The genus *Passiflora* is well known for its climbing habit by means of tendrils. The leaves are alternate, usually lobed and have gland bearing petioles. Stipules are present, often foliaceous, sometimes extended into filamentous gland-tipped threads at the margins. The plants climb by means of lateral, simple, spiral and elastic tendrils. The flowers which are often large and showy, are axillary and may be solitary in pairs or racemose, seated on a short pedicel which is joined to a 3-bracteate peduncle (Bor and Raizada, 1954).

There are about 400 species, most common in America, though a few species are also common in Asia and Australia. Many of them are cultivated as curiosity and some for their beautiful flowers and for festooning foliage (Bailey, 1929). According to Bor and Raizada (1954), *P. caerulea, P. racemosa, P. minima, P. quadrangularis* and *P. suberosa* are commonly cultivated in India.

A tendril, one or two flowers and an accessory vegetative bud are present in the axil of the leaf. The tendril appears to be closely associated with 1 or 2 flowers. Each of the flowers arises on either side of the tendril. The flower is borne on a long unbranched peduncle.
The peduncle bears 3 bracts below the calyx, out of which one is supposed to have been raised on the flower stalk and it forms an involucre with the other two bracts (Rendle, 1952). Therefore, the tendril is considered to correspond with the central flower of the dichasium or the first flower of the monochasium (Lawrence, 1960; Rendle, 1952). The bracts are always sessile and spirally arranged just below the receptacle (Puri, 1947).

The tendril in *Passiflora* has been a morphological problem of great interest. Mohl (1827) considered it as a modified flower peduncle. Wydler (1852) considered it as a branch which bears a bract at its base. In the axil of this bract, a flower is borne. Tendril is also thought to be a flowerless branch of a dichotomised bud (Masters, 1879) or a lateral shoot from the flower peduncle (Darwin, 1875). Hagerup (1930) reported that in *P. foetida* the main bud gives rise to a prophyll in the axil of which another bud is initiated which develops into a floral bud. Thus, according to Hagerup (1930) the tendril in *P. foetida* is a branch which bears a prophyll at its base. Gangstad (1938) described the forking of an axillary meristematic protuberance in *P. caerulea* in which one division forms the tendril and the other a flower bud.

Worgitzky (1887), MacDougal (1892, 1896), Brush (1912)
and Lisk (1954) have worked and discussed the anatomy of tendrils of some members of Passifloraceae. The present investigation has been undertaken to understand the anatomy of the young and old tendrils.

The present chapter describes some aspects of tendril anatomy and ontogeny and vascularization of tendril and other associated organs in 18 species of *Passiflora* as mentioned in chapter II.

**OBSERVATIONS**

(A) **ONTGENETIC AND DEVELOPMENTAL STUDIES**

*Passiflora foetida* Linn.

*P. foetida* is a herbaceous climber with simple axillary tendrils (Fig. 1). The leaves are simple, stipulate and alternate. The free lateral stipules are semi-circular about the stem and deeply cleft into filiform, gland-tipped segments. At the axil of each leaf there are an unbranched tendril, one or two laterally situated flower buds and one accessory vegetative bud.

**SHOOT APEX**: The vegetative shoot apex is flat or sometimes slightly elevated above the first or second node. In terms of tunica-corpus theory one layer of tunica and an inner mass of corpus are distinguished. The second layer simulates tunica but periclinal divisions occur in
the cells (Fig. 2). The outer tangential walls of T₁ cells sometimes appear wavy (Fig. 3). During the initiation of leaf periclinal divisions occur in cells of the second layer (Figs. 2, 4). The tunica cells are generally elongated. The T₁ cells are markedly vacuolated though at the site of leaf initiation they appear densely stained. The light stained central meristem is present but its position is varying, depending upon the plastochronic phase of the shoot apex. Sometimes it is hardly distinguishable at the minimal stage. The stratification is also a varying feature of the peripheral meristem (PN, Fig. 4). At the site of leaf initiation stratification is absent. But in the peripheral meristem where no leaf initiation occurs, stratification is observed. The rib meristem is not distinct but the lowermost corpus cells differentiate into young pith cells which are arranged in longitudinal rows at the lower nodes.

The plastochronic changes of the shoot apex are well marked. They are indicated by variations in size and shape of the shoot apex. As stated above the stratification in the peripheral meristem, the discreteness of the central meristem and its centric and acentric position in the shoot apex are some of the histological features of the plastochronic changes. Sometimes the plastochronic period is very short and shoot apex shows quick succession
PLATE XXX

Figs. 1 - 4
**Passiflora foetida** L.

**Fig. 1.** A twig of *P. foetida*, X 1.

**Fig. 2.** L.s. shoot apex showing cytohistological zonation, X 1250.

**Fig. 3.** L.s. shoot apex showing leaf initiation, X 1250.

**Fig. 4.** L.s. shoot apex showing periclinal divisions in T₂, X 1250. inset, X 124.

AC = accessory bud; CM = central meristem; FL = flower; L = leaf; L₁ = first leaf; PC = procambium; PM = peripheral meristem; SA = shoot apex; ST = stipule; T = tendril.
The leaf initiation is indicated by periclinal divisions either in the second layer and/or the layer subjacent to it (Fig. 5). Usually first periclinal divisions are observed in $T_2$ layer at the site of leaf initiation (Fig. 4). The leaf trace procambium at the incipient stage of differentiation is sometimes discrete (Fig. 4).

INCEPTION AND VASCULAR SUPPLY OF STIPULES: The number of main veins arising directly as branches of the lateral leaf trace and traversing the stipule is five to six (Fig. 6). In the older stipules, vascular strands arising from these veins are present in the lobes. In $P. edulis$ the number is from 1-3, and in $P. minima$, 3.

The node is trilacunar. The lateral leaf traces while girdling the node give out branches to the stipule before meeting the median leaf trace (Fig. 6). At the base of the leaf, a number of vascular strands arising from the three traces, constitutes the petiolar vascular supply (Fig. 6). The stipular scar is cauline. The broad based stipule arises at the node, near the base of the leaf, where the lateral leaf trace girdles.

Majumdar (1955, 1956), Mitra and Majumdar (1952) and Mitra (1960) have concluded that stipules are without
Passiflora foetida L.

Fig. 5. L.s. shoot apex, X 1250.

Fig. 6. A cleared node showing vascular supply of the leaf and its stipules (only one stipule is shown in the figure), X 36.

Figs. 7 - 9. T.s. shoot apex at second node, X 540.

Fig. 10. T.s. a portion of the leaf (L) and stipule showing procambium cells associated with the developing stipule, X 1250; inset X 1250.

Figs. 11 and 12. T.s. 4th node, showing leaf, stipules and axillary bud, X 310.


