Chapter III

Observations

I Series - Tubuliflorae

Tribe I - Vernonieae

Elephantopus scaber Linn.

The Plant

It is a dichotomously branched annual herb with deeply penetrating roots, 1 to 2 feet high. The stem is erect, stringose and villous. The leaves are mostly sessile, radical, 4-5 inch long, oblong, tapering towards the base with crenate margin. Heads are homogamous, few flowered and enclosed in flattened cups.

The achenes are somewhat hairy having a pappus of 4-5 rigid bristles dilated at the base.
The Embryo

General

The embryo is 4.3 to 5 mm in length and 1.2³ to 1.5 mm in breadth. The cotyledons are almost twice as long as the hypocotyl-radicle-axis. They are almost equally broad throughout and enclose a double hump shaped plumule. Hypocotyl-radicle-axis is triangular, tapering towards the root tip, covered by a prominent root cap (Figs. 1,2).

Anatomy

In cross section up to about 40 microns from the radicle tip, no differentiation is seen in the cells in the embryo (Fig. 5).

Proceeding about 60 microns upward a large cortex of 6-7 layers of large cells and a small core of small cells are differentiated. The core is enclosed in an endodermis and pericycle (Fig. 6).

About 130 microns further up the central mass increases in size and is roughly partitioned into two groups of smaller cells with granular contents by a strip of larger cells. These groups differentiate as two procambial strands. The endodermis becomes double layered at two points opposite these groups. Slightly above in each group the cells increase in number (Fig. 7; M.P. 1).

Proceeding further about 60 microns upwards in the widening axis a few sieve mother cells are recognisable. Each procambial strand gradually enlarge sideways (Fig. 8; M.P. 2).
By about another 40 microns up two cells on each end of the partitioning band of larger cells near the pericycle become prominently angular and thickwalled. These can be identified as protoxylem mother cells (Fig. 9; M.P. 3). Towards the middle of the hypocotyl in the widening axis the central region increases and forms a pith like structure. The procambial strands extend sideways and become bilobed.

About 200 microns still upwards the two lobes of the strands separate and migrate towards the nearest xylem mother cells, forming a bilobed structure on the cotyledonary plane (Fig. 10; M.P. 4). Each lobe of this structure buds out a branch towards the anticotyledonary plane. Two such adjacent branches meet on this plane forming another bilobed structure. The structures on the two planes remain connected by a procambial bridge forming a lobed ring like structure on the base of the cotyledonary node (Fig. 11).

As the procambial strands divide in the mid of hypocotyl, the double layered sectors of the endodermis also derived and go with the daughter strands (Fig. 10). At the node these bridges fade out leaving two dumbbell shaped strands as cotyledonary medians on the cotyledonary plane. The bilobed structures on the anticotyledonary plane give out a massive branch that bifurcates to supply the cotyledonary laterals. The remaining small portion supplies the epicotylar leaves (Figs. 12, 13, 14).

The procambial system of epicotyl is in continuation with and is derived from that of the radicle-hypocotyl axis (Fig. 3).
The median trace of the cotyledon is a double fused structure gradually becoming elliptical (Fig. 15). It branches in the lamina to form the reticulate venation. The vein-ends fuse with the laterals to form the areoles. At its termination the median forks and each arm joins the laterals on its side (Fig. 4).

In the median trace, double layered sectors of the endodermis are traced till the two procambial strands are not completely fused (Figs. 16, 17).

The cotyledonary node is trilacunar and the first type venation (i.e., one median and two laterals) is found in the cotyledons.

**Tribe II - Eupatorieae**

*Ageratum conyzoides* Linn.

**The Plant**

The plant is an annual wild herb distributed very widely in this country. It is 1-3 ft. high. The stem is erect, branched and more or less hairy. The leaves are simple, prominently petioled, opposite and 2-3 inches long and 1-2 inches broad.

Heads are homogamous, tubular, white and in small dense terminal corymbose clusters.

The achenes are 2 to 2.5 mm long and sharply angled or glandular. They are black, smooth and have a prominent hairy pappus.
The Embryo

General

The embryo is very delicate and small. Its size is 0.025 to 0.03 mm long and 0.0045 to 0.005 mm broad. The cotyledons are slightly longer than hypocotyl-radicle-axis and are oblong and slightly curved (Fig. 18). There is a prominent root cap. The apex of the hypocotyl-radicle axis is blunt. The plumule has two embryonic leaf-primordia, enclosing a dome shaped shoot-apex (Figs. 19, 21).

Anatomy

Up to 50 microns from the radicle-tip there is no differentiation in the cells as seen in a cross section (Fig. 22).

At about 60 microns from the root-tip a distinct central region of smaller cells, enclosed in a single layered endodermis and pericycle is distinguishable from a cortex of larger cells with intercellular spaces (Fig. 23).

Proceeding about 15-20 microns upwards, the circular central core gradually becomes elliptical. On the longer diameter at two ends the endodermis becomes double layered at two opposite poles. The core is roughly partitioned into two groups of smaller cells opposite the double layered sectors of endodermis by a band of larger cells across the pericycle identifiable as procambial strands by their granular contents (Fig. 24).

About 65 microns further up a sieve mother-cell is recognised in each of these of the periphery (Fig. 25).
By about 25 microns further up a cell near the pericycle at right angles to the phloem procambial strands becomes prominently angular and thick walled, identifiable as protoxylem mother-cell (Fig. 26).

Towards the middle of the hypocotyl in widening axis, the central portion of the axis increases and forms the pith like structure of larger cells. The procambial strands extend sideways and divide into two strands each. Each portion gradually moves towards the protoxylem mother-cells. Simultaneously the double layered sectors of endodermis also divide and move along with the daughter procambial strands.

About 75 microns still further up some more xylem initials can be recognised (Figs. 27, 28).

Gradually each procambial strand buds out a small strand towards the intercotyledonary plane. The adjacent daughter strands fuse on this plane. The newly formed fusion masses give out two branches each for the cotyledonary laterals (Figs. 29, 30). In this way six procambial strands are formed. Simultaneously the remaining strands on either side of the anticotyledonary plane close in, fuse and form cotyledonary medians. The residual parts of the fusion masses on the anticotyledonary plane, after giving out laterals for the cotyledons go to the plumule (Figs. 31, 32, 33).

The median trace is a double fused structure but as it enters the cotyledon the two strands fuse together. Later, the median branches in the lamina, its vein-ends joining with branches
of laterals to form a closed venation pattern. Ultimately it forks distally, the two arms joining the ends of the laterals (Fig. 20).

