ANATOMY OF PLANTS

Introduction:

The study of gross internal structure of plant organs by the technique of section cutting is called plant anatomy. (Pandey, 2002). Various plant organ viz. root, stem, leaves, flower, seed show their typical anatomical structure after section cutting. The development and organization of tissue in plant organs is the result of their function, in words tissue in specific plant organ are developed to perform a specific function. Several anatomy features are specific-to-specific taxa. Hence these are used for delimitation of the species. These anatomical features having taxonomic values are used as criteria for separating the species, genera and even families. The anatomy of plant parts gives the criteria of cork cells, cortex secondary phloem, medullary rayes, fibers etc. which forms the important parameters.

Results of anatomy:-

T.S. of Root:

1. *Datura inoxia* Mill.

   The transverse section of root of *D. inoxia* shows that the cork is the outermost layer; it is composed of 3-4 layers. It having squaresh, oval, rectangular or irregular shape with impregnations. It is interrupted at places. It measuring 20-45 x 35-85 µ. Cortex is differentiated into two zones, outer cortex and inner cortex. Outer cortex is composed of 5-7 layers, cells are large, irregular measuring 30-55 x 55-120 µ. Inner cortex composed small rectangular cells, measuring 20-35 x 30-65 µ. Endodermis is in patches of 2-5 layers, pericycle is not clear. Phloem composed of squariesh or rectangular cells 4-7 layers. It is measuring 15-25 x 20-30 µ. Vessels in patches, 2-5 rarely single circular or oval. It measures 45-95 µ in diameter. Vessels are surrounded by fibers. Rest of the space is filled by parenchyma at the center thick walled triachiery element are arranged like a small pith. Because of abnormal secondary growth xylem elements are distributed in patches (Plate - 3).
2. *Datura ferox* L.: 

Transverse section of *Datura ferox* root shows the cork is outermost layer, it is composed of 2-5 layers. The cells are rectangular, irregular. It is measures 30-45 x 40-60 µ. It is followed by cortex. The cortex is composed of 5-10 layers, the cells of cortex is rectangular, oval and irregular in shapes. It measured from 30-95 x 45-115 µ. Endodermis is in patches of 10-15 layers. Cells are rectangular or oval measuring 12-25 x 20-35 µ. Phloem is followed by large circular strands of xylem. Vessels circular or oval in shapes, Single or in groups of 2-4, it measuring 55-170 µ in diameter. Vessels are surrounded by fibers. Axil parenchyma apotrichal. Ray parenchyma uni, bi or multiseriate, it is composed of radially elongated rectangular cells. It measures 10-25 x 20-45 µ. Thick walled trachyery elements placed at the center (Plate - 3).

3. *Datura metel* L.: 

The transverse section of *Datura metel* root shows cork is the outermost layer, it is composed of 3-5 layers, and it may be interrupted at places. The cork cells are oval, squerish, rectangular and irregular in shapes, it measures 35-40 x 60-120µ. It is followed by cortex, the cortex is composed of 12-16 layers, and the cells are oval, rectangular or irregular in shape. It is greatly varied in sizes and shapes. Small cells measured 10 µ. Some cells are impregnated with black and brown impregnations. Endodermis is in the form of irregular patches. Pericycle is not prominent. Phloem is in continuous ring 5-8 layers. The cells are rectangular smaller and compactly arranged; it measured 8-20 x 15-35 µ. Xylem is in radiating patches. Metaxylem patches surrounded by protoxylem elements. Vessels are oval, single or in groups of two or three. Their diameter ranges 70-170 µ. Ray parenchyma is bi-multicellular and never reaching at the center. There is no pith axile parenchyma lies in between the xylem patches (Plate - 4).

4. *Datura stramonium* L.: 

Transverse section of *Datura stramonium* root reveals the cork is the outermost layer. It is composed of 3-4 layers, cells of which are irregular, interrupted at places. It measured 20-60 x 40-110µ. It is followed by cortex. The
cortex is 8-12 layers, the cells are ovate, rectangular, and irregular certain cells are impregnated. Endodermis; paricycle is not prominent. Phloem composed of 3-5 layers. It is having rectangular cells. It measured 10-20 x 20-35 µ. Phloem is followed by large circular strands of xylem; vessels are circular, oval in outline, single or in groups of two. It measures from 35-105 µ. Ray parenchyma is uniseriate, cells are radially elongate, ovate, rectangular, fibers places and axil parenchyma occupies the rest of the space. Thick walled vessels and fibers placed at the center. It resembles small pith (Plate - 4).