A = axis; AX₂-axillary bud at 2nd node;
AX₄ = axillary bud at 4th node; B = lateral trace of the leaf; BM = bud meristem complex;
C = lateral trace of the leaf; CN = central meristem; D = stipule; E = petiole; L = leaf;
L₂ = leaf at 2nd node; L₄ = leaf at 4th node;
LB = leaf buttress; M = median leaf trace;
PA = arcuate zone; PC = procambium; ST = stipule;
ST₂ = stipules of 2nd leaf; ST₄ = stipules of 4th leaf; X and Y = meristematic regions at the margins.
The cells of T1 and second layer divide anticlinally. The bud meristem at this stage is not completely delimited from the adjacent cells of the leaf. Probably some of the cells at the base of the leaf also participate in growth and development of the bud (Fig. 16).

In the further development of the bud a significant histogenetic development occurs. The cells of the bud meristem adaxial to the axis appear to be stratified and form a distinct zone (F1 in Fig. 18). A similar development occurs on the opposite side. Figures 19 and 20 illustrate this development in transections. Thus a bud complex is formed consisting of two laterally placed accessory bud primordia (F1 and F2) and a centrally situated meristem (T). The F1 and F2 bud primordia finally develop into two flowers and the centrally situated region of the bud meristem complex (T) develops into a tendril primordium (Fig. 21). Sometimes instead of two flower buds, only one flower bud develops. In this case the bud complex differentiates into a tendril meristem and a floral meristem.

With this morphogenetic development the initiation of another accessory bud (AC) occurs (Figs. 23, 24). This bud meristem appears at an angle formed by the tendril with the axis. Some of the cells (V) of the tendril primordium, adaxial to the axis appear light stained and
**Passiflora foetida** L.

**Figs. 16 - 18.** L.s. further developmental stages of bud meristem complex, X 1250; inset diagrams of Figs. 16 and 18, X 124.

**Fig. 19.** T.s. of bud complex $F_1$, $F_2$ and $T$, at 4th node, X 1250.

**Fig. 20.** T.s. more developed bud complex of $F_1$, $F_2$ and $T$ at lower node, X 1250.

**Fig. 21.** L.s. bud complex of $F_1$ and $T$, X 1250.

BM = bud meristem complex; $F_1$ - the first bud meristem for flower; $F_2$ - the second bud meristem for flower; $L_2$ - leaf at second node; PA = arcuate zone; PC = procambium; $T$ - tendril bud.
PLATE XXXIII

Figs. 22 - 25
Passiflora foetida L.

Fig. 22. A bud complex of \( F_1 \) and \( T \) in t.s., X 1250.

Figs. 23 and 24. T and accessory bud meristem in l.s., X 1250.

Fig. 25. L.s. tendril and flower bud with its first bract and acropetally developing procambium (PC), X 1250.

AC = accessory bud; BR = bract; \( F_1 \) = flower bud; L = leaf; PC = procambium; T = tendril primordium.
PLATE XXXIV
Figs. 26 - 33
Passiflora foetida L.

Figs. 26 and 27. Accessory bud meristem and its vascular relationship with tendril and axis. Fig. 26, X 710; Fig. 27, X 1250.

Figs. 28 and 29. L.s. tendril primordium and accessory bud, Fig. 28, X 1250; Fig. 29, X 710.

Fig. 30. L.s. tendril tip showing vacuolated cells extending into the projections, X 1250.

Figs. 31 - 33. Tendril tips with four projections arching over the central cavity, X 72.

AB - abaxial side; AC - accessory bud;
AD - adaxial side; M - meristematic region;
PC - procambium; TA - tendril tip.
Passiflora foetida L.

Figs. 34 - 35. L.s. tendril tip, X 1250; Fig. 35 inset, X 124.

Fig. 36. L.s. accessory bud with its prophyll (PR), X 1250; inset, X 124.

Fig. 37. Leaf initiation in the accessory bud, X 1250; inset, X 124.

Figs. 38 - 40. Vascular relationship of bud complex, leaf and axis, X 310.

Fig. 41. An overarching bud complex trace (TT) near median leaf trace (LT), X 310.

A - axis; AC - accessory bud; F1 & F2 - floral meristems; FL - flower; L - leaf; LB - leaf buttress; LT - leaf trace; PC - procambium; PR - prophyll; SA - shoot apex; T - tendril; TT - trace for the bud complex; V - vacuolation.
PLATE XXXVI

Figs. 42 - 51
Passiflora foetida, L.

Figs. 42 - 43. T.s. showing vascular relationship of the bud complex, leaf and axis. Fig. 42, X 1250; inset, X 125; Fig. 43, X 310.

Figs. 44 - 46. Vascular relationship of flower, tendril and axis, X 310.

Figs. 47 - 51. Vascular relationship of flower, tendril, accessory bud and axis, X 310.

A - axis; AC - accessory bud; FL - flower; FT - trace for the flower; L - leaf; LT - leaf trace; T - tendril; TT - trace of the bud complex.
be slightly peculiar. It lies in the axil of the subtending leaf, though a part of the bud meristem is disposed towards the base of the leaf. Its positional relationship vis-a-vis the leaf indicates that its origin is partly from the foliar tissue and partly from the apical meristem. The bud meristem is separated from the apical meristem by an arcuate zone of elongated lightly stained cells (PA, Fig. 54). The bud protrudes out in the axil due to increased meristematic activity in its cells (Fig. 55). The axillant leaf trace procambium appears very close to the bud (Fig. 55). The bud trace procambium develops acropetally, i.e. a sector of the ground meristem cells lying between the leaf trace and the bud differentiates into procambium and becomes an early vascular link between the bud and the stem.

The further development of the bud complex is illustrated in figures 56 and 57. The bud complex organizes into two distinct bud meristems, one (F₁) which may develop into a flower and the other (T) which develops into tendril. Initially the F₁ bud appears light stained but later appears eumeristematic in its further development. The F₁ bud immediately gives rise to a bract. At this stage the procambialization of the bud complex is distinct (Fig. 56). The tendril bud appears convex with a stratification of 2-3 layers. At this stage no marked
histological features are evident, suggestive of different morphogenetic destinies of the two buds. The accessory bud meristem is present at an angle between the tendril and the axis (Fig. 57). Its origin is from the cauline meristematic tissue. It develops as a vegetative branch.

Figures 59 and 60 illustrate further development of the bud complex. The three bud primordia T, F1 and F2 are developed. The accessory bud meristem shifts to cauline position. Figure 66 is a transverse view of the bud complex. From its histogenic development it appears that F1 and F2 arise as the accessory buds from the main bud. But as the development of these buds is rapid the three buds T, F1 and F2 appear to form a common bud complex. The general development of the tendril is similar to that of P. foetida (Fig. 61).

VASCULAR RELATIONSHIP: Figures 62 to 65 illustrate the vascular relationship of the flower buds, tendril and axis. The positional relationship of the three buds (T, F1 and F2) and the accessory bud (AC) is illustrated in figure 62. The vascular meristem of the tendril is in the form of a continuous meristem. The vascular meristem of F1 bud is more developed than that of the F2 bud as the former develops earlier. The vascular systems of the tendril and F2 bud unite first. As the two circular vascular
systems come nearer at the lower level of the node, they appear horse-shoe shaped and finally the two vascular systems become continuous (Fig. 63).

