxalate (H, x 427), xylem vessel (I, x 392).
ep., epidermis; gr.t., ground tissue; mes., mesophyll; pe., perianth; ra.cr., raphide crystals of calcium oxalate; st.tu., staminal tube; v.st., vascular strand.

The epidermal cells of the ovary "Fig. 11G" are polygonal to rectangular with beaded anticlinal wall, covered with thick cuticle. They measure 15 to 26µ in length, 11 to 14 µ in breadth and 6 to 10 µ in height. Stomata and trichomes are completely absent.

**The mesophyll**

The mesophyll "Fig. 11C" is formed of rounded, moderately thin walled parenchyma with small intercellular spaces, measuring 15 to 21 µ in diameter and some cells contain few calcium oxalate raphide crystals "Fig. 11H" which measure 40 to 54 µ in length. It is traversed longitudinally by (3 to 4) vascular strands which composed of xylem showing few lignified spiral vessels "Fig. 11I" measure 7 to 14 µ in diameter and phloem formed of thin-walled cellulosic elements.

**The powdered inflorescence**

The powdered inflorescence is red in colour with characteristic odour and slightly salty taste. It is characterized microscopically by the following features:

1. Numerous raphide and prismatic crystals of calcium oxalate.
2. Fragments of the epidermal cells of lamina of bracts which are polygonal cells with wavy anticlinal walls and covered with smooth cuticle.
3. Fragments of the neural epidermal cells of bracts which are polygonal, axially elongated with straight anticlinal walls and covered with thin, smooth cuticle with many bulbous glandular and covering trichomes.
4. Fragments of non-lignified pericyclic fibres of the bract which have acute apices and moderately thick walls showing few projections (dentate-like).
5. Fragments of the epidermal cells of perianth which are sudrectangular polygonal and axially elongated with straight anticlinal walls and are covered by smooth cuticle, with many bulbous glandular, branched glandular and covering trichomes.
6. Fragments of the epidermal cells of the filament which are rectangular or polygonal cells with straight anticlinal walls and covered with thin smooth cuticle.
7. Fragments of the fibrous layer of the anther which are polygonal, axially elongated cells having straight anticlinal walls with lignified spiral bands of thickening which appear as bar in the anticlinal plane and as beads in surface view.
8. Fragments of the epidermis of the connective which are rectangular or polygonal, axially elongated with straight anticlinal walls and are covered with thin smooth cuticle.
9. Numerous spherical pollen grains with a rough reticulate exine.
10. Fragments of the epidermal cells of the ovary wall formed of polygonal to rectangular cells with beaded anticlinal wall and covered with thick cuticle.
11. Fragments of the epidermal cells of the style formed of polygonal, axially elongated cells with beaded anticlinal moderately thick walls and covered with thin smooth cuticle.
12. Fragments of the epidermal cells of the stigma formed of thin-walled axially elongated polygonal cells, with straight anticlinal walls and covered with thin smooth cuticle, the outer periclinal walls of the cells are prolonged into long cylindrical or conical-shaped papillae at the apex and short ones on the sides, they have rounded apices.
13. Fragments of lignified spiral vessels.
14. Fragments of idioblast of calcium oxalate needle like crystal of the perianth.

## CONCLUSION

Most of the features of the anatomy of *Bougainvillea* 'Scarlett O'Hara' are fairly typical of plants that exist in temperate to tropical environments. Features that are unusual in *Bougainvillea* include [15]:

1. The leaves of this plant have adapted to a hot, dry weather in several ways. Flat surface makes it ideal for extreme light capture, while the wide surface permits for a denser distribution of stomata complexes.
2. Other adaptations of the leaves include occurrence of non-glandular trichomes and raphide crystals of calcium oxalate. The non-glandular trichomes prevent herbivory by insects, prevent pathogens from living the surface, and decrease the loss of water by creating a buffer against air flow. The raphide crystals of calcium oxalate are a part of the plant's passive defence structure and act in deterring herbivory. These crystals also found throughout many other structures including the stem, root, flower and spine.
3. *Bougainvillea* 'Scarlett O´Hara' is characterized by its woody old stem as it matures and is accompanied by a periderm layer which adds extra safety to the stem.
4. Young stem did not have well-developed periderm but rather an epidermal layer.
5. In the young stem, the thin layer of pericyclic fibres found just outside the vascular bundles, protect the outer most layer of the phloem.
6. In the old stem, secondary growth provide further strength and flexibility as the stem continues to grow expand.
7. There are sharp structures located near leaf buds on the stem which are referred to spines. These structures are another feature of this plant's defence system against large herbivores. Moreover, young spines are green and involved in photosynthesis. As these structures age and become woodier, their photosynthetic capabilities terminate.
8. In the spine, the vascular bundles also become much smaller and eventually collapse. This allows for the plant to divert its energy sources to other structures.
9. Furthermore, a mature spine will be mostly composed of sclerified parenchyma, fibres, and a thick periderm which aid in creating a strong structure for protection and deterrence to pests.
10. The colourful bracts are, in fact, not petals but

modified leaves, adapted to attract pollinators to the creamy white flowers residing on the upper surface.