**T. S. of Stem:**

1. *Datura inoxia* Mill.:

   Transverse section of *Datura inoxia* stem shows epidermis is the outermost single layer, it is composed of barrel shaped cells, and some epidermal cells give long multicellular trichomes. Trichomes are of two types glandular trichomes and multicellular trichomes. Epidermal cells are measuring 20-30 x 25 -40 µ. Outer cortex 2-3 layered composed of collenchymarous cells, cells similar with endodermis cells with angular thickening. Inner cortex is 4-6 layered, cells are circular oblong thin walled, measuring 180-260 µ. Endodermis is not prominent. Pericycle 2-3 layered, cells tangentially elongated, oblong interrupted by stone cells. Stone cells are various sizes and shapes. Phloem is 4-6 layered, the cells are rectangular, tangentially elongated, and it measures 10-20 x 15-30 µ. Below the phloem continuous ring of xylem, it is 8-10 layered, thick but at certain places xylem strands grows up to 15-20 layers with large diametered vessels, average of the vessels 100 µ. Fibers thick walled radially arranged. Rays are uniseriate. Below the xylem 4-5 layers of thin walled parenchymatous cells are present, it is compactly arranged, tangentially elongated or polygonal. Large pith is present at the center; it is composed of large parenchymatous cells, cells measures up to 350 µ in diameter, some cells are with crystal sand (Plate - 5).

2. *Datura ferox* L.:

   The transverse section of *Datura ferox* stem shows 2-3 layers of cork observed at certain places, cork cells are squerish to rectangular or irregular in
shape it measures from 20-35 x 30-60 µ. Where cork is absent, epidermis is outermost layer, it is composed of barrel shaped cells, it is sometimes suberised, and it is measuring 20-40 x 30-60 µ. Hypodermis single layered, cells are barrel shaped, slightly larger than the epidermal cells. Outer cortex 4-6 layers, collenchymatous cells of various sizes and shapes with angular thickening inner cortex composed of 3-5 layers. Cells circular, ovate, elongate, irregular loosely arranged, it is ranging from 35-90 µ in diameter and 30-70 x 40-120 µ.

Endodermis 1 or 2 layered, interrupted, barrel shaped rectangular cells, thick walled it measures 20-30 x 30-80 µ. Pericycle 1-2 layered, continuous cells, rectangular or barrel shaped thin walled, it measures 15-25 x 20-40 µ. Phloem is composed of 3-7 layers, it having rectangular cells. It is tangentially elongated; it measures 10-25 x 20-30 µ. Below the phloem there are continuous 6-18 layers of xylem. Metaxylem towards the periphery and protoxylem is towards the center. Vessels are single or in pairs. A fibers thick walled radially arranged. Xylem strands are separated by uni or biseriate rays below the xylem strands. 8-12 layers of parenchymatous polygonal cells are compactly arranged in which certain thick wall. Lignified cells, stone cells and cells with crystal sand are observed. Large pith is present at the center. It is composed of large parenchymatous cells, the cells are circular, thin walled, loosely arranged, and their diameter ranges from 80-170 µ. Crystal sand is also seen in these cells (Plate - 5).

3. *Datura metel* L.:

The transverse section of *Datura metel* stem shows, epidermis is single layered, composed of barrel shaped cells, suberised, it measuring 10-15 x 18-40 µ. Hypodermal layer is rectangular or barrel shaped larger than the epidermal cells. It also gets suberised, suberin deposition observed in patches. Hypodermis is followed by outer cortex, composed of 8-10 layers. Collenchymatous cells are squished, rectangular, oval, circular or irregular with angular thickening, it measuring 15-18 x 40-60 µ. Inner cortex composed of 5-8 layers of parenchymatous cells, it is circular oval or polygonal in shapes, it is loosely arranged with intercellular spaces, it is varied in sizes it measures 40-120 µ in
diameter. Endodermis is not prominent. Pericycle is in continuous patches or strands. It is composed of thin walled fibers, 3-5 layers thick. Some stone cells are scattered among the pericycle strands. Phloem is composed of 3-7 layers rectangular, tangentially elongated measuring 10-20 µ in average. Below the phloem xylem strands are radially arranged. Metaxylem elements present towards the periphery and protoxylem elements are towards the center. Vessels are single or in groups of two to three it measures 80-110 µ in diameter. It is circular or irregular. Xylem strands are separated by broad patches of multiseriate rays, rays composed of radialy elongated barrel shaped cells. Xylem is in 8-10 layers. There is large pith composed of thin walled parenchymatous cells, cells are circular or polygonal, additional phloem patches and xylem patches penetrating in to the pith (Plate - 6).