At the lower level of the node the vascular system of the $F_1$ bud is continuous with the vascular system of $F_2$ bud and the tendril. The general histological process is similar as described above. The vascular relationship between $F_1$ and $F_2$ buds confirms their morphogenetic relationship.

*Passiflora minima* Blanco.

*P. minima* is a climber with simple, entire, alternate and stipulate leaves (Fig. 67). The stipules are linear and free lateral. A tendril (T), two small flowers (FL) and an accessory vegetative bud (AC) are present in the axil of the leaf.

**SHOOT APEX:** Figures 68-70 illustrate the structure of the shoot apex at its various plastochronic stages. At the minimal phase it appears slightly elevated. There is a single layer of tunica enclosing a mass of corpus. The tunica cells appear somewhat flattened parallel to the surface while some of the subjacent cells appear elongated perpendicular to the surface. The shoot apex at this stage appears slightly inclined and hence its tip portion is obliquely oriented (Fig. 68). The cytohistological
Passiflora racemosa Brot.

Fig. 57. L.s. bud complex of F1 and T with accessory bud (AC), X 1250; inset, X 310.

Fig. 58. L.s. bud complex of F1 and T showing 1st bract initiation, X 1250.

Fig. 59. Flower and tendril primordia in L.s., X 1250; inset, X 124.

Fig. 60. L.s. bud complex showing F2 and T with accessory bud (note acropetally developing procambium = PC), X 1250.

A = axis; AC = accessory bud; BR = bract; F1 = flower bud; L = leaf; PC = procambium; T = tendril; V = vacuolation.
PLATE XXXIX

Figs. 61 - 65
Passiflora racemosa Brot.

Fig. 61. A well developed tendril with an accessory bud, X 710.

Figs. 62 - 65. T.s. vascular relationship of the tendril, flower buds, an accessory bud and axis, X 310.

A = axis; AC = accessory bud; F1 and F2 = vascular supply of the flower; PC = procambium; T = tendril; TA = tendril tip.
Passiflora racemosa Brot.

Fig. 66. T.s. bud complex of F₁, F₂ and T in transection, X 1250.

Passiflora quadrangularis L.

Fig. 66A. Twig showing tendril, leaf, flower and accessory bud, X 1.

Passiflora edulis Sims.

Fig. 66B. Twig showing tendril, leaf, flower and accessory bud (FL = flower stalk), X 1.

A - axis; AC - accessory bud; F₁ & F₂ - floral bud meristems; FL = flower; L = leaf; ST = stipule; T = tendril; V = vacuolation.
zonalization is not distinct but a small sector of cells, which is eccentrically situated, appears comparatively lightly stained. The rib meristem lies below the first visible node.

At the minimal stage the shoot apex is a tiny mound of eumeristematic tissue, with no evident cytohistological zonation. The peripheral meristem and rib meristem are distinct. This histogenic development of shoot apex is due to the differentiation of the bud meristem at the second plastochron (Fig. 70).

For the inception of the axillary bud a critical height of the subtending leaf is essential as in *Micellia fuscata* (Tucker, 1963). Figure 69 illustrates the earliest observed inception of the bud meristem. Towards the adaxial side of the leaf a sector of the peripheral meristem of the shoot apex appears densely stained. Some of the adjacent peripheral cells appear periclinally divided. Figure 70 shows a further stage in the development of the bud. It appears as a detached meristem in the axil of the second leaf, though the part of the bud meristem is still lateral in position. The shoot apex is histologically separated from the bud by a narrow zone of columnar cells 1-4 layers deep. These cells are vacuolated and comparatively light stained (arrow in Fig. 70).
ONTOGENY OF TENDRIL: The main bud hereafter also referred as bud complex, differentiates into a tendril and two flower buds. The flower buds arise on either side of the tendril. An additional accessory bud develops between the axis and the tendril (Fig. 80). It differentiates as a vegetative branch. Figure 71 illustrates the early development of the bud complex. It is axillary in position and from its adaxial side an arcuate band of cells (PA) extending up to the base of the bud is distinguished. The bud meristem at this stage is not procambialized. Between the bud and the procambium of the axis the light stained ground meristem is observed.

Figure 73 illustrates the further development of the bud complex. In a transection it appears flattened and extended on two lateral sides towards the axis. It has been difficult to determine whether $F_1$ and $F_2$ bud primordia arise before the initiation of their first bract. Available observations indicate that the $F_1$ and $F_2$ bud primordia arise simultaneously. It could not be concluded that $F_1$ and $F_2$ primordia are axillary to the first bract primordia (Fig. 72).

The histological relationship of the tendril, $F_1$ and $F_2$ resembles to that of $F_3$ racemosa (Fig. 66). The $F_1$ and $F_2$ bud primordia are densely staining and delimited from the tendril axis by an arcuate band of cells.
Passiflora minima Blanco.

Fig. 67. Twig of _P. minima_, X 1.

Figs. 68 and 69. L.s. shoot apex, X 1250.

Fig. 70. L.s. shoot apex with bud meristem complex (BM) at second node, X 1250.

Fig. 71. Bud meristem complex with arcuate zone (PA) at second node in l.s., X 1250.

Fig. 72. Bud complex at lower node in t.s., X 1250.

A - axis; AC - accessory bud; BM - bud meristem complex; CM - central meristem; 
F₁ & F₂ - flower bud meristems in bud complex; FL - flower; L - leaf; L₁ - leaf at the first node; L₂ - leaf at the second node; PA - arcuate zone; PC - procambium; PM - peripheral meristem; 
SA - shoot apex; ST - stipule; T - tendril.
PLATE XLII

Figs. 73-77A
Passiflora minima Blanco.

Fig. 73. Bud complex with flower (F₁ and F₂) and tendril (T) bud meristems, t.s., X 1250.

Fig. 75. Developing tendril and accessory bud, X 710; inset, X 124.

Fig. 75. L.s. tendril tip, x 710; inset, X 124.

Figs. 76A and 76B. Accessory bud with three leaf primordia and a prophyll. Fig. 76 A, X 12b; Fig. 76B, X 1250.

Fig. 77A. Bud complex showing two procambial strands of the bud trace (BT), X 710.

A = axis; AC = accessory bud; BM = bud complex; BT = bud trace; F₁ and F₂ = floral meristems; L = leaf; L₁, L₂, and L₃ = leaves at 1st, 2nd and 3rd nodes respectively; LT = leaf trace; M = meristematic region; PC = procambium; PR = prophyll; SA = shoot apex; ST = stipule; T = tendril.
The accessory bud develops between the axis and the bud complex. It originates from the cauline tissue. The accessory bud produces a single prophyll. Figure 76 illustrates a well developed stage of the accessory bud with three leaf primordia ($L_1$, $L_2$ and $L_3$) and a prophyll (PR). The shoot apex is similar in structure and organization to the main shoot apex.