11. Pink-purple trichomes protrude from the tubular perianth, epidermal cells of leaves and bracts which contain betalains content. It has been strongly suggested that these betalains role to keep the plant from the stress of high temperature and strong light.

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**AUTHORS' CONTRIBUTIONS**

All authors made considerable contributions to the manuscript. FA, AE, EF, MA and SR designed the study.

FA, MA, EF and SR performed the experiments. FA, AE, MA, EF and SR interpreted the results. EF, ME, FA and SA wrote the manuscript. All authors revised the manuscript and approved it for publication.

**REFERENCES**

1. Bittrich V, Kühn U. Nyctaginaceae. Flowering Plants· Dicotyledons: Springer, 1993; 473-86.
2. Mabberley DJ. The plant-book: a portable dictionary of the vascular plants; Cambridge university press, 1997.
3. Struwig M, Siebert S. An introduction to the four-o'clocks of southern Africa. Plant Life, 2010; 39: 66-70.
4. Xu Z, Deng M. Nyctaginaceae. Identification and Control of Common Weeds: Volume 2: Springer; 2017; 303-8.
5. Ahmad Z, Singh K, Rasool A, Imran M, Yousuf F. Effect of Co administration of extract of *Bougainvillea spectabilis* and *Catharanthus roseus* on acid phosphatases and alkaline phosphatases on alloxan induced diabetic albino rats. Journal of pharmacognosy and phytochemistry, 2017: 453-5.
6. Kobayashi KD, McConnell J, Griffis J. Bougainvillea. Ornamentals and Flowersk. OF-38, Cooperative Extension Service, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, 2007.
7. Joshny J, Devi R, Hari V. Phytochemical and in-vitro anthelmintic activity of hydro alcoholic extract of *Bougainvillea glabra*. Int J Pharm Pharm Sci, 2012; 4(15.7).
8. Saleem H, Htar TT, Naidu R, Anwar S, Zengin G, Locatelli M, Ahemad N. HPLC–PDA Polyphenolic Quantification, UHPLC–MS Secondary Metabolite Composition, and In Vitro Enzyme Inhibition Potential of *Bougainvillea glabra*. Plants, 2020; 9(3): 388.
9. Abarca-Vargas R, Petricevich VL. Bougainvillea genus: A review on phytochemistry, pharmacology, and toxicology. Evidence-Based Complementary and Alternative Medicine, 2018; 2018.
10. He M, Wang X, Zhuang Y, Jin X. The complete chloroplast genome of *Bougainvillea glabra*. Mitochondrial DNA Part B, 2020; 5(1): 889-90.
11. Singh KK, Singh SP, Bairwa B, Chauhan J. Production Technology of *Bougainvillea* Spp. Biotica Research Today, 2020; 2(6): 472-4.
12. Saifuddin M, Khandaker MM, Abdullah MA, Mahmud K, Sajili MH. Physiological stresses and phyto-hormones: Effects on the flowering process and longevity of *Bougainvillea.* Bioscience Research, 2017; 14(3): 558-65.
13. Kumar PP, Janakiram T, Bhatt K, Jain R, Prasad K, Prabhu K. Molecular characterization and cultivar identification in *Bougainvillea* spp. using SSR markers. Indian Journal of Agricultural Sciences, 2014; 84(8): 1024-30.
14. Randhawa G, Mukhopadhyay A. Tuberose. Floriculture in India Allied publishers Private Limited, New Delhi, 1986: 425-6.
15. Chew S. Anatomical features of *Bougainvillea* (Nyctaginaceae). SURG Journal, 2010; 4(1): 72-8.
16. Swarna J, Lokeswari T, Smita M, Ravindhran R. Characterisation and determination of in vitro antioxidant potential of betalains from *Talinum triangulare* (Jacq.) Willd. Food Chemistry, 2013; 141(4): 4382-90.