ANATOMICAL STUDIES IN THE GENUS DIGITALIS

PART I. THE ANATOMY OF THE INFLORESCENCE OF *D. purpurea* L.

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The morphology and detailed anatomy of the inflorescence of *Digitalis purpurea* have been described. The diagnostic characters which are the most valuable in identifying the inflorescence are the glandular trichomes, which are present on most parts; the pollen grains; the striated cuticle of the calyx and pedicel; the pericyclic fibres of the calyx, pedicel and stem, also the lignified cells of the anther, fruit wall and seed coat.

FLORAL organs have been found in commercial samples of the leaves of *Digitalis purpurea* and *D. lanata*, and these organs must be regarded as foreign organic matter. Since no adequate description of the anatomical characters of the flowers of any *Digitalis* specie could be found, it was decided to make a detailed investigation of the structure of the inflorescence of a number of the more commonly occurring species in the genus. In this way the means may be provided whereby such structures can be identified in crushed or powdered leaf samples. This paper deals with the anatomical structure of the inflorescence of *D. purpurea* L.

Although no description of the anatomy of the flowers of *D. purpurea* could be found, certain descriptions of their morphology have been made[1–12]. These vary considerably in their completeness, and to some extent in their accuracy. Morphological characters, additional to those mentioned in these descriptions, together with details of size, are mentioned under "Gross Morphology".

Material

The inflorescences used for this study were those from several clones grown in the Experimental Gardens of the Museum Department of the Pharmaceutical Society, Birdsgrove House, Mayfield, Derbyshire, also inflorescences from wild plants growing in Sussex and North Wales. In each case the mature flowers possessed all those characters of floral morphology accepted as typical of *Digitalis purpurea* L.

Experimental Methods

At all times chloral hydrate proved to be a satisfactory clearing agent for surface preparations. In order to prepare sections the dried material was soaked in a solution of chloral hydrate containing 8 g. of chloral hydrate in 5 g. of water, for 4 to 6 hours at 40 to 50°. The material was then washed in several changes of distilled water, embedded in polyethylene glycol according to the method of Fell and Rowson[13], and finally sectioned by microtome. Macerates were also prepared using Schulze's maceration fluid and solution of potassium hydroxide.

Gross Morphology

The shape of the sepals was not found to vary with the location of the calyx upon the inflorescence axis and this finding is not in accord with that of Clapham, Tutin and Warburg[5]. The lateral sepals are ovate, 0·6 to 2·2 cm. long and 0·3 to 1·3 cm. broad; the posterior sepal is lanceolate and reduced, 0·5 to 1·2 cm. long and 0·3 to 0·5 cm. broad (Fig. 1, A). The sepals become reflexed as the fruit matures (Fig. 6, B). Each corolla lobe has a slightly recurved margin and 3 to 4 main veins, secondary and tertiary veinlets are present in the distal region only (Fig. 3, A, G). The corolla tube is 1 to 3 cm. in diameter at the distal end.

The androecium consists of four didymous stamens. The filaments are glabrous, curved, about 1 mm. wide. Each member of the posterior-lateral pair is 14 to **18** to 21 mm. long and the members of the anterior-lateral pair are 20 to **24** to 26 mm. long. The length of the adherent portion of the filament, 10 to **11** to 13 mm. for the posterior-lateral pair and 8 to **10** to 12 mm. for the anterior-lateral pair, varies inversely with the total length of the filament[14]. The didymous anther lobes are glabrous, conical, with convex sides, 1·75 to 2·25 mm. long and about 1 mm. wide at their base. Dehiscence is introrse, the split extending the entire length of the lobe (Fig. 4, A and H).

The yellowish-green gynoecium (Fig. 5, A), is 9 to 12 mm. long and 4 to 6 mm. wide at the base. There are about 40 more or less parallel veins in the ovary wall, with very few secondary and tertiary veinlets (Fig. 5, P). The nectary at the base of the ovary consists of four slightly curved portions of tissue, yellow in colour, with their ends closely appressed to the adjacent portions (Fig. 5, A). The firm, erect, glabrous style, 18 to 24 mm. long and 1 to 2 mm. wide, arises from the apex of the ovary. The terminal, glabrous stigma is formed of two slightly diverging lobes (Fig. 5, A and C).