The development of the tendril is more rapid as compared with that of flower buds and the accessory bud. Its general development is similar to that of *P. foetida*. Figures 74 and 75 illustrate the important histological features of the tendril development.

**VASCULAR RELATIONSHIP:** The bud complex shows in its early stage of development two procambial strands (BT; Figs. 77A, 77B). Figures 78-81 show in transections the vascular relationship between the accessory bud (AC), the tendril (T) and two flowers (FL) at an advanced stage of development. The accessory bud has developed into a small vegetative branch. It bears one prophyll (PR) and prophyll bud (PB). The two flowers are confronting the stipules of the subtending leaf. A ring of about eleven primary vascular bundles connected with residual meristem is present in the tendril. The residual meristem is partly differentiated into interfascicular parenchyma (Fig. 78). The axis of the vegetative branch (AC) shows
about nine primary vascular bundles. There are three procambial strands for the prophyll trace (PT) and two for the prophyll bud trace (PBT, Fig. 79).

At the lower level of the node two floral axes, tendril and the vegetative branch show a complex of trilobed structure. It shows four vascular systems. The vascular system of the vegetative branch appears horseshoe shaped and is associated with that of the axis (Fig. 80). At this level of the node, the vascular system of the flower becomes narrow and its adjacent vascular bundles appear united (Fig. 80). Finally this vascular system resolves into two vascular strands (Fig. 82). At lower level of the node, the two strands of each flower get associated together and form a strand complex which becomes a part of the vascular system of the tendril. Figure 81 illustrates the general configuration of vascular relationship of the tendril (T), flowers (F₁ and F₂), vegetative branch (AC) and the axis.

ONTOGENY OF TENDRIL IN SOME MORE SPECIES OF PASSIFLORA

The following species of Passiflora are also investigated:

Passiflora alato-caerulea Lindl.

P. antioquiensis Karst.
PLATE XLIII

FIGS. 77B - 82
Passiflora minima Blanco.

Fig. 77B. Bud complex showing two procambial strands of the bud trace (BT), X 310.

Fig. 78 - 82. Vascular relationship of accessory bud (AC) tendril (T) and two flowers (FL) and axis (A) at an advanced stage of development, X 152.

A - axis; AC = vascular supply of accessory bud; BM = bud complex; BT = bud trace; FL = vascular supply of flower; L = leaf; L₃ = leaf at 3rd node; PBT = prophyll bud trace; PR = prophyll; PT = prophyll trace; ST = stipule; T = vascular supply of tendril.
P. caerulea Linn.
P. capsularis Linn.
P. coccinea Aubl.
P. coriacea Juss.
P. adulis Sims.
P. mixta Linn.
P. pruinosa Mast.
P. quadrangularis Linn.
P. suberosa Linn.
P. trifasciata Lom.
P. umbilicata (Griseb) Harms.
P. vespertilio Linn.
P. watsoniana Mast.

Having studied in some details the ontogeny and development of the tendrils and other associated organs in *P. foetida*, *P. racemosa* and *P. minima*, I prefer to give a comparative account of these aspects of studies in the above mentioned species. It has not been possible to investigate the structure of the shoot apex and the detailed ontogeny of the tendril, flower and accessory bud in all the species. My main aim has been to bring out the salient developmental features of the main axillary bud which ultimately differentiates into a tendril and one or two flowers (Figs. 83-85).
SHOOT APEX: In the investigated species of *Passiflora* the shoot apex is generally dome shaped but its height and width vary during the plastochron. Figures 86-90 illustrate the plastochronic variations in the shoot apices of some species of *Passiflora*. In terms of tunica and corpus $T_1$ is distinct. The second layer simulates tunica though periclinal divisions are common. In *P. trifasciata* (Fig. 88) the second layer does not simulate tunica. The cells of the second layer are elongated like those of $T_1$ cells in a number of species (Figs. 86, 87, 89 and 91). The cytohistological zonation is not a constant feature. But even in the same species it varies depending upon the plastochronic phase of the shoot apex. In *P. caerulea* cytohistological zonation is distinct at the phase of leaf initiation (Fig. 86). The cells of the central meristem appear prominently vacuolated. In *P. vespertilio* (Fig. 87), *P. pruinosa* (Fig. 92) and *P. watsoniana* (Fig. 93) the cytohistological zonation is not distinct. In *P. mixta* the central region sometimes appears lighter stained at the maximal phase. A similar situation is observed in *P. anticuquisis* (Fig. 94). In *P. umbilicata* (Fig. 95) and *P. edulis* (Fig. 96) not only the central region of the shoot apex but some cells of peripheral and rib meristem also appear vacuolated. Hence it was difficult to determine whether the central meristem consists of tunica
and corpus initials or of metrameristem in its functional sense (Johnson and Tolbert, 1960). The outer tunica cells appear much vacuolated in a number of species and especially where the central meristem was identified, its tunica cells were pronouncedly vacuolated. Sometimes as in P. suberosa (Fig. 89) where no cytohistological zonation was distinct, a group of centrally situated cells of first two layers appear prominently vacuolated. The stratification of the cells is present up to four layers, though it is a varying feature depending upon the plastochronic phase of the shoot apex. Figure 89 illustrates the minimal phase of the shoot apex in P. suberosa where stratification is absent. On the other hand, figure 90 illustrates the minimal phase of the shoot apex in P. antioquiensis where some degree of stratification is marked.

LEAF INITIATION: The leaf initiation occurs by periclinal divisions either in the second layer or/and the third layer (Figs. 86, 87 and 93). In P. edulis the initiation of the leaf is due to periclinal divisions in the cells of third and fourth layers of the peripheral meristem.

ONTOGENY OF TENDRIL: As already described above the tendril and the flower buds arise from a single bud, referred hereafter as a main bud or bud complex. In most
PLATE XLIV

Figs. 83 - 89
Figs. 83 - 85. Constructed figures showing tendril, flower and accessory bud in *P. mixta* (Fig. 83), *P. edulis* (Fig. 84) and *E. alato-caerulea* (Fig. 85), X 124.

Fig. 86. L.s. shoot apex, *P. caerulea* showing leaf initiation (*L*), *V* = cells of central meristem, X 1250.

Fig. 87. L.s. shoot apex - *P. vespertilio*, X 1250.

Figs. 88, 89. L.s. shoot apex, *P. suberosa*, X 1250; Fig. 89 inset, X 124.