4. *Datura stramonium* L.:

Transverse section of *Datura stramonium* stem shows, epidermis is the outermost layer, it is composed of oblong or barrel shaped cells. Outer tangential walls suberised, it measures 20-30 x 25-45 µ. Outer cortex collenchymatous, the cells are squerish, circular, irregular with angular thickenings 5-7 layers of various sizes, inner cortex 3-7 layered. Cells thin walled polygonal or circular or oblong 40-110 x 60-200 µ. Endodermis not prominent pericycle 1-2 layered. Irregular cells intermingled with stone cells Phloem 3-5 layers. Rectangular cells tangentially elongated 10-20 x 20-35 µ. Phloem continuous ring of 20 x 25 layers of xylem fibers thick walled, vessels circular or polygonal in outline up to 70 µ in diameter rays uni or biseriate below xylem few layers of compactly arranged cells are their additional phloem strands penetrating in to the pith. Large pith at the center composed of large thin walled polygonal parenchymatous cells, cells measuring up to 150 x 220 µ. Sancells of cortex and pith are with crystal sand (Plate - 6).
ANATOMY OF LEAVES

In present work leaf anatomy of selected drug plants is carried out. In leaf the tissues, are developed for the purpose of photosynthesis & food assimilation. The leaf is perhaps anatomically the most varied organ of angiosperms and its anatomical variation of ten concur closely with generic and specific occasionally familial-line (Carlquist 1961). Therefore a leaf anatomy can be a good source for standardizing a leaf drug as specific leaf shows specific anatomical structure. For describing leaf anatomy, a hand section of midrib region of leaf / leaflet was taken and observed. Systematically valuable histological features and references dealing with study of specific leaf anatomy used in this work are listed below: -

1) Structure of upper & lower epidermis with dimension, presence of hairs & stomata on epidermis & their types. (Vashishta, 1972).

2) Mesophyll: -

Isobilateral or dorsiventral (Metcalfe and Chalk, 1950) Merophyll undifferentiated / differentiated into palisade and spongy tissue (Carlquist,1961; Vashishta, 1972; Eame & Macdainels, 1992; Chandurkar, 1977; Pandey, 2002; Roy, 2006; Metcalfe and Chalk, 1950); shape of palisade and spongy cell, merophyll cell with thickening or converted into sclerids (Carlquist, 1958); Secretary canals, cavities or cell in leaves (Carlquist, 1958).

3) Sheaths: -

Sheaths present or absent (Carlquist, 1961). Sheaths cell conspicuously large (Metcalfe and Chalk, 1950; Solereder, 1908); cells large and with choroplates (Carlquist, 1961); Sclerenchyma present in bundle sheath (Bailey and Nast, 1944; Carlquist, 1957 a, 1958);

4) Vascular bundle: -

Conjoint, collateral or radial, open or closed, (Carlquist, 1961; Vashishta, 1972; Eames, 1992; Chandurkar, 1977; Pandey, 2002; Roy, 2006; Metcalfe and Chalk, 1950), shape of xylem tissue (Carlquist, 1961; Vashishta, 1972; Eames, 1992; Chandurkar, 1977; Pandey, 2002; Roy, 2006; Metcalfe and
All these characters along with other anatomical features are used to standardize selected leaf drugs anatomically. All measurements are taken by using ocular and stage micrometers.

**T.S of leaves:**

1. *Datura inoxia* Mill.