The brownish-green fruit is about 15 mm. long and 9 to 11 mm. wide at the base. Dehiscence is septicidal and loculicidal (Fig. 6, A, B and D).

In most of the seeds[15] which have been examined two or three longitudinal grooves were present. One, indicating the line of the raphe extends the entire length of the seed, whereas the others vary in both length and depth (Fig. 2, E).

Histology

Calyx. The abaxial surface of the sepal is covered by a thin, striated cuticle, the striations tending to radiate from the trichome bases and from the stomatal guard cells (Fig. 1, B). The epidermal cells at the base of the sepal are polygonal, with straight, or slightly wavy, thickened, anticlinal walls (Fig. 1, C). Their measurements[16] are: L, 28 to **51** to 80 μ; T, 20 to **32** to 48 μ; R, 16 to **23** to 30 μ*. Over the remainder of the surface the epidermal cells are polygonal, with thin, wavy walls having

* In recording measurements the letters L, T and R, have reference to the longitudinal, tangential, and radial directions respectively, of the axis of the plant member in question. In cases where orientation of the subject relative to the plant axis is absent, values for L and T are combined.

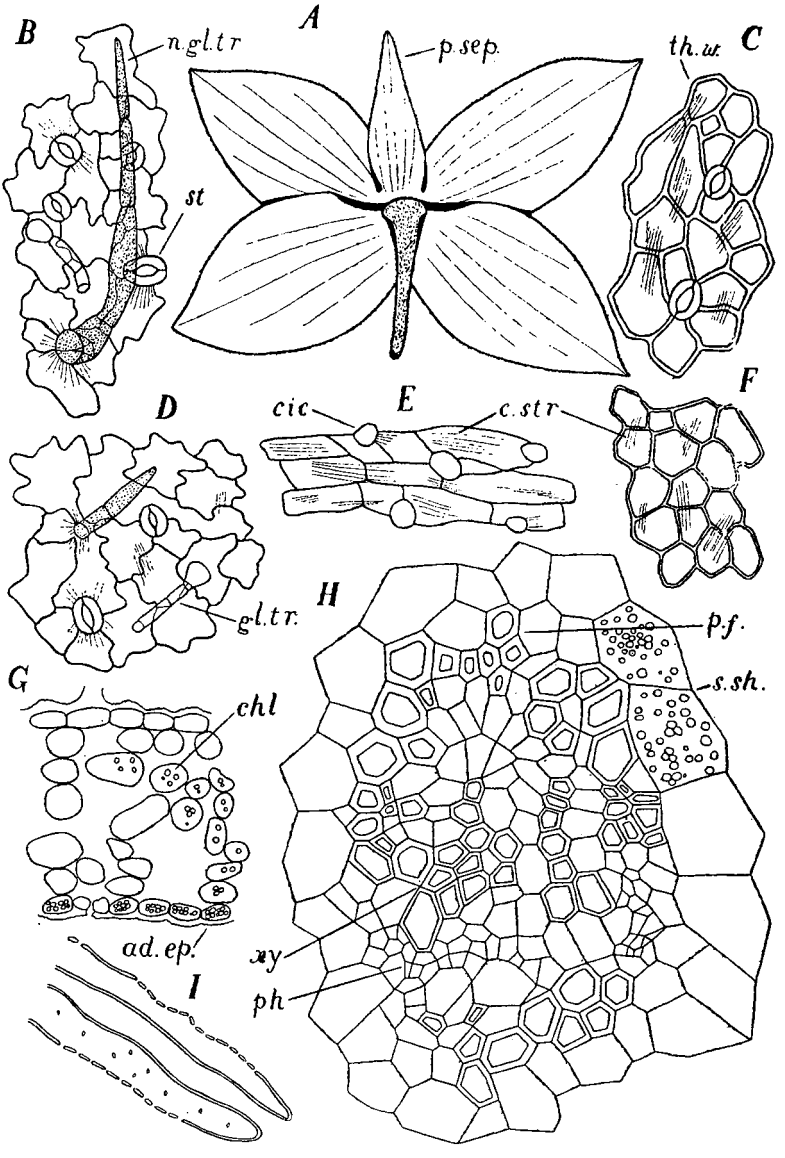

FIG. 1. *Digitalis purpurea* L. Calyx. A, Ventral view of calyx × 1·5. B, Abaxial epidermal cells from apical and central regions. C, Abaxial epidermal cells from basal region. D, Adaxial epidermal cells from central and apical regions. E, Epidermal cells over a vein. F, Adaxial epidermal cells from basal region. All × 150. G, Transverse section of interneural lamina in basal region × 250. H, Transverse section through a main vein × 425. I, Parts of pericyclic fibres, about half of length, × 425. *ad. ep.*, adaxial epidermis with chloroplasts and associated starch grains; *chl*, chloroplasts with associated starch grains; *cic*, cicatrix; *c.str.*, cuticular striations; *gl.tr.*, glandular trichome; *n.gl.tr.*, non-glandular trichome; *p.f.*, pericyclic fibres; *ph*, phloem; *p.sep.*, reduced posterior sepal; *s.sh.*, starch sheath; *st*, stoma; *th.w.*, thickened cellulose walls; *xy*, xylem.