A = axis; AC = accessory bud; BM = bud meristem; FL = flower; L = leaf; *L* = first leaf; SA = shoot apex; T = tendril; *V* = cells of central meristem.
of the species the bud complex is not differentiated at the first node. Its differentiation at the first node generally depends upon the developmental phase of the shoot apex. The critical height of the first leaf when the incipient bud meristem is visible varies in different species of Passiflora. When the first leaf is young the bud meristem is considered to be at the incipient stage of development (Figs. 88, 92, 96 and 98). Its early differentiation is completed at the second node (Figs. 89 and 99). The bud meristem is a part of the peripheral meristem of the shoot apex and it differentiates as a detached meristem. It is axillary in position. Sometimes it is partly lateral in position. The earliest bud meristem is distinct due to the characteristic alignment of its cells. It is usually 4 layers deep with outer 3 layers regularly arranged. The arcuate zone as described earlier is associated with the early bud meristem (Figs. 90, 92). The bud protrudes out due to anticlinal, periclinal and oblique divisions in the cells below the second layer (Figs. 89, 100). The cells of $T_1$ divide anticlinally and those of the second layer divide periclinally. Figure 101 illustrates a well developed main bud at the second node below the shoot apex in $P. edulis$. The stratification up to three layers is evident.
PLATE XLV

Figs. 90 - 92
Fig. 90. L.s. shoot apex, *P. antioquiensis*, X 1250; inset, X 124.

Fig. 91. L.s. shoot apex, *P. mixta*, X 1250; inset, X 124.

Fig. 92. L.s. shoot apex, *P. pruinosa*, X 1250; inset, X 124.

BM - bud meristem; IABM - incipient axillary bud; L - leaf; L2 - second leaf; PA - arcuate zone; SA - shoot apex.
PLATE XLVI
Figs. 93-98
Fig. 93. L.s. shoot apex, *P. watsoniana*, X 1250.

Fig. 94. L.s. shoot apex, *P. antioquiensis*, X 1250.

Fig. 95. L.s. shoot apex, *P. umbilicata*, X 1250; inset, X 124.

Fig. 96. L.s. shoot apex, *P. edulis*, X 1250.

Fig. 97. L.s. bud meristem in the axil of second leaf, *P. caerulea*, X 1250; inset, X 124.

Fig. 98. L.s. incipient bud meristem in the axil of first leaf, *P. caerulea*, X 1250.

BM - bud meristem; CM - central meristem;
L1 - first leaf; L2 - second leaf; PC - procambium; PM - peripheral meristem;
SA - shoot apex.
and some of the corpus cells below appear differentiated into rib-meristem zone.

The histogenetic differentiation of this bud into floral and tendril meristems occurs at the nodes immediately below the shoot apex in P. foetida, P. minima and P. racemosa. While in others this differentiation generally occurs at the lower nodes. The floral meristem is initiated as an accessory bud meristem from the tissue of the main bud (Figs. 102 - 104). A group of cells by their characteristic alignment and deep staining, at the basal region of the main bud and adaxially placed to the axis, appears to be differentiated into accessory bud meristem. This ultimately differentiates into a floral meristem. If two flowers are present, a similar histogenetic development occurs on the other side of the main bud apex.

In P. antioquiensis another group of cells (Fig. 104) lying in between the axis and the bud complex also appears cumeristematic. These cells are not distinctly differentiated, but from their alignment and position I consider them as belonging to an incipient accessory bud which in future develops into a vegetative branch. In other species also the vegetative branch arises from a similar accessory bud.

Figures 105 - 108 illustrate these developmental
features of the main bud in transsections. The one or two accessory bud meristems and the residuum of the main bud form a complex of meristems. Each of the former differentiates into a branch bearing a flower and the latter into a tendril. The lateral bud meristems, i.e., the future floral meristems ($F_1$ and $F_2$) are rapidly organized into floral apices. Figure 107 illustrates the differentiation of the bud complex in $P. vespertilio$. The complex appears someristematic. At this stage two small procambial strands as bud traces are observed (Fig. 106). On two lateral sides facing the main axis (A), floral branches $F_1$ and $F_2$ are differentiated. Figure 108 illustrates a further developmental stage in $P. vespertilio$. The positional relationship between the first bract, the floral apex and the tendril is evident. In $P. vespertilio$ the bract initiation is rapid. In a transection it sometimes appears as if the floral apex is axillary to the bract. Ontogenetic studies in all the species have revealed that the initiation of the bract is a later development.

Figures 109 and 110 illustrate some developmental stages in $P. quadrangularis$. Two floral buds, $F_1$ and $F_2$ are separated from a tendril primordium by an arcuate zone of elongated and vacuolated cells. Here the initiation of the bract is not as rapid as it is in $P. vespertilio$. As mentioned previously, at this stage of development another
Fig. 99. L.s. shoot apex of accessory bud (where \( L_1 \) is not shown), \( P. \) suberosa, \( \times 1250 \).

Fig. 100. L.s. axillary bud (BM), \( P. \) edulis, \( \times 1250 \).

Fig. 101. L.s. axillary bud, \( P. \) edulis, \( \times 1250 \).

Fig. 102. L.s. bud complex of tendril (T) and floral bud (\( F_1 \)) meristems, \( P. \) pruinosa, \( \times 1250 \).

Fig. 103. L.s. bud complex similar to Fig. 102, \( P. \) edulis, \( \times 1250 \).

Fig. 104. L.s. bud complex and accessory bud, \( P. \) antioquiensis, \( \times 1250 \).

Fig. 105. T.s. bud complex of tendril and two floral meristems (\( F_1 \) and \( F_2 \)), \( P. \) coerulescens, \( \times 1250 \); inset, \( \times 124 \).

A - axis; AC - accessory bud meristem; BM - axillary bud meristems; \( F_1 \) and \( F_2 \) - two floral meristems; L - leaf; \( L_2 \) - second leaf; SA - shoot apex; ST - stipule; T - tendril meristem.
histogenic development also takes place. A vegetative accessory bud meristem is differentiated at a region between the tendril and the axis.

TENDRIL: The development of the tendril is more rapid as compared to that of the flower bud and the vegetative bud. As mentioned earlier the tendril elongates due to marked meristematic activity of the rib-meristem zone (Figs. 111 - 113). At the terminal region of the young tendril a meristematic zone is observed which contributes to the growth in length of the tendril. The intercalary growth is also common in the tendril. Most of the developmental features of the tendril as described in P. foetida, P. racemosa and P. minima are also observed in the investigated species.

DEVELOPMENT OF ACCESSORY BUD: In all the investigated species the accessory bud is present. Generally it differentiates into a vegetative branch. It arises at the region between the tendril and the axis. The meristem of this bud is differentiated when the development of the main bud into a complex of flower and tendril meristems occurs (Fig. 110 of P. quadrangularis). The differentiation of the accessory bud at its incipient stage is already described for P. antiquiensis (Fig. 104). Its development is much retarded as compared with that of the
Fig. 106. T.s. bud complex of tendril and two floral meristems ($F_1$ and $F_2$), *P. coriacea*, X 1250.

Fig. 107. T.s. bud complex, *P. vespertilio*, X 1250.

Fig. 108. T.s. further development of the bud complex, *P. vespertilio* (Note the development of bract primordia from organized floral apex), X 1250.

A = axis; $F_1$ and $F_2$ = two floral meristems;
L = leaf; PC = procambium; T = tendril meristem.
PLATE XLIX

Figs. 109 - 111
Fig. 109. T.s. bud complex, *P. quadrangularis*, X 1250; inset, X 124.