The cotyledonary node is trilacunar. The procambial system of the epicotyl is in continuation and is derived from that of the hypocotyl-radicle-axis.

The sectors of double layered endodermis move with the medians and rudimentary schizogenous canals (Fig. 34).

The cotyledonary venation is of the fourth type (i.e., three strands enter each cotyledon but peculiar feature is the branching of median by middle region of cotyledons).

Tribe III - Asterae

**Cosmos bipinnatus** Cav.

The Plant

The plant is herbaceous and a native of Mexico, often grown in the gardens attaining height of several feet. The leaves are opposite to alternate and highly dissected. Heads are heterogamous with pretty coloured rays. The involucre is of eight separate green bracts.

The mature achenes are hard elongated and black with scaly pappus. They are 1.3 to 1.5 cm long, 0.1 to 0.2 cm broad and tapering on both the ends.
The Embryo

General

It is 0.5 to 0.7 cm long and 0.05 to 0.1 cm broad and slightly curved. There are two thick oblong cotyledons. The hypocotyl-radicle-axis is almost triangular. Its apex is slightly round with a prominent root cap (Figs. 35, 36, 37). The plumule has two small embryonic leaves enclosing somewhat dome shaped apex (Fig. 37).

Anatomy

Cross sections of the embryo up to 40 microns from the radicle tip show no differentiation in the cells (Fig. 39).

Proceeding about 40 microns upward a central core and a cortex get differentiated, the former by smaller cells, the enclosing endodermis and pericycle (Fig. 40).

About 100 microns above this, the endodermis becomes double layered at two points on the anticotyledonary plane. Opposite these, double layered endodermis groups of smaller cells with granular contents are differentiated as two procambial strands separated by a strip of the larger cells formed at cotyledonary plane (Fig. 41; M.P. 5).

Going about 170 microns further up the procambial strands enlarge (Fig. 42). In each of these a few sieve mother cells can be recognised. By about another 220 microns upwards two xylem mother cells at right angle to procambial strands are
distinguished (Fig. 43). Proceeding upwards the procambial strands enlarge sideways, closing upon the xylem mother cells. Thus a ring of procambium is formed (Fig. 44; M.P. 6). This ring shows prominent lobes, two in the cotyledonary and two in the intercotyledonary planes (Figs. 45,46). The lobes in the cotyledonary plane become bilobed (Fig. 47). In the narrow bridge of the procambium between the four earlier lobes two additional lobes are differentiated (Fig. 48).

At the cotyledonary node the double lobed masses of the ring separate and form as cotyledonary medians. The lobes on the anticotyledonary plane give out a prominent branch outward which forks to supply the cotyledonary laterals (Figs. 49,50; M.P. 7,8). The remaining part of the ring i.e., the four strips between the lobed masses as well as the remaining parts of the lobes on the anticotyledonary plane move inwards and go to the epicotyl is thus in connection with and is derived from that of the hypocotyl-radicle-axis. The cotyledonary median is fused and bilobed. The embryonic leaves receive three strands shared from the six, left at the cotyledonary node (Fig. 51; M.P. 9). Later on cotyledonary, as the tube separates in the median lobed strands of cotyledons, more xylem mother cells are formed (Figs. 52,53).

The endodermis remain double layered at two ends of the strand and forms the schizogenous canals (Figs. 54,55).

The median trace of the cotyledon branches into the lamina and forms the reticulate venation as usual (Fig. 38).
The cotyledonary node is trilacunar and venation is of the fifth type in which the lateral veins do not end blindly but their branches fuse with adjacent branches of the median.

Tribe IV - Inuleae

**Caesulia axillaris** Roxb.

( = *Meyera orientalis* Don. )

The Plant

It is a glabrous tall herb, with weak, slender stem usually straggling or climbing by growing in between other growths, when it attains a height of several feet. Internodes are long and leaves are alternate sessile with prominently sheathing base. Branching is profused. Capitula are white, borne characteristically in the axils and enclosed in the basal sheaths.

The achenes are 0.25 cm to 0.3 cm long, typically flattened with a prominent wing like structure allarround bifid at the top and have a prominent rib down the middle of each face, sparsely hairy with scaly pappus.

The Embryo

General

The mature embryo is about 1.98 mm long and 1.08 mm broad. It is straight and pear shaped. The hypcotyl-radicle-axis is almost as large as the cotyledons. The root cap is
prominent (Figs. 56, 57, 58). The cotyledons are membranous
very broad towards the apex and narrow sharply towards the
cotyledonary node.

**Anatomy**

In cross sections up to 50 microns from the radicle tip,
there is no differentiation of the cells (Fig. 60).

At about 80 microns from the tip the structure shows a
well marked central core of compact small cells enclosed in an
endodermis and pericycle (Figs 61; M.P. 10).

Proceeding 40 microns upwards the central mass becomes
elliptical. It gets partitioned roughly into two groups by a
band of larger cells across the pericycle, in the vertical plane
of the shorter diameter of the cross section. It is in these
groups that the procambial strands differentiate with their
granular contents at right angle to this band (Fig. 62; M.P. 11).
Here instead of the endodermis the pericycle becomes double
layered at two points.

Proceeding upwards next 40 microns a few protoxylem
mother cells are differentiated in each procambial strand near
the pericycle (Fig. 63; M.P. 12). By about next 30 microns the
first protoxylem mother cells differentiate next to the peri-
cycle at right angles to the plane of the procambial strands
(Fig. 64).
By about 180 microns, upward, in the middle region of the hypocotyl the procambial strands extend sideways and divide into two each, the daughter strands migrating towards the protoxylem mother cells, forming a prominent bilobed structure on the cotyledonary plane (Fig. 65). Each lobe of this bilobed structure buds out a branch towards the anticotyledonary plane. Two such branches meet on this plane forming another bilobed structure. The structures on the two planes remain connected by a procambial bridge forming lobed ring like structure on the base of the cotyledonary node (Fig. 66).

On the node these bridges fade out leaving two dumbbell shaped structures on the cotyledonary plane as the cotyledonary medians and the bilobed structures on the anticotyledonary plane give out a massive branch that bifurcates to supply the cotyledonary laterals. The remaining small portion of these supplies the epicotylar leaves (Figs. 67, 68, 69).

In each cotyledon a dumbbell shaped median strand and four lateral strands two on each side are formed by branching of main lateral (Figs. 69, 70).