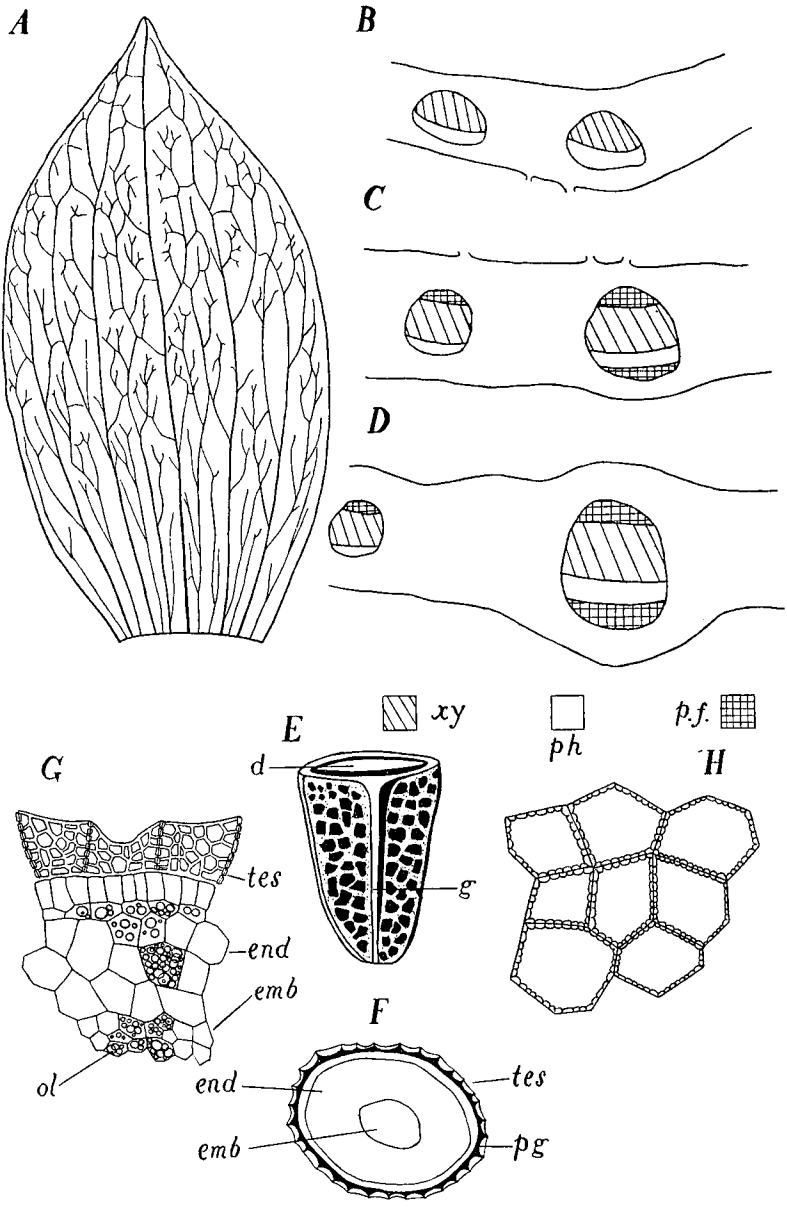

FIG. 2. *Digitalis purpurea* L. Calyx and Seed. A, Sepal, plan of venation × 3. B, C, and D, Tissue plans of transverse sections through mid-rib of sepal in the apical, central and basal regions respectively. E, Seed × 16. F, Tissue plan of transverse section of seed × 50. G, Transverse section of seed × 180. H, Testa in surface view × 180. *d*, depression; *end*, endosperm; *emb*, embryo; *g*, groove marking position of raphe; *ol*, oil globules; *p.f.*, pericyclic fibres; *ph*, phloem; *pg*, pigment; *tes*, testa; *xy*, xylem.

acute re-entrant angles, L and T, 20 to **40** to **60** to 80 μ; R, 16 to **23** to 30 μ (Fig. 1, B). The thin, straight walled epidermal cells over the veins are elongated in the direction of the vein (Fig. 1, E). No starch grains or chloroplasts were found in the epidermal cells. Numerous anomocytic[17] stomata, 28 to **40** to 44 μ long and 18 to **22** to 28 μ wide, are present on this surface (Fig. 1, B and C). The Stomatal Index varies from 3 to **10** to **15** to 22. Abundant trichomes of two types are present on this surface. The non-glandular hairs are multicellular and uniseriate, rarely unicellular, with a slightly warty cuticle, and an acute apical cell (Fig. 1, B). Some of these occur along the edges of the sepal in numbers varying from 12 to 32 per mm. of margin, these are 60 to **248** to 480 μ long, 16 to **26** to 32 μ wide at the base, with 2 to **3** to **4** to 7 cells per trichome. In the interneural areas there are 35 to 60 non-glandular trichomes per sq. mm. which are 40 to **130** to 