Figs. 110A and T.s. main bud (BM) and accessory bud (AC), *P. quadrangularis*. Fig. 110A, X 1250; Fig. 110B, X 124.

Fig. 111. L.s. young tendril, *P. umbilicata*, X 1250.

A - axis; AC - accessory bud; BM - axillary bud; F₁ and F₂ - two floral meristems; IBM - incipient axillary bud; L - leaf; LT - lateral leaf trace; MT - median leaf trace; PC - procambium; ST - stipule; T - tendril.
tendril and flower buds. The early bud meristem is eumeristematic and 5-7 cells deep (Fig. 114). Due to anticlinal and periclinal divisions in inner corpus cells the bud protrudes out (Fig. 115). The cells of the two outer layers appear elongated (Figs. 113 and 116). A well developed accessory bud does not show any cytohistological zonation. The bud bears a single prophyll. A prophyll has an axillary bud (Fig. 116). The initiation of the leaf occurs due to periclinal divisions in the cells of the second and third layers in a sector of the peripheral meristem (Fig. 117).

VASCULAR RELATIONSHIP: The fundamental nature of the vascular relationship between the flower, tendril, accessory bud, axillant leaf and the axis is similar in most of the investigated species. It could be favourably compared with that of P. foetida, P. racemosa and P. minima. Figure 118 illustrates the positional relationship of the flower and its bracts, tendril, the subtending leaf and its stipules and the axis in P. antiquiensis. The node is trilacunar. The bract has one trace. Three bracts of the flower develop more or less simultaneously.

As already mentioned two procambial strands represent the bud trace of the main bud when it is differentiating into a complex of flower and tendril meristems. The
accessory bud also has two traces (Figs. 119 - 121).

Figures 122 - 129 illustrate a typical vascular relationship observed in P. suberosa. Two procambial strands of the main bud trace are observed near the median leaf trace (Fig. 122). At the higher level of the node each of these strands branches into two. The pair of strands facing the median leaf trace is very prominent. While those of the other pair, two adjacent to them are small. The former constitutes the traces of the bud complex and the later of the accessory bud. Still at the higher level of the node the traces of the bud complex resolves into a number of procambial strands (Figs. 125 and 126). They are connected with one another by residual meristem and form a semicircular configuration. This constitutes the primary vascular system of the bud complex (Figs. 125 and 126). At a higher level, the vascular meristem of the accessory bud also appears in the form of a ring consisting of two procambial strands and the residual meristem. The primary vascular system of the bud complex shows 11 procambial strands (Fig. 127). The traces of the two flowers appear prominent. At a higher level of the node a single procambial strand of the floral trace branches into three or more strands. They constitute the primary vascular system of the floral axis (Figs. 128 and 129).
PLATE L
Figs. 112-1178
Fig. 112. L.s. young tendril, P. edulis, X 710.

Fig. 113. L.s. young tendril with accessory bud, P. antioquiensis, X 1250.

Fig. 114. L.s. accessory bud meristem, P. antioquiensis, X 1250.

Fig. 115. L.s. developed accessory bud, P. secrulca, X 1250.

Fig. 116. L.s. well developed accessory bud with prophyll bud (PB), P. mixta. First leaf (L₁) is obliquely cut, X 1250.

Figs. 117A and 117B L.s. accessory bud with its prophyll and two leaves (L₁ and L₂), P. capsularis (Note initiation of leaf in Fig. 117A). Fig. 117A, X 1250; Fig. 117B, X 540.

A - axis; AB - abaxial side; AC - accessory bud; AD - adaxial side; L₁ - first leaf; L₂ - second leaf; N - meristematic tip; PA - arcuate zone; PB - prophyll bud; PC - procambium; PR - prophyll; SA - shoot apex.
Figures 130-132 show vascular relationship between two flowers, tendril, accessory bud and the axis in *P. coriacea*. The vascular meristem of the accessory bud appears horse-shoe shaped and that of the bud complex appears as two arcs when two vascular systems are linked.

In *P. alato-caerulea* there is a single flower associated with the tendril and the accessory bud. Figures 136-140 show the pattern of the vascularization in a well developed accessory bud. The bud has five stipulate leaves and one prophyll with its axillary bud. The leaf has three teeth. The vascular system of the accessory bud shows the procambial strands connected by residual meristem. At a lower level of the node it becomes semicircular or horse-shoe shaped facing the vascular meristem of the axis. There is a single prophyll trace (PT in Fig. 136). The vascular relationship of the prophyll bud with that of the accessory bud is illustrated in figure 136. Finally a number of procambial strands constituting the vascular supply of the accessory bud form the part of the axial vascular system (Fig. 135).

(B) Anatomy of Tendril: The anatomy of the young and old tendrils is studied from the basal middle and terminal regions.

The young tendril is
PLATE LI
Figs. 118-127
Fig. 118. T.s. positional relationship of flower (FL) and its bracts (BR), tendril, leaf and its stipules and axis, *P. antiquiensis*, X 310.


A - axis; AC - accessory bud; AT - accessory bud trace; BM - bud meristem; BR - bract; BT - main bud trace; FL - flower; FT - flower trace; L4 - fourth leaf; L5 - fifth leaf; LT - lateral leaf trace; MT - median leaf trace; PC - procambium; RM - residual meristem; ST - stipule; T - tendril; TT - tendril trace.
Figs. 128 - 129. Vascular relationship continued from Fig. 124, P. suberosa, X 310.

Figs. 130 - 133. Vascular relationship of two flowers, tendril, accessory bud and axis, P. coriacea, X 310.

A - axis; AC - accessory bud; BRT - bract trace; FL - flower; FT - floral trace; L - leaf; LT - lateral leaf trace; MT - median leaf trace; PR - prophyll; T - tendril.
Fig. 135-139. Vascularization of tendril, flower and accessory bud, *P. alato-caerulea*. Fig. 135, X 72; Figs. 136 - 139, X 310.

Fig. 140. Relative position of tendril, flower, accessory bud and axis, *P. alato-caerulea*, X 72.

A - axis; AC - accessory bud; ABM - axillary bud meristem; FL - flower; LT - lateral leaf trace; ML - median leaf trace; PB - prophyll bud; PR - prophyll; PT - prophyll trace; T - tendril.
studied in *P. foetida, P. edulis, P. minima* and *P. alato-caerulea*. The tendril is considered young when it is uncoiled and tender (Fig. 1).

The epidermis is uniseriate. The cells are tabular or columnar (*P. foetida*). The outer tangential walls appear corrugated (Figs. 12, 14). The structure of the epidermis remains more or less similar in three regions of the tendril. The stomata are anomocytic or paracytic (Figs. 8, 9, 10, 22). The guard cells are kidney shaped with outer ledges. In some cases the stomata are slightly raised above the epidermis.