Transverse section of *Datura inoxia* shows that, the epidermis is single layered, cuticle is present at the outer surface. Epidermal layer interrupted by stomata, epidermal cells measures 20-35 x 40-85 µ. Followed by single layered palisade cells, vertically elongated, rectangular, measuring 85-110 x 12-24 µ. Below the palisade, 1-3 layers of crystal cells which are spherical or polygonal; their diameter ranges 25-40 µ. Each cells consisting a rosette crystal of calcium oxalate crystal cells are three layered near mid rib region and single layered towards the margin of lamina, below the crystal cells 3-5 layers of mesophyll cells, which are squires, rectangular spherical and oval, loosely arranged with intercellular species, lower epidermis single layered, barrel shaped, smaller than the upper epidermis, lower epidermis gives numerous simple and glandular trichome, the glandular trichome have elongated stalk and large rectangular gland.

At midrib region on the upper epidermis a hemispherical bulge composed of 4-6 layers of collenchymatous patch, their diameter ranges from 18-50 µ. Below this a triangular patch is composed of thin walled parenchymatous cells. The cells are circular or irregular; their diameter ranges 50-120 µ. This parenchymatous patch is followed by a horse shoe shaped strand of bicollateral vascular bundle. Metaxylem is at the center and protoxylem towards the periphery. Metaxylem consisting large vessels, their diameter ranges 25-55 µ. Phloem present on either side of xylem which is in patch. Phloem cells are the smaller ones and their diameter 10-18 µ. The strand is enveloped by endodermal layer, below the vascular strand 4-5 layer of
parenchymatous cells, which are spherical or irregular. They are impregnated with crystals and other substances, their diameter ranges 50-120 µ units. Lastly, 2-3 layers of collenchymatous hypodermis composed of circular or irregular cells, compactly arranged with angular thickening, diameter ranges from 15-40 µ. Lower epidermal cells give numerous trichomes simple and glandular. Anemocytic stomata were observed in *D. inoxia* Mill. (Plate - 11).

2. *Datura ferox* L.:

Epidermis single layered, barrel shaped cells, and it measures 36-85 x 25-45 µ. Epidermis interrupted at certain places by stomata. Palisade cells single layered, cells vertically elongated, measures 55-95 x 10-24 µ. Below the palisade layer there is a continuous layer of crystal cells at certain places two layers. The cells are polygonal spherical ovoid or irregular. The crystals of calcium oxalate are rosette. Crystals are measures 16-28 µ in diameter. Below the crystal cells 2-5 layers of cells of mesophyll cells, which are loosely arranged, cells are of various sizes and shapes. Lower epidermis composed of single layered, barrel shaped cells; it measures 30-55 x 24-42 µ.

Transverse section passing through the midrib shows a small bulging patch composed of 8-12 layered collenchymatous cells below epidermis. Collenchymatous cells are spherical; their diameter ranges 15-35 µ. Upper epidermis gives several trichomes, below the collenchymatous patch parenchymatous cells form a oval patch, the cells 8-10 layered, very thin walled, spherical or polygonal, their diameter ranges 35-95 µ. This parenchymatous patch followed by a horse shoe shaped strand of vascular bundle. The vascular bundles are bicolateral, enveloped by clear endodermal sheath. Among the xylem metaxylem element are most prominent and their diameter ranges from 20-50 µ. Xylem patch ranges from 120-170 µ in length and 50-90 µ in width. Phloem elements are smaller and their diameter hardly reaches up to 15 µ. Phloem is in patches below the vascular strand, 5-7 layered of parenchymatous cells which are mostly circular or thin walled. Some cells are impregnated with crystals or other substances. Their diameter ranges from 50-120 µ, below this 4-5 layers of collenchymatous hypodermis consisting
of almost spherical cells. Their diameter ranges from 18-35 µ. Anemocytic stomata were observed in D. ferox L. (Plate – 11).

3. Datura metel L.:

Transverse section of the Datura metel leaf shows that, upper epidermis is single layered, barrel shaped, hyaline, and impregnated with orange, brown or black circular substances, amphistomatic, guard cells small bean shaped; it measures 12-15 x 8-10 µ. Palisade cells in single row, unilayered vertically elongated 48-70 x 8-12 µ. Below the palisade cells crystal cells are their alternating with spongy mesophyll cells. Crystal cells contain asteroids crystals. In the lamina vascular bundles are seen alternating with spongy mesophyll cells and crystal cells. Diameter of crystal cells 40-55 µ and diameter of crystal 30-40 µ.