The median trace is a double fused structure. It branches into the lamina. Ultimately veinlets are fused with the laterals to form the reticulate venation (Fig. 59).

The median trace remains dumbbell shaped till the two procambial strands are separated but gradually the two strands fuse and form a circular strand (Figs. 71, 72).
The cotyledonary node is trilacunar. The procambial system of the epicotyl is in continuation with and is derived from that of the hypocotyl-radicle-axis.

The cotyledonary venation is of the third type i.e., one median and four laterals enter in the cotyledon. The inner laterals branch into two each and medians into three. Thus here also like second type, in the middle region of cotyledon there occur nine strands.

Tribe V - Heliantheae

Xanthium strumarium Linn.
(= Xanthium indicum Koen )

The Plant

The plant grows in rainy season as a very hardy and widely distributed annual herb and flowers during December to February. The stem is erect, branched and rough with short hairs; leaves numerous, 5 to 10 cm long, often 3-lobed; rough with appressed hairs on both sides. There are three main veins. The heads are homo or heterogamous. The fruit is about 1.5 cm long with two erect mucronate beaks; thickly clothed with hooked prickles. It is two celled, hard and rough containing two seeds, in separate chambers.

The Embryo

General

The mature embryo is about 11 mm long and 4 mm broad. It is straight and thick. The cotyledons are much longer than the
hypocotyl-radicle-axis. There is a prominent root-cap. The epicotyl has two large triangular and blunt leaf-primordia enclosing a more or less dome-shaped apex (Figs. 73, 74, 75).

Anatomy

Up to 30 microns from the radicle tip, no differentiation of cells is seen in the cross sections of the embryo (Fig. 77).

At about 230 microns from the tip it shows a well marked central core of compact small cells and a very wide cortex of the larger cells with intercellular spaces. This cortex is differentiated into two equally wide zones. The outer zone has large cells while the inner is again clearly differentiated into three by size of cells. The central core of small cells is surrounded by a distinct and circular pericycle and endodermis (Figs. 78; M.P. 13).

Proceeding about 230 microns upward the central mass increases in size and becomes slightly elliptical in cross section. Soon, it is roughly partitioned into two groups by a band of large cells across the pericycle in the vertical plane. It is in these groups that the procambial strands with granular contents are differentiated at about 460 microns from the radicle tip. Going upwards the endodermis becomes double layered at two points in the anticotyledonary plane. By about 480 microns from the tip some of the peripheral cells of these strands opposite the double layered sectors of endodermis appear like protophloem mother cells (Fig. 79; M.P. 14).
About 230 microns further up the protoxylem mother cells differentiate next to the pericycle at right angle to the protophlem mother cells usually in unequal numbers (Fig. 80). The protoxylem mother cells maintain their position through out the hypocotyl and cotyledons in relation to the pericycle.

By the middle region of the hypocotyl, each procambial strand extends sideways and divide into two, remaining connected by a narrow strip (Figs. 81, 82). The entire structure form a ring shaped procambium. Proceeding upwards this initially smooth and symmetrical radially ring becomes differentiated into 8 regions as follows:

1) Two dumbbell shaped regions on the cotyledonary plane

2) Two dumbbell shaped regions in the intercotyledonary plane

3) Four elliptical regions in between each adjacent dumbbell shaped regions (Figs. 83, 84, 85).

Just below the cotyledonary node the ring resolves out into eight independent strands i.e., four dumbbell shaped and four circular strands in original position (Fig. 86; M.P. 15). The dumbbell shaped strand branches twice in succession, outwards to form two laterals for each cotyledon and the residual portion remain goes to the epicotyl. Those of the intercotyledonary plane first bud out twice to form two sets of laterals for the adjacent cotyledons (Fig. 87). The four circular and smaller strands divide into two each. The daughter strands
towards the anticotyledonary plane go as the additional third laterals to the cotyledons, other ones go to the epicotyl. The two dumbbell shaped strands on the anticotyledonary and four small strands, two on either side of this plane, in all six strands go to the epicotyl (Fig. 88). Each of the dumbbell shaped strand on the anticotyledonary plane divides into two forming eight strands, ten in all. The adjacent daughter strands on the anticotyledonary plane fuse to form medians for the first pair of epicotyl resulting into six strands (Figs. 89, 90). The remaining four strands other than the newly formed fusion products divide into two each again forming ten strands (Fig. 91). The daughter strands flanking the median goes laterals to the leaves. The remaining two adjacent strands on the cotyledonary plant fuse to form two strands in all (Fig. 92). These two fusion products move inward to the first shoot apex. There, they divide twice to form eight strands adjacent daughter strands on the cotyledonary plane fuse to form six strands. These pass on in a ring to the shoot apex (Fig. 93). A ring for two embryonic leaves and two procambial strands for the shoot apex. These again divide and redivide further up to form six strands (Fig. 94).

Thus in the embryo the procambium of the epicotyl is in connection with that procambial system of the radicle-hypocotyledon axis (Figs. 74, 75).

The cotyledons have a median trace which is a double fused structure and three laterals on its either side. The median branches into the lamina to form a reticulate venation,
the ultimate veinlets fusing with the similar veinlets of the branching laterals, form areoles. At its termination the median forks, each arm joining the lateral on its side (Fig. 76).

The double layered sectors of endodermis divide into two each. Two such sectors go with the medians to the cotyledons to form schizogenous canals (Figs. 95, 96).

The cotyledonary node is multilacunar and venation is of the second type in which at middle region of the cotyledon there occur nine strands.

*Helianthus mollis* Lam.

**The Plant**

The plant is a cultivated annual herb and 2 to 3.5 ft high. The stem is erect and branched. It is more or less hairy. The leaves have a prominent petiole and are 3 to 4 inches long and 2 to 3 inches broad. They are alternate and hairy. Heads are large heterogamous and the rayflorets are neutral. The achenes are large and rough without pappus. They are black in colour, 3 to 5 mm long and 2 to 3 mm broad.

**The Embryo**

**General**

The embryo is stout and large, 3 to 4.5 mm long and 1.5 to 2 mm broad. The cotyledons are longer than hypocotyl-radicle-axis. They are oblong and straight (Figs. 97, 98).
The hypocotyl-radicle-axis is almost triangular with slightly acute apex and a prominent root cap. The plumule has two embryonic leaves enclosing a somewhat flattened shoot apex (Figs. 98, 100).