The cortex varies in structure and number of layers in various regions of the tendril. In the extreme basal region on the concave side, the number of cortical layers appears to be more than that in the convex side (Fig. 4).

This unequal development of the cortex confers a distinct dorsiventral feature to the tendril but this may not be well marked in the outer parts of the tendril (Fig. 5). Though certain features of the vascular system in the basal and middle regions of the tendril make it to appear dorsiventral (Figs. 3, 5).
The cortex is distinguished into two regions; the outer consists of collenchyma and the inner parenchyma. The continuity of the collenchyma is generally disturbed below the stomatal cavity (Fig. 10). The thin walled chlorenchyma is present in this region. The collenchyma is lacunar or lamellar with or without chloroplasts. Figures 13, 15, 16 illustrate the variations in arrangement and structure of collenchyma in the convex and concave sides of basal, middle and terminal regions.

The inner cortex consists of thin walled parenchyma with or without chloroplasts (Figs. 14, 23, CL). In the extreme basal region the parenchyma on the concave side are usually without chloroplasts while the parenchyma of convex side are with abundant chloroplasts. The sphaeroocrystals are present.

The pith consists of large thin-walled cells with intercellular spaces. Some of the cells near the primary xylem and along with interfascicular parenchyma appear thick-walled and lignified forming a complete or an incomplete ring of mechanical tissue (Figs. 3, 5, 7). Sometimes the pith appears hollow (Fig. 2).

The number of primary vascular bundles at the base of the tendril of the species investigated varies from 7-16. The number of vascular bundles in the tendril is
5-6 in *P. watsoniana*; 6-8 in *P. quadrangularis* and *P. foetida*; 9-12 in *P. minima*, *P. pruinosa* and *P. foetida var. hibiscifolia*; 10-16 in *P. edulis* and 13-1½ in *P. alato-caerulea*. The number also varies from the base to the terminal region of the same tendril. Solitary patches of phloem with phloem fiber cells are observed in *P. foetida* (Figs. 2, 7, 13). The starch sheath is distinct or indistinct (Figs. 14, 23). The cells of the interfascicular parenchyma are thin but some of them along with the adjacent cells of the pith become thickened and lignified to form a continuous ring, as mentioned above. Sometimes it is absent on the concave side but the variations in its occurrence are not definite (Figs. 3, 5, 7). Each primary vascular bundle shows a cap-like group of parenchyma cells towards the periphery (Fig. 14, f). In the old tendril they develop as extra-xylary fibers. Ontogenetically they appear to be primary phloem fibers. The degree of thickness of these cells varies from base to terminal region. Their development is more on concave side than on the convex side. Sometimes the vascular bundles are arranged in an eccentric manner in basal region (Fig. 4). This feature is absent in *P. alato-caerulea*, *P. pruinosa* and *P. watsoniana*.

THE OLD TENDRIL : The anatomy of the old tendril is studied in *P. foetida*, *P. foetida var. hibiscifolia*, *P.*
minima, P. watsoniana, P. pruinosa, P. alato-caerulea and P. quadrangularis. The tendril is considered as old when it is hard and coiled. The epidermis is uniseriate. The cells are tabular with thick corrugated cuticle. The cuticle sometimes shows distinct striations (P. quadrangularis, Fig. 47). The cuticle is thicker on convex side (Fig. 62) and thinner on concave side (Fig. 61). Sometimes as in P. minima, P. watsoniana and P. quadrangularis epidermal cells become highly thickened and irregular in arrangement (Figs. 49, 47, 48, 51). The outer tangential wall of the epidermis appears in ridges and furrows (Figs. 37, 51). The brownish particles are observed in the furrows of the epidermis of P. foetida var. hibiscifolia (Fig. 36). The lumen appears very narrow and occasionally filled with phenolic contents (P. watsoniana, P. foetida var. hibiscifolia, Figs. 49, 47, 51). In P. pruinosa the epidermis of the middle and terminal regions shows thin cuticle. The guard cells are kidney shaped, with outer ledges (Figs. 44, 36, 58). Stomata of P. foetida var hibiscifolia show outer and inner ledges (Fig. 36). Multicellular epidermal hairs are present (Figs. 42, 43).

The cortex is generally distinguished into outer and inner regions. Sometimes it is not differentiated into outer and inner cortex but all the cells are
PLATE LIV

Figs. 1 - 13
**Passiflora foetida** L.

**Fig. 1.** Young tendril, X 2.

**Figs. 2 - 4.** T.s. basal region, X 124.

**Fig. 5.** T.s. middle region, X 124.

**Fig. 6.** T.s. terminal region, X 124.

**Fig. 7.** T.s. basal region, X 124.

**Fig. 8.** A stoma with subsidiary cells, X 540.

**Fig. 9.** A stoma with two subsidiary cells, X 540.

**Fig. 10.** A stoma with outer ledges (LE), X 1340.

**Fig. 11.** Thin cuticular epidermis and outer cortex, X 1340.

**Fig. 12.** Cuticle showing corrugations, X 3210.

**Fig. 13.** T.s. basal region with flower, X 72.

A - axis; AC - accessory bud; BA - basal region; CC - collenchyma; CU - cuticle; CV - concave side; CX - convex side; EP - epidermis; F - fibers; FS - flower stalk; GC - guard cell; L - leaf; LE - ledge; ME - middle region; P - pith; PA - parenchyma; PL - phenolic contents; SC - subsidiary cell; SS - starch sheath; ST - stipule; T - tendril; TE - terminal region; VB - vascular bundle.
Passiflora foefcida L.

Fig. 14. T.s. basal region, X 1250.

Fig. 15. T.s. cortex from the concave side of basal region, X 1340.

Fig. 16. T.s. cortex from the convex side of basal region, X 1340.

Figs. 17-19. T.s. middle (Fig. 17) and terminal region (Figs. 18 and 19), X 124.

Passiflora adulis Sims.

Figs. 20 and 21. Young and old tendrils, natural size.

Fig. 22. Stomata, X 310.

Fig. 23. T.s. showing developing vascular bundles, X 710.

Fig. 24. Obliteration in the phloem of middle region of the old tendril, X 1340.

A = axis; CC = companion cell; CL = chlorenchyma; CO = collenchyma; CR = sphaero-crystal; CU = cuticle; CV = concave side; CX = convex side; EP = epidermis; F = fibers; GC = guard cell; IP = interfascicular parenchyma; L = leaf; P = pith; PA = parenchyma; PH = phloem; SC = subsidiary cell; SI = sieve tube; SS = starch sheath; ST = stipule; T = tendril.
parenchymatous and 1-5 layered. The number of collenchyma layers varies in different species. The collenchyma may be in discontinuous strands as in P. edulis, P. foetida (Figs. 17, 19) and P. foetida var. hibiscifolia (Fig. 31) or in a continuous ring as in P. watsoniana, P. pruinosa, P. minima, P. alato-cærulea and P. quadrangularis (Fig. 41). The collenchyma may be angular or sometimes show uniform thickening (Fig. 55). The phenolic contents are present in P. watsoniana (Fig. 51), P. quadrangularis and P. foetida var. hibiscifolia (Fig. 37). Sphaerocrystals are also present in P. alato-cærulea, P. foetida var. hibiscifolia, P. foetida, P. pruinosa, P. minima and P. quadrangularis (Figs. 47, 55, 62).