360 μ long, 16 to **25** to 30 μ wide at the base, and with 1 to **2** to **3** to 5 cells per trichome. The glandular trichomes have a unicellular, or multicellular, uniseriate stalk, with a unicellular, clavate, glandular head. Along each mm. length of margin there are 24 to 32 such trichomes, they are similar in size and in the number of cells per pedicel, to the non-glandular interneural trichomes. In the interneural areas there are 20 to 40 glandular trichomes per sq. mm., 20 to **60** to 200 μ long, 10 to **15** to 20 μ wide at the base, 1 to **1** to **2** to 4 cells per pedicel.

On the adaxial surface the epidermal cells are similar to those on the abaxial side except that the cells in the basal region are less heavily thickened and contain numerous chloroplasts with associated starch grains (Fig. 1, D, F, and G). The stomata also are similar but comparatively rare, the Stomatal Index varies from 0 to **0·2** to **1·7** to 10. Both types of trichome are found on this surface but the non-glandular type is uncommon, and both types are very rare in the basal region. Over the remainder of the surface there are 10 to **60** to 115 glandular trichomes per sq. mm., 20 to **70** to 200 μ long, 12 to **14** to 20 μ wide at the base, with 1 to **1** to 3 to 4 cells per pedicel.

The interneural mesophyll is a loose, lacunose tissue of about five to nine layers of undifferentiated, round to ovoid, or irregularly ovoid parenchymatous cells which contain numerous chloroplasts with associated starch grains, 2 to 8 μ in diameter and possessing a central hilum (Fig. 1, G).