Anatomy

Up to 60 microns from the radicle tip no differentiation of the cells is seen in the cross sections of the embryo (Fig. 101). Gradually some intercellular spaces are formed. At about 125 microns from the radicle-tip single layered endodermis and pericycle formation is clearly seen enclosing a central core of smaller cells separate from the cortex (Figs. 102, 103).

Proceeding about 20 microns upward, the central core starts dividing into two groups by the formation of a band of larger cells (Fig. 103). Going about 15-20 microns upwards instead of endodermis, pericycle become double layered at two points while the central core remains almost circular. The two groups of granular cells opposite these sectors constitute the procambial strands (Fig. 104; M.P. 16). Further up more cells increase in each of the procambial strands.

By about 30 microns further up a few sieve tube mother cells in each strand can be seen (Fig. 105). They are surrounded from three sides by the procambium cells. At this level the central cells form a pith like structure of comparatively larger cells (Fig. 106; M.P. 17).
Going still further upward by about 75 microns two xylem mother cells are distinguishable near the pericycle in the cotyledonary plane at right angles to that of the procambial strands. These cells are prominently angular and thick walled (Figs. 106, 107; M.P. 18).

By about 30 microns above this level, the procambial strands extend sideways. The size of the cells of the embryo become larger and many intercellular spaces are formed in the cortical region (Fig. 107).

By about another 200 microns upwards one more xylem like cell is added to one pole. Gradually pericycle appear to be becoming three layered at four points. The central core now becomes elliptical. The extended procambial strands gradually divide into two each with a few elements of the protophloem mother cells. At this stage the central core become star-shaped (Fig. 108; M.P. 19).

Proceeding about 125 microns further up four procambial strands move sideways towards the cotyledonary plane and the bud out small strands towards the anticotyledonary plane. The adjacent such strands meet and fuse on this plane. All these remain connected with each other by the narrow procambial strips forming a lobed ring (Fig. 109). Near the cotyledonary node this ring disintegrates leaving two large dumbbell shaped strands on the cotyledonary plane and two another plane at right angles to it (Fig. 110). The lobes of the cotyledonary plane close in and completely go as medians to the cotyledons.
The others those on the intercotyledonary plane give out a branch which bifurcates to form the laterals for the cotyledons. These laterals may bifurcate to produce secondary branches (Figs. 111, 112). The residual portions of the strands on the anticotyledonary plane go to the epicotyl (Figs. 113, 114, 115).

The double layered sectors of the pericycle four in numbers gradually move out flanking the cotyledonary medians and disorganise with rudimentary schizogenous canals. The median is a double fused structure (Figs. 116, 117). It branches in the lamina, the veinlets further forming a network to form the reticulate venation of the cotyledon (Fig. 99).

The cotyledonary node is trilacunar. The procambial system of the epicotyl is in continuation with and is derived from that of the radicle-hypocotyl-axis.

The cotyledonary venation is of the third type as found in Caesulia.

**Tridax procumbens** Linn.

**The Plant**

It is a perennial herb, procumbent and branched from the base. The leaves are opposite, simple and notched. The heads are on very long peduncles and are heterogamous and rayed. Rayflorets are female one and discflorets are bisexual. The achenes are oblong about 3 mm long, more or less sericeovillous. The persistent calyx forms long, densely silky haired pappus.
The Embryo

General

The mature embryo is about 2 to 3 mm long and 0.52 mm broad. It is straight, long and pear shaped. The cotyledons are slightly longer than the hypocotyl-radicle-axis. The root cap is prominent (Figs. 118, 119, 120).

Anatomy

Up to 20 microns there is no differentiation in the cells in the cross sections of the embryo (Fig. 122). At about 70 microns from the tip the embryo shows a well marked central region of compact small cells separate from the cortex. Intercellular spaces in the cortex are present (Fig. 123). By about 130 microns the central core appears surrounded by distinct and circular pericycle and endodermis. The pericycle appears double layered at two points (Fig. 124; M.P. 20).

Proceeding about 270 microns upwards the central mass increases and becomes elliptical in cross section. It is partitioned roughly into two groups by a band of large cells across the pericycle in the vertical plane of the shorter diameter of the cross section (Fig. 125; M.P. 21). It is in these groups that procambial strands are differentiated at about 400 microns from the tip of the radicle. They are formed opposite the double layered sectors of pericycle. A few protophloem mother cells get differentiated in each strand.
By about 470 microns from the tip the first protoxylem mother cell is differentiated next to pericycle at right angle to the protophloem mother cells (Fig. 126). The protoxylem mother cells maintain their position throughout the hypocotyl and cotyledons.

By the middle region of the hypocotyl the procambial strands extend sideways and resolve into two. They become pear shaped and curved towards the protoxylem mother cells. The cells of these strands are comparatively smaller and have granular contents (Figs. 127, 128).

Further up each of the four procambial strands moves towards the nearest xylem mother cell-pole and gives out a small strand towards the anticotyledonary plane. Adjacent daughter strands fuse on this plane. All these strands remain embedded in a ring like procambium having six lobes two large lobes on each end of the cotyledonary plane and two on each side of this plane (Fig. 129). The lobes on the anticotyledonary place, come together and fuse, and the fusion product buds out a massive branch outwards. This departs and bifurcates to form the cotyledonary laterals. Those on the cotyledonary plane close in and form dumbbell shaped strands, the cotyledonary medians. The residual portion of the fusion mass on the anticotyledonary plane goes to the epicotyl (Figs. 130, 131, 132).

The median trace of the cotyledon is a double fused structure. It branches into the lamina to form a reticulate venation. The ultimate veinlets are fused with each other (Fig. 121).
In the median trace the, two procambial strands remain separately for a long distance (Fig. 133). Two schizogenous canals are formed by the double layered sectors of pericycle and at this level the two procambial strands are fused (Fig. 134).

The cotyledonary node is trilacunar. The procambial system of epicotyl is in continuation with and is derived from that of the hypocotyl-radicle-axis.

The venation of the cotyledon is of the fifth type as found in Cosmos.

*Zinnia linearis* Benth.

**The Plant**

The plant is an ornamental, grown in rainy season in the gardens. It is annual unarmed, herb with hollow stems. The leaves are opposite decussate 7 to 10 cm long surface of the entire plant is roughly hairy.

The achene is flattened, triangular, 6 to 8 mm long and 2.5 to 3.5 mm broad. It is rough and brown and without pappus.