The inner cortex consists of 2-4 layers of parenchyma. The number of layers varies in the concave and convex sides of the same tendril. Chloroplasts are occasionally present. In P. watsoniana and P. quadrangularis the inner cortex shows cells with thickened walls and phenolic contents (Figs. 47, 51). In P. pruinosa the parenchyma cells are tangentially elongated with large intercellular spaces (Figs. 60, 61, 62). In P. minima the cortex on the concave side is entirely parenchymatous with only one layer of thickened cells (Fig. 41).
The starch sheath is one layered though its identity is not always distinct (Fig. 55). In the old tendrils of *P. watsoniana* and *P. quadrangularis* the starch sheath is indistinct (Figs. 47, 61). In *P. minima* only few cells of the starch sheath show presence of starch grains.

Most of the pith cells remain parenchymatous as in *P. edulis*, *P. quadrangularis*, *P. foetida*, var. *hibiscifolia* (Figs. 18, 25, 31) or a hollow cavity is formed as in *P. watsoniana*, *P. pruinosa*, *P. foetida* and *P. alato-caerulea* (Figs. 17, 19, 50) or all pith cells become thick and lignified as in *P. minima* (Fig. 41).

The vascular bundles are eccentrically placed. The vascular bundles are conjoint collateral and open. The dorsiventrality of the tendril is due to unequal distribution of parenchyma, fibres and xylem cells. They are more on the concave side than on the convex side of the tendril (Figs. 18, 19, 41, 50). Similar dorsiventrality could not be observed in *P. alato-caerulea*. Figures 25, 41, 50 illustrate the development and distribution of the fibers in the concave and convex sides of the tendril. The extraxylary fibers in *P. minima* are 516 μ to 1750 μ long and 6.6 μ to 16.6 μ broad and in *P. pruinosa* they are 133 μ to 3833 μ long and 5.3 μ to 8.3 μ broad.

Secondary growth is not marked even in the old
tendrils. The complete cambial ring is sometimes observed but differentiation of the secondary xylem and secondary phloem is markedly noticed in the fascicular region. The secondary xylem consists of thick walled lignified fibers. In the interfascicular region a few thickwalled lignified cells are differentiated. All these cells along with the peripheral pith cells which are also thickened and lignified form a ring of mechanical tissue. Sometimes a discontinuous band of thin walled parenchyma is also found in secondary xylem (Figs. 18, 28, 33, 34). The differentiation of the secondary xylem is more on the concave side (Figs. 41, 50). The vessels with simple perforation plates are observed. The xylem fibers are elongated tapering cells. Measurements of the fibers were taken in a number of species and their range of variations in length and breadth is 316 μ - 433 μ and 6.6 μ - 23.3 μ respectively. In *P. quadrangularis* some of the protoxylem vessels breakdown and form a lysigenous cavity (Figs. 47, 52). The phloem appears much compressed and irregularly arranged. Phenolic contents are present in some of the phloem parenchyma in *P. watsoniana* (Fig. 51) and *P. foetida var. hibiscifolia*. Obliteration in phloem is a common phenomenon (Figs. 24 and 32).
Passiflora foefcida L.

Fig. 25. T.s. basal region, X 12k.
Fig. 26. T.s. magnified portion of basal region, X 1250.
Fig. 27. T.s. middle region, X 1250.
Fig. 28. Magnified portion from Fig. 18 showing thick walled xylem parenchyma, X 1340.
Fig. 29. Collenchema in terminal region, X 1250.

Passiflora foefcida var. hibiscifolia

Fig. 30. A coiled tendril, natural size.
Fig. 31. T.s. basal region, X 72.
Fig. 32. Obliterating phloem cells, X 1340.
Figs. 33 and 34. Magnified xylem parenchyma from Fig. 31, X 540.
Fig. 35. Stomata, X 1250.
Fig. 36. A stoma with outer and inner ledges, X 1250.
Fig. 37. Thick walled epidermis and cortex, X 1250.

A - axis; AR - air chamber; BP - brownish particles, CC - companion cell; CO - collenchyma; CV - concave side; CX - convex side; EP - epidermis; F - fibers; GC - guard cell; L - leaf; LB - ledge; PA - parenchyma; PH - phloem; PL - phenolic contents; SC - subsidiary cell; SI - sieve tube; ST - stipule; T - tendril; XY - xylem.
Passiflora minima Blanco.

Fig. 38. A young tendril, natural size.

Figs. 39 and 40. Old and coiled tendril, natural size.

Fig. 41. T.S. terminal region, X 184.

Fig. 42. A multicellular hair, X 540.

Fig. 44. A stoma with outer ledges and two subsidiary cells, X 1960.

Fig. 45. A 'T' shaped hair, X 240.

Fig. 48. T.S. from concave side of terminal region, X 710.

Passiflora quadrangularis L.

Fig. 43. Thickened and deformed epidermal and cortical cells with phenolic contents (shown black), X 1250.

Fig. 46. An old tendril, natural size.

Fig. 47. T.S. from middle region. Note cuticle with striations and lysigenous cavity (C) in the xylem, X 710.

Fig. 52. Magnified portion of xylem showing lysigenous cavity, X 710.

Passiflora watsoniana Mast.

Fig. 49. An old tendril, natural size.

Fig. 50. T.S. terminal region, X 184.

Fig. 51. Thickened and deformed epidermis and cortex with phenolic contents, X 1960.

A - axis; AR - air chamber; C - lysigenous cavity; CC - collenchyma; CU - cuticle; CV - concave side; CX - convex side; EP - epidermis; F - fiber; FL - flower; FS - flower stalk; H - hair; L - leaf; P - pith; PA - parenchyma; PH - phloem; SC - subsidiary cells; ST - stipule; T - tendril.
Passiflora alato-caerulea Lindl.

Figs. 53 and 54. Young and old tendrils, natural size.

Fig. 55. T.S. basal region, X 1030.

Fig. 56. A stoma with outer lodges and two subsidiary cells, X 1250.

Fig. 57. A stoma with five subsidiary cells, X 1250.

Passiflora pruinosa Mast.

Fig. 58. A stoma with two subsidiary cells, X 1250.

Fig. 59. An old tendril, natural size.

Figs. 60 - 61. Tangentially elongated parenchyma cells, X 710.

Fig. 62. T.S. basal region, X 710.

A = axis; AR = air chamber; CC = collenchyma;
CR = sphaero-crystal; CU = cuticle;
RD = epidermis; F = fiber; FL = flower;
GC = guard cell; L = leaf; PA = parenchyma;
SC = subsidiary cell; ST = stipule;
T = tendril.