The lateral vascular bundles are conjoint collateral and closed. Xylem elements are placed towards the upper epidermis and phloem is facing towards lower epidermis mesophyll cells are of mesophyll cells in 6-8 layer variable sizes, variously shaped, it measures 20-40 x 10-20 µ. These are thin walled, loosely arranged with large intercellular spaces. Lower epidermis is barrel shaped rectangular or squarish, hyaline, without impregnation. Lower epidermal cells are smaller then upper epidermal cells. At the mid rib region, upper surface consisting 4-7 layers of collenchymatous cells, a longitudinal ridge above the mid rib on the surface of leaf composed of collenchymatous cells, it is variable in sizes and shapes. Below collenchymas, parenchymatous cells from a circular patch above the horse shoe shaped vascular strands. Parenchymatous cells are usually circular, sometimes polygonal; it measures 30-80 µ in diameter. Major parenchymatous cells are impregnated with rectangular squerish or irregular crystals. Vascular strand in horse shoe shaped or arch shaped.

The endodermis forms a sheath around the vascular bundle or strands. Xylem is in several patches, metaxylem elements are facing towards lower epidermis and protoxylem elements facing towards upper epidermis metaxylem elements are polygonal and ranges from 30-50 x 27-37 µ.
Phloem cells are also in patches, below the xylem patches. Phloem cells polygonal ranging from 8-12 µ in diameter. Below the xylem strands 6-8 layered, parenchymatous cells constituting ground cells. The cells are larger than the upper patch and their diameter measures up to 95 µ. Crystals of calcium oxalate of various sizes and shapes are seen in the parenchymatous cells. Some tanniniferous cells are randomly distributed below the ground tissue 3-5 layers of collenchymatous cells from a lower most patch. Collenchymatous cells are irregular their sizes very vary. They also contains some crystal, at the midrib region several hair or hair bases are seen. Anisocytic stomata were observed in *D. metel* L. (Plate – 12).

4. *Datura stramonium* L.:

Transverse section of *Datura stramonium* leaf shows, epidermis single layered, barrel shaped, hyaline, measuring 25-36 x 28-36 µ. It is covered with thin layer of cuticle. Below the epidermis single row of palisade cells which are vertically elongated, it measuring 36-55 x 10-18 µ. Upper epidermis interrupted by stomata at certain places, below the palisade cells a continuous layer of crystal cells are present. The crystal cells are polygonal, irregular; their size ranges from 30-55 µ in diameter. Crystals are rosette crystal of calcium oxalate or like the bunch of grapes. Below to this layer 3-5 layers of mesophyll cells, which are various shapes like squerish, rectangular, polygonal or irregular. Their sizes ranges from 25-45 x 15-35 µ, loosely arranged with intercellular spaces, but more compact than *D. metel*. Lower epidermis composed of single layered squerish or barrel shaped cells smaller than the upper epidermal cells, interrupted at places by stomata, the cells sometimes broader than their breadth, thickness of the lamina 140-175 µ.

Midrib bulges out slightly on upper surface and more on lower surface, 5-7 layers of collenchymatous cells form a patch below the upper epidermis. Collenchymatous cells are of various sizes, their size ranging from 20-52 µ in diameter. They are circular, oval or polygonal, below the patch of collenchymas 7-10 layered parenchymatous cells from a circular patch, the cells are polygonal, irregular, ranging from 30-75 µ in diameter. Below to these patch
arch shaped vascular strands of bicollateral vascular bundle is present. Metaxylem facing towards the lower epidermis, ranges from 20-35 µ in diameter. Xylem gets completely surrounded by phloem. Phloem elements are smaller, ranging from 8-12 µ in diameter. Below to the vascular strand, 5-7 layers of parenchymatous cells forming a ground tissue, the cells are polygonal, ranging from 40-100 µ in diameter. Some cells are impregnated with crystals of calcium oxalate, the crystals are of various sizes and shapes. Anemocytic stomata were observed in *D. stramonium* L. (Plate – 12).