**The Embryo**

**General**

The embryo is 7 mm long and 3 mm broad. The cotyledons are oblong but the hypocotyl-radicle-axis is acute and triangular. There is a prominent root cap. The epicotyl has two long, triangular primordia (Figs. 135, 136, 137).
Anatomy

Up to 100 microns from the radicle tip, no differentiation is seen in the cells of the cross sections of the embryo (Fig. 139). At about 300 microns from the tip the embryo shows a well marked central region of compact small cells enclosed in a endodermis and pericycle separate from the cortex (Fig. 140).

Proceeding 100 microns upward the central mass increases in size and is partitioned roughly into two groups by a band of large cells across the pericycle. Going upward, the endodermis becomes double layered at right angles, to that plane. Opposite these two procambial strands are organised near the pericycle. These are identified by smaller cells having granular contents (Fig. 141). There, few phloem sieve mother cells are also organised.

By about 430 microns away from the tip the protoxylem mother cells are distinguishable at the ends of the band of large cells (Fig. 142). The protoxylem mother cells maintain their position through out the hypocotyl and cotyledons in relation to the pericycle.

By the middle region of the hypocotyl the procambial strands extend sideways and divide into two each and the daughter strands move towards the protoxylem mother cells remaining connected by narrow bridge of procambium (Fig. 143). Simultaneously double layered endodermis sectors also divide and remain behind
the main lobes of the procambium at four corners of the squarish central region. As the axis widens upwards, large cells produce a pith like structure (Fig. 144).

By about 435 microns further up a few more protoxylem mother cells appear. After about 175 microns still further up each of the procambial strand lobes out a strand towards the anticotyledonary plane where the adjacent ones fuse. The entire structure form an angular ring (Fig. 145).

At the base of the cotyledonary node the lobed masses on the intercotyledonary plane give out two feeble branches in succession outwards which bifurcate to supply the two laterals of the cotyledons (Fig. 146). The residual parts of these lobes remain on the anticotyledonary plane (Figs. 147, 148).

As the cotyledons start separating the ring like structure is dissolved into two dumbbell shaped cotyledonary medians in the cotyledonary plane and two strands on the anticotyledonary plane. The later two strands go to the epicotyl (Figs. 149, 150). Gradually four laterals two on either side of the median strand in the cotyledon are formed (Figs. 151, 152).

The double layered sectors of endodermis remain on either side of the strands forming a cotyledonary median and organise into schizogenous canals (Figs. 153, 154).

The cotyledonary node is trilacunar. The procambial system of the epicotyl is in continuation with and is derived from that of the radicle-hypocotyl-axis (Fig. 137).
The median trace of the cotyledon is a double fused structure. It branches in the lamina to form reticulate venation. Ultimately veinlets are fused with the similar veinlets of the two laterals on either side which are branched to form areoles. At its termination on the median it forks and each arm joins the laterals on its side (Fig. 138).

The cotyledonary venation is of the third type as found in Caesulia and Helianthus.

Acanthospermum hispidum DC.

The Plant

The plant is a profusely hairy annual herb of wasteland growing in the rainy season. The leaves are obovate or spatulate. The capitula are lax and solitary produced in the forks of dichotomons branches. Only a few achenes are formed per head. They are triangular and prickled with two prominent spines on the back.

The Embryo

General

The embryo is about 5 mm long and 3 mm broad. The cotyledons are slightly oblong and the hypocotyl-radicle-axis is acute and triangular (Fig. 155). There is a prominent root cap. The epicotyl has two long triangular leaf primordia (Figs. 156, 157, 159).

Anatomy

Up to 90 microns from the radicle tip there is no differentiation in the cells as seen in the cross sections of the
embryo (Fig. 160). At about 150 microns from the tip the embryo shows a well marked central region of compact cells separate from the cortex of a few layers and enclosed in endodermis and pericycle. There are intercellular spaces in the cortex. The endodermis gradually becomes double layered at two points (Fig. 161). Proceeding upwards at about 30 microns central mass increases in size and becomes elliptical in cross section. Soon it is roughly partitioned into two groups by large cells across the pericycle in the vertical plane. It is in these groups that procambial strands are differentiated. Going upwards sieve tubes mother cells are seen near the pericycle, opposite the double endodermis sectors (Fig. 162).

Going up about 95 microns two protoxylem mother cells at each end near the pericycle on the shorter diameter are formed (Fig. 163). Protoxylem mother cells maintain their position throughout the hypocotyl and cotyledons in relation to pericycle.

By the middle region of the hypocotyl, the procambial strands extend sideways towards the protoxylem and tend to divide into two.

Further up still about 250 microns four clear procambial strands are formed at four corners. Simultaneously the double layered sectors of endodermis also divide and go behind each main strand. The pith like region is formed in the centre. These cells are comparatively larger than procambial cells (Figs. 164, 165).
After about 600 microns upward the procambial strands gradually extend more and a ring of the procambium is formed with four pairs of lobes, two at each end of the cotyledonary and anticotyledonary planes near the pericycle (Fig. 166). The cells of these strands are comparatively smaller and they have granular contents (Figs. 167, 168).

As we go up higher, about 350 microns the ring disintegrates. Two dumbbell shaped strands, in the cotyledonary plane go as cotyledonary medians and those of the intercotyledonary plane bud out a traces to bifurcate to form the adjacent cotyledonary laterals and remaining parts go to the epicotyl (Figs. 169,170,171,172). Thus in the embryo the procambium system of the epicotyl is in connection with and is derived from that of the radicle-hypocotyl-axis (Figs. 156,159).

The median trace of the cotyledon is a double fused structure. It branches into the lamina to form reticulate venation. Ultimately veinlets fuse with the similar veinlets of the branching laterals to form the areoles. At its termination the median forks and each arm joins the laterals on its side (Fig. 158).

In the median trace of the cotyledon two procambial strands remain separate for some distance. Double layered sectors of endodermis at the sides of them gradually form schizogenous canals. At this stage two procambial strands are completely fused (Figs. 173, 174).
The cotyledonary node is trilacunar and venation is of the third type as found in *Caesulia*, *Helianthus* and *Zinnia*.

**Tribe VI - Helenieae**

**Tagetes erecta L.**

**The Plant**

The plant is an ornamental annual herb commonly known as African marigold and is grown abundantly in the gardens. It grows about 3/4 meter high with erect stem and branches. The leaves are opposite decussate and pinnatisect.

The capitula are large solitary terminal on the axillary branches. They have a long tubular involucre and they may be homogamous tubular or ligulate or heterogamous. Mature seeds become black in colour and have a crown of scaly pappus.

**The Embryo**

**General**

The size of the embryo is 6 to 7 mm long and 1.5 to 2 mm broad. The cotyledons are longer than hypocotyl-radicle-axis. They are oblong. There is a prominent root cap. The apex of the hypocotyl radicle-axis is blunt (Figs. 175, 176, 177).

**Anatomy**

Up to 70 microns from the radicle tip there is no differentiation in the cells in the cross sections of the embryo (Fig. 179). The embryo has only few layers of the cortex.
enclosing a central solid mass of smaller cells.

At about 150 microns from the root tip single layered endodermis and pericycle formation is clearly seen (Fig. 180).

Proceeding about 400 microns upwards endodermis becomes double layered at two points on the anticotyledonary plane. The central mass increases in size and becomes elliptical in cross section. Soon it is roughly partitioned into two groups of smaller cells with granular contents by a band of larger cells. These groups differentiate as procambial strands (Fig. 181). Further up the cells increase in number in these groups which are situated just opposite the double layered sectors of the endodermis.

Going about 50 microns upward, in the widening axis the rudimentary sieve mother cells are recognisable on the periphery in each procambial strand. The cells around it are protophloem mother cells (Fig. 182).

About 25 microns further up, one cell on each end of the group of the large cells becomes prominently angular and thick walled and can be identified as protoxylem mother cells (Fig. 183). Towards the middle of the hypocotyl in the widening axis, the central parenchyma increases and forms a pith like structure. The procambial strands extend sideways and divide into two each.

By about 150 microns further up the daughter strands migrate towards the nearest xylem but remain connected by trace of small cells with granular contents (Fig. 184). Along with
the procambial strands the double layered sectors of endodermis also divides and go with the daughter strands (Fig. 185). All the four procambial groups are embedded in a ring.

As we go about 750 microns upwards the central region becomes elliptical (Fig. 186). Further up about 350 microns, the procambial strands bud out small strands towards the anticotyledonary plane forming a six lobed ring at the base of the cotyledonary node. These bud out traces which bifurcate to form cotyledonary laterals. As the cotyledons separate, the ring breaks to form two elongated dumbbell shaped strands in the cotyledonary plane as cotyledonary medians and two strands in the anticotyledonary plane for the epicotyl (Figs. 187, 188, 189, 190; W.P. 22).

The cotyledonary node is trilacunar. The procambial system of the epicotyl is in connection with and is derived from that of the radicle-hypocotyl-axis (Fig. 177).

The median trace of the cotyledon is a double fused structure. It branches in the lamina to form reticulate venation. Ultimate veinlets are fused with the similar veinlets of the two laterals on either side which are branched to form areoles. At its termination on the median it forks and each areol joins the laterals on its side (Fig. 178).

The double layered sectors of endodermis remain at two points even in the cotyledonary median and later on by gradually formation of schizogenous canals it disappears (Figs. 191, 192, 193).
The cortyledonary venation is of the first type as found in *Elephantopus*.

**Tribe VII - Anthemideae**

*Chrysanthemum indicum* Linn.

**The Plant**

It is an ornamental plant, 1-3 ft tall, cultivated for its bright yellow flowers. It is an annual herb, propagated by seeds. The leaves are alternate pinnatifid. Heads are heterogamous.

The achene is without pappus and rough. It is about 5.5 mm long and 3 to 3.5 mm broad. The testa and tegmen both are present.

**The Embryo**

**General**

The embryo is flattened and about 5.5 mm long and 3 mm broad. The cotyledons are very broad and the hypocotyl-radicle-axis is triangular, acute and as long as the cotyledons. There is a prominent root cap (Figs. 194, 195).

**Anatomy**

A cross section at 10 microns from the radicle tip shows no differentiation in the cells (Fig. 198). At about 100 microns from the tip the embryo shows a well marked central core of more compact small cells enclosed in a pericycle and endodermis. The cortex has got 5 to 6 layers (Fig. 199).
Proceeding about 200 microns upward, the central mass increases and becomes elliptical. It is partitioned roughly into two groups by a band of large cells. The endodermis becomes double layered opposite to these groups which are recognised as procambial strands near the pericycle in the central mass. These are identified by their granular contents (Fig. 200; M.P. 23).

About 20 microns further up 2 to 3 cells are distinguished as protophloem mother cells on the periphery in each procambial strand (Fig. 201). After about next 30 microns protoxylem mother cells are distinguished at right angles to the procambial strands (Fig. 202; M.P. 24). They maintain their position throughout the hypocotyl and cotyledons in relation to the pericycle.

Going about 40 microns the procambial strands extend sideways and divide into two each. The daughter strands move towards the nearest protoxylem mother cell poles to form two bilobed strands (Fig. 203). In the widened axis the large cells produce a pith like structure in the centre (Fig. 204; M.P. 25). As the cotyledonary node approaches, the newly formed strands bud out the branches on their either side towards the anticotyledonary plane. Adjacent branches meet on this plane forming a large lobe resulting into a ring like structure of the procambium (Fig. 205). Slightly above the bridge between the main lobes is last leaving four strands, two each at the cotyledonary and anticotyledonary planes (Fig. 206). Those of the cotyledonary planes are small and elliptical and form the cotyledonary medians. The ones on the anticotyledonary planes arelarged and bilobed (Fig. 207). The
later gives out a trace towards the outer sides. This bifurcates to produce a set of laterals for the cotyledons near the margins. Near the base of this trace the lobes give out another pair of branches to form another sides of laterals larger than the first and going between the median and the first laterals. The residual parts of these strands go to the epicotyl (Figs. 208, 209, 210, 211).

The median trace of the cotyledon is a double fused structure (Figs. 212, 213). It branches in the lamina. Ultimate branches fused with the inner laterals to form the areoles. The outer laterals continue submarginally (Fig. 197).

The procambial system of the epicotyl is in continuation with and is derived from that of the radicle-hypocotyl-axis (Fig. 196).

The cotyledonary node is trilacunar and venation is of the fifth type as found in *Cosmos* and *Tridax*.

**Tribe VIII - Senecioneae**

*Volutarella divaricata* Benth. & Hook.

(= *Amberboa ramosa* Roxb. Jafri)

**The Plant**

The plant often grows on waste ground especially where the soil is sandy. It flowers from November to April. It is a straggling stiff annual, dichotomously branched with scabberous branches 20 to 36 cm long. The leaves are; sessile pinnatifid and spinous.
Heads are homogamous 1.5 to 2.5 cm long, elliptic oblong with a long spinescent awned involucre. The corolla is purple. The achenes are about 1.25 cm long, acutely angled grooved and punctate. The pappus is of many unequal scaberulous silvery brown hairs.

The Embryo

General

The embryo is 6 to 8 mm long and 1.5 to 2 mm broad, and straight. The cotyledons are longer than the hypocotyl-radicle-axis. This axis is tapering and there is a prominent root cap (Figs. 214, 215). The plumule has two small embryonic leaves which enclose the dome-shaped apex (Fig. 216).

Anatomy

Up to 100 microns from the radicle tip there no differentiation in the cells is seen in the cross-sections (Fig. 218).

Proceeding about 90 microns upward the central core of smaller compact cells differentiated from the larger cortical cells. At this level endodermis and pericycle are also seen (Fig. 219).

About 70 microns further up the endodermis becomes double layered at two points on the larger axis of the central core which is considerably enlarged.

By about 250 microns from the root tip two groups of small cells with granular contents are organised as two procambial strands opposite the two double layered portions of the endodermis.
They are separated by a strip of the larger cells formed at right angle to the longer diameter (Fig. 220).

Going about 80 microns further up the procambial strands enlarged and a few sieve mother cells are also formed (Fig. 221).

By about another 50 microns up two xylem mother cells at right angle to the procambial strands are also distinguished. These cells are quite prominent than other cells (Fig. 222).

At higher level the procambial strands enlarge sideways and reaching almost up to the xylem mother cells forming a bilobed structure on the cotyledonary plane (Fig. 223). Each lobe of this structure buds out a branch towards the anticotyledonary plane. Two such adjacent branches meet on this plane forming another bilobed structure. The structures on the two planes remain connected by a procambial bridge forming a lobed ring like structure on the base of the cotyledonary node (Fig. 224).

On the node these bridges fade out leaving two dumbbell shaped structures in the cotyledonary medians on the cotyledonary plane. The bilobed structures on the anticotyledonary plane give out a massive branch that bifurcates to supply the cotyledonary laterals. The remaining small portions supply the epicotylar leaves (Figs. 225, 226, 227).

The procambial system of the epicotyl is in continuation with and is derived from that of the radicle-hypocotyl-axis (Fig. 216). The cotyledonary median is a double fused structure. The
embryonic leaves receive the strands from the strand of the plumule axis.

In the median elliptical strands of the cotyledons, xylem elements are not organised more. The endodermis remains double layered at two points of the strands (Fig. 229). Later on the strand become circular from the elliptical (Figs. 223, 230).

The cotyledonary node is trilacunar and venation is of the fifth type as found in *Cosmos*, *Tridax* and *Chrysanthemum*.

The median trace of the cotyledon branches in the lamina and form the reticulate venation as usual (Fig. 217).

**Tribe IX - Calandulace**

**Calendula officinalis** Linn.

**The Plant**

It is an ornamental plant with radical leaves. The heads are heterogamous with prominent disc and several series of rays. The leaves are alternate.

The achenes are hard, curved and rough. Inner ones are shorter and more curved and spindle shaped. They are about 1 cm long.

**The Embryo**

**General**

The embryo is quite large and curved to various degrees. It is about 9.0 mm long and 1.6 mm broad. The cotyledons are
thick and longer than hypocotyl-radicle-axis. The curvature is prominent at the junction. There is a prominent root cap (Figs. 231, 232). The plumule has two embryonic leaves enclosing somewhat dome-shaped apex (Fig. 233).

**Anatomy**

Up to 40 microns from the radicle tip, no differentiation is seen in the cross sections of the embryo (Fig. 235).

Proceeding about 80 microns upward a central core is distinguishable by enclosing endodermis and pericycle (Fig. 236).

Going about 100 microns further the endodermis becomes double layered at two points in large sector. Opposite these, a group of smaller cells with granular contents is distinguishable separated by a broad band of larger cells across the pericycle. These are the procambial strands organised on the anticotyledonary plane (Fig. 237). These groups enlarge sideways and a few cells next to the pericycle appear larger than others. They are distinguished as sieve mother cells (Fig. 238).

By another 110 microns upward two xylem mother cells at right angle to the procambial strands are distinguished, next to pericycle in the cotyledonary plane and divide into two each (Fig. 239).

Further above the procambial strands gradually start dividing into two. Each of these daughter strands bud out small branches towards the cotyledonary plane which reach up to the protoxylem mother cells (Fig. 240). This results the formation
of a ring of procambium which is almost circular outside and having four bilobed buldgings on the inner sides enclosing a cross shaped plate of pith like tissue (Fig. 241). As the axis widens upward the ring becomes elliptical in the anticotyledonary plane (Fig. 242).

Just below the cotyledonary node the buldgings on anticotyledonary plane give out a massive branch which bifurcates to supply the cotyledonary laterals. The bilobed portions on the cotyledonary planes start migrating outwards (Figs. 243, 244). On the node as the cotyledons separate and the forked branch for the laterals departs away, the ring breaks. The lobes on the cotyledonary plane go as medians and the residual portions of the lobes on the anticotyledonary plane slowly pass into the epicotyl. In the cotyledons the laterals divide to form secondary laterals (Figs. 245, 246).

The median trace of the cotyledon is a double fused structure. This branches in the lamina and forms the reticulate venation with opposite poles of xylem mother cells separated by two large strands of procambium (Fig. 246). The veinlets are fused with the laterals to form the laterals to form the areoles. At the termination of the median vein it forks and each arm joins the laterals on its side (Fig. 234).

In the median strand double layered sectors of the endodermis remain on two sides (Fig. 247) but later on these double layered sectors are disorganised (Fig. 248).
The procambial system of the epicotyl is in continuation with and is derived from that of radicle-hypocotyl-axis (Fig. 233).

The cotyledonary node is trilacunar and venation is of the fifth type as found in *Cosmos*, *Tridax*, *Chrysanthemum* and *Volutarella*.

**Tribe X - Cynareae**

*Echinops echinatus* Roxb.

**The Plant**

The plant is a wild herb of arid lands. It is much branched rigid perrenial, 0.5 to 1.0 meter high. Branches are widely spreading from the base and white with cottony pubescence. The leaves are sessile 6 to 13 cm long and minutely scaberulous. They are oblong and deeply pinnatifid. The lobes are triangular oblong sinuate and spinescent. The spines are often 1.5 to 2.5 cm long.

The heads are spherical, compound, white, lax and 2.5 to 6.5 cm in diameter. The involucral bracts are free, seriate and spinous. Each bract is very large and sharp. The individual head of the compound head has only one tubular flower.

The achene is 1.5 to 2.3 cm long. A short cylindric brush like pappus is present. It is obconic.
The Embryo

General

The embryo is quite large. Its size is 0.8 to 1.5 cm long and 0.35 to 0.5 cm broad. It is obconic. The cotyledons are conical at the tip and broader at the base. The embryo is straight and very stout. The hypocotyl-radicle-axis is almost triangular. Its apex is slightly acute. There is a prominent root cap (Figs. 249, 250). The plumule has two small embryonic leaves enclosing somewhat conical shoot apex (Fig. 251).

Anatomy

Up to 50 microns from the radicle tip there is no differentiation in the cells as seen in the cross sections of the embryo (Fig. 253). At about 110 microns from the radicle tip a central core of small compact cells get differentiated from the cortex, enclosed in an endodermis and pericycle (Fig. 254).

At about 270 microns from the radicle tip the pericycle gradually becomes double layered at two points. Opposite these two procambial strands are organised as groups of smaller cells with granular contents, separated by a strip of the larger cells formed at right angle to the cotyledonary plane (Fig. 255; M.P. 26).

Proceeding about 70 microns upward the two procambial strands become more prominent and 2-4 protophloem mother cells are seen in each. They are surrounded from three sides by the cells of the procambium. At this level the pericycle becomes
three layered towards the procambial strands and pith like cells are also formed. They are comparatively larger without intercellular spaces (Fig. 256).

By about 40 microns up the protoxylem mother cells are organised in the cotyledonary plane (Fig. 257; M.P. 27). Further up, the two procambial strands gradually extend sideways and meet on the cotyledonary plane (Fig. 258; M.P. 28).

Going about 480 microns further up the procambial strands become prominently lobed at their ends. As a result of this a ring of procambium is formed. It has four bilobed portions, two either ends of on the cotyledonary and anticotyledonary plane. The ring is squarish in outline towards the cortex and lobed towards the medulla. The protoxylem mother cells lie at the constriction of the double lobes on the cotyledonary plane (Fig. 259). Additional lobes with xylem mother cells are differentiated between the four lobes in the ring which becomes roughly circular and eight lobed. The new lobes become double resulting into 16 lobes in all prominently seen towards the inner side of the ring (Figs. 260, 261; M.P. 29, 30).

As the cotyledonary node approaches by about 70 to 90 microns upwards the ring is stretched and the lobes between, the one on the cotyledonary and anticotyledonary planes are last in smooth bridge of procambium but faint identity of two strands in each is seen (Fig. 262; M.P. 31). At the base of the node the lobed masses on the intercotyledonary plane form traces
outwards thrice in succession which bifurcate to form three sets of laterals for the cotyledons (Figs. 263, 264). On the node after departure of laterals, two horse-shoe shaped masses of procambium are left on the cotyledonary plane (Fig. 265). The middle portion of each of these forms the cotyledonary median while the lateral portions separate and close in towards the centre forming a faint ring of procambium for the epicotyl (Fig. 266). This further resolves in 6 strands 3 of which go to each of the leaf primordia (Figs. 267, 268).

In the fused median strands of the cotyledons more xylem elements are formed. The pericycle remains triple layered at two points of the strand (Fig. 270). By gradual formation of the schizogenous canals in the pericycle the three layers disappear (Fig. 271).

The median trace of the cotyledon is a double fused structure which branches in the lamina. Its veinlets join with the branches of the laterals to form closed venation pattern (Fig. 252).

The procambial system of the epicotyl is in continuation with and is derived from that radicle-hypocotyl-axis (Fig. 251).

The cotyledonary node is trilacunar and venation is of the second type as found in Xanthium.
II Series - Liguliflorae

Tribe XI - Cichorieae

Launaea asplenifolia Hook.
(= Prenanthes asplenifolia Roxb.)

The Plant

The plant is a wild small herb with radicle and lyrate leaves with long flowering stem and contains yellow latex. The heads are homogamous and ligulate. The fruits are large with prominent pappus capable of floating in air through long distances.

The Embryo

General

The embryo is small. Its size is 3.8 mm long and 0.5 to 0.8 mm broad. The cotyledons are slightly longer than the hypocotyl-radicle-axis. They are straight and almost equally broad through out except the tip. The hypocotyl-radicle-axis is blunt at the apex (Fig. 272). The plumule has two embryonic leaf primordia which enclose the dome shaped shoot apex. There is a prominent root cap (Figs. 273, 274).

Anatomy

Up to 80 microns from the radicle tip there is no differentiation in the cells as seen in a cross section of the embryo (Fig. 276).

About 100 microns away from the tip a small central core of comparatively smaller cells is seen enclosed in a single layered endodermis and pericycle (Fig. 277).
Proceeding about 70 microns upward, the central core further differentiates into two groups of smaller cells near the pericycle on the anticotyledonary plane separated by a prominent band of larger cells across the pericycle. Sectors of endodermis become double layered opposite these groups (Fig. 278).

By about 290 microns further up a few cells with granular contents appear in each group constituting the procambial strands. Two rudimentary sieve elements are recognised on the periphery of these strands (Fig. 279; M.P. 32). Higher up in the axis as these group enlarge sideways, two xylem mother cells are established next to the pericycle in the cotyledonary plane (Fig. 280).

The procambial strands extend sideways and divide into two. Each portion gradually moves towards the protoxylem mother cells. Simultaneously the double layered sectors of endodermis also divide and move along with the daughter procambial strands (Fig. 281).

Gradually each procambial strand buds out a small strand towards the intercotyledonary plane. The adjacent strands fuse and go in the anticotyledonary plane (Figs. 282, 283).

The remaining portions from either sides of the cotyledonary plane come together and along with the xylem mother cell elements form the cotyledonary median. The strands on the anticotyledonary plane bud out massive traces which fork to supply
the cotyledonary laterals. The remaining portions go to the epicotyl (Figs. 284,285,286).

The median trace is a double fused structure, as it enters the cotyledons, the two strands fused together. Later on the median branches in the lamina. Its veinlets joining with branches of the laterals, form a closed venation pattern. Ultimately it forks distally, Its two arms join the ends of the laterals (Figs. 275,287).

The procambial system of the epicotyl is in continuation with and is derived from that of the radicle-hypocotyl-axis (Fig. 274).

The cotyledonary node is trilacunar and venation is of the first type as found in Elephantopus and Tagetes.