In each sepal the vascular tissue consists of about five main veins, united, in all but the basal fifth, by a network of lateral veinlets (Fig. 2, A). Each main collateral strand is surrounded by a ring of large, rounded cells forming a starch sheath[18], within which is a pericycle[19], consisting of parenchyma and sclerenchyma. The latter is formed of thickened, pitted, sometimes wavy walled fibres of ligno-cellulose, 440 to **560** to 800 μ long, and 8 to **13** to 20 μ wide, with rounded or pointed ends (Fig. 1, H, and I). Their number varies greatly, but generally increases from apex to base (Fig. 2, B-D). The small amount of phloem tissue consists of strands of sieve tubes, each tube being 2 to 4 μ in diameter, together with companion cells and phloem parenchyma. The xylem consists of

a crescent shaped arc of polygonal, spirally and annually thickened, vessels of ligno-cellulose, 4 to **9** to 13 μ wide. The vessels are arranged in files or small groups separated by medullary rays which are one cell in width (Fig. 1, H). The veinlets are not associated with a starch sheath or a pericycle; the xylem is composed of a small group of polygonal tracheids, 4 to **6** to 8 μ wide, with spiral or annular thickening; the very small amount of phloem tissue is somewhat indistinct.

Corolla. The abaxial surface is covered by a thin, smooth, cuticle. The epidermal cells at the base are polygonal, isodiametric, with straight walls, L and T, 6 to **27** to **37** to 60 μ; R, 22 to **30** to 44 μ, this value for R is similar in all regions of the corolla (Fig. 3, B). In the proximal half of the central region the cells have straight walls and are elongated in the longitudinal direction of the corolla, L, 40 to **68** to 100 μ; T, 16 to **25** to 50 μ (Fig. 3, E). Over the remainder of the surface the epidermal cells are polygonal, nearly isodiametric, with wavy walls, very wavy on the free lobes, L and T, 24 to **25** to **50** to 90 μ (Fig. 3, C and D). All the epidermal cells contain simple and compound starch grains; the simple grains are round, 1 to 3 μ in diameter, compound grains of about 4 to 10 components are 8 to 12 μ in diameter, hilum and striations are not visible (Fig. 3, H). Stomata similar to those on the calyx are present on this surface, but are absent from the basal region (Fig. 3, D). The Stomatal Index varies from 1 to **2** to **4** to 7. Trichomes similar to those found on the calyx are present, they are numerous in the distal region and especially so on the free lobes (Fig. 3, C). There are 5 to 10 non-glandular trichomes per sq. mm., 140 to **550** to 2700 μ long, 16 to **23** to 53 μ wide at the base, with 2 to **4** to 7 cells per trichome. The glandular trichomes occur to the extent of 25 to 150 per sq. mm., 60 to **300** to 900 μ long, 16 to **20** to 25 μ wide at the base, with 2 to **4** to 7 cells per trichome. A very few glandular trichomes having a bicellular head with a transverse division were seen.

On the adaxial surface the cuticle and epidermal cells are similar to those of the abaxial side, except that the anticlinal walls of the epidermal cells in the distal region are not so wavy (Fig. 3, F), and the value for R is greater, namely 44 to **55** to 67 μ. Neither stomata nor glandular trichomes were found on this surface, moderately numerous non-glandular trichomes were present but in the distal region only, they have a warty cuticle and an acute apical cell. Their length is 3·4 to 4·7 mm., their width at the base 50 to **70** to 80 μ, the cells per trichome 9 to **12** to 15.

The mesophyll is similar to that of the calyx save for the absence of chloroplasts with associated starch grains, and the presence of anthocyanin and flavone pigments (Fig. 3, H). Ten to 20 main veins are found in the corolla together with secondary and tertiary veinlets. Veins and veinlets are similar except for the size and number of the elements. Starch sheath and pericycle are absent. The xylem vessels, 4 to 10 μ in diameter, with polygonal, ligno-cellulose walls, with spiral or annular thickening, are grouped without obvious arrangement and medullary ray cells are not obvious. The phloem tissue contains sieve tubes 2 to 4 μ in diameter, companion cells and phloem pharenchyma (Fig. 3, I).

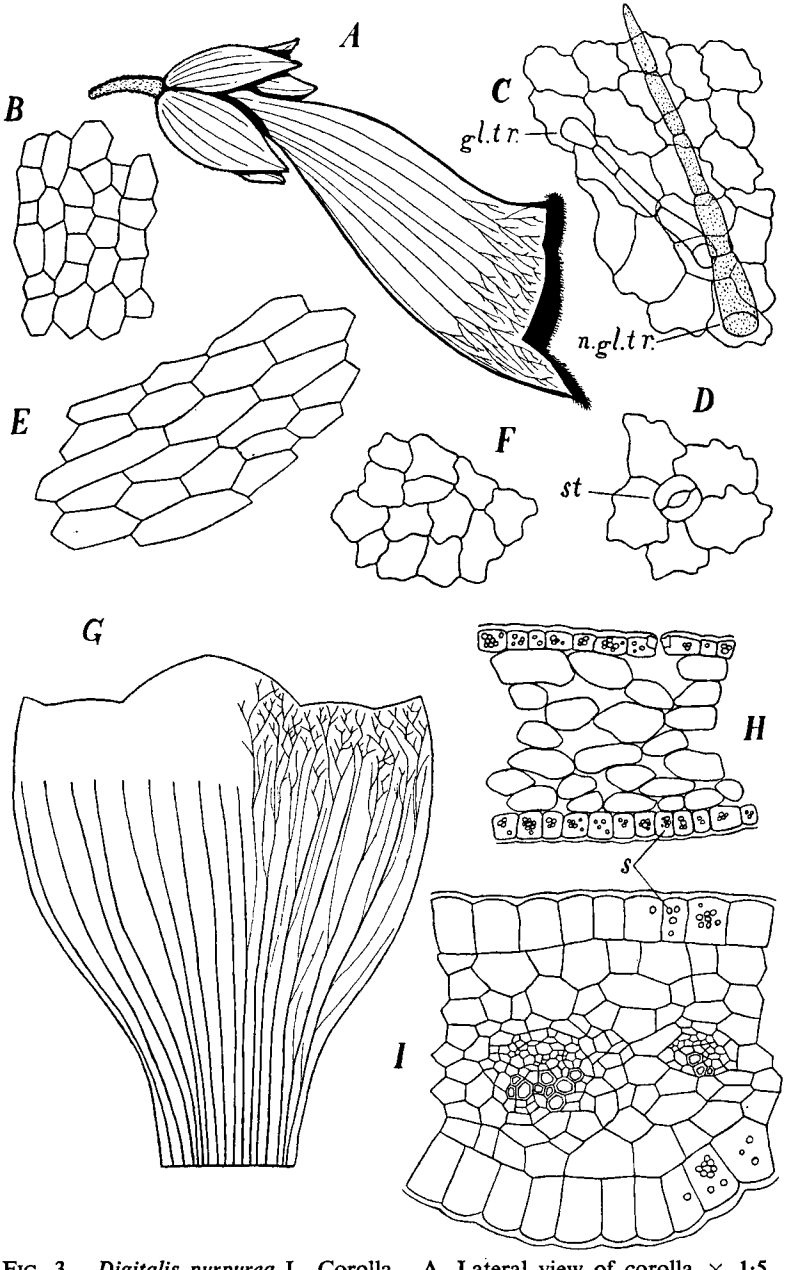

FIG. 3. *Digitalis purpurea* L. Corolla. A, Lateral view of corolla × 1·5. B, Abaxial epidermal cells from extreme proximal region. C and D, Abaxial epidermal cells from distal region. E, Abaxial epidermal cells from central region. F, Adaxial epidermal cells from distal region. All × 150. G, Corolla, plan of venation × 2. H, Transverse section through central region of corolla. I, Transverse section through vascular tissue of corolla, both × 150. *gl.tr.*, glandular trichome; *n.gl.tr.*, non-glandular trichome; *s*, starch; *st*, stoma.