T. S. of Petiole:

1. **Datura inoxia** Mill.:

   Transverse section of petiole shows epidermis is outer most layer, which is composed by rectangular to barrel shaped cells, with cuticle, single layered and protective in nature, which is interrupted by several trichomes. Cells are measuring 25 -20 x 35 -30µ. Just beneath the epidermis there is multilayered cortex which is divided in to adaxial outer cortex and abaxial inner cortex. Outer cortex is 1-2 layered and composed of compactly arranged collenchymatous cells, which measures 5 - 15 x 10 - 20µ. Inner cortex is 6-7 layered and made up of loosely arranged parenchymatous cells, the parenchymatous cells are storasive in nature. The cells are oval to rounded in shape and varied in size. The cells are measures 50 - 30 x 120 - 80µ.

   Vascular bundle is horse shoe shaped or half moon shaped, which is separated by single layered parenchymatous endodermis. It is bicollateral, metaxylem is at the center and protoxylem towards the periphery. Metaxylem consisting vessels, their diameter ranges from 25 - 55µ. Phloem present on either side of xylem, which is in patch. Phloem cells are smaller ones and their diameter is 10-18µ.

2. **Datura ferox** L.:

   Transverse section of petiole is more or less circular to oval in outline concave adaxially. The epidermis is single layered composed of compactly arranged rectangular cells. The cells of epidermis are small, thick walled with moderate cuticle, which measures 15 - 10 x 30 - 25µ. Hypodermis consists of
two layered collenchymatous and parenchymatous cells, collenchymaotus cells are 5-6 layered and compactly arranged, measuring 10 - 5 x 50 - 25 µ. The parenchymaotus cells are thin walled loosely arranged and 7-9 layered, measuring 30 - 20 x 200 - 150µ.

Vascular bundle is an arc shaped and bicolateral, enveloped by clear endodermal sheath. Among the xylem element are most prominent and their diameter ranges from 125µ. Xylem patch ranges from 120 - 170 µ in length and 50 - 90 µ in width. Phloem elements are smaller and their diameter hardly reaches up to 15µ. Phloem is in patches below the vascular strand, 5 - 7 layered of parenchymatous cells which are mostly circular thin walled.

3. *Datura metel* L.:

Transverse section of petiole is circular in outline; the outer most layer is epidermis which is made up of compactly arranged rectangular cells, which measures 15 - 10 x 20 - 15 µ. Just beneath the epidermis there is hypodermis which is divided in to two zones outer collenchymatous and inner parenchymatous, collenchymatous cells are compactly arranged, 5-7 layered and gives mechanical support to the leaf lamina, which measures 10 - 5 x 20 - 15 µ. Parenchymatous region is composed by thin walled cells, which are 7-9 layered, cells ranges from 20 - 15 x 200 - 150 µ.

Vascular strand is horse shoe shaped or arc shaped. The endodermis forms a sheath around the vascular bundle or strand. Xylem is in several patches, metaxylem elements are at centre and protoxylem elements are at periphery. Metaxylem element are polygonal and ranges from 30 - 50 x 27 - 37µ. Phloem cells are also in patches, below the xylem patches. Phloem cells are polygonal and ranging from 8-12µ in diameter.

4. *Datura stramonium* L.:

Transverse section of *Datura stramonium* petiole shows epidermis which is outermost layer, composed by rectangular to barrel shaped cells. It is single layered and with cuticle, protective in nature, which is interrupted by several trichomes. Cells are measuring 20 - 15 x 35 - 35µ. Just beneath the epidermis there is multilayered cortex which is divided in to outer cortex and inner cortex.
Outer cortex is 1-4 layered and composed of compactly arranged collenchymatous cells, which measures 7 - 15 x 10 - 25µ. Inner cortex is 6-7 layered and made up of loosely arranged parenchymatous cells, the cells are storasive in nature. The cells are oval to round in shape and varied in size. The cells are measures 55 - 30 x 110 - 70µ.

Vascular bundle is half moon shape, which is separated by single layered parenchymatous endodermis. It is bicollateral, metaxylem is at the center and protoxylem towards the periphery. Metaxylem consisting vessels, their diameter ranges from 25 to 55µ. Phloem present on either side of xylem, which is in patch. Phloem cells are smaller ones and their diameter is 10-18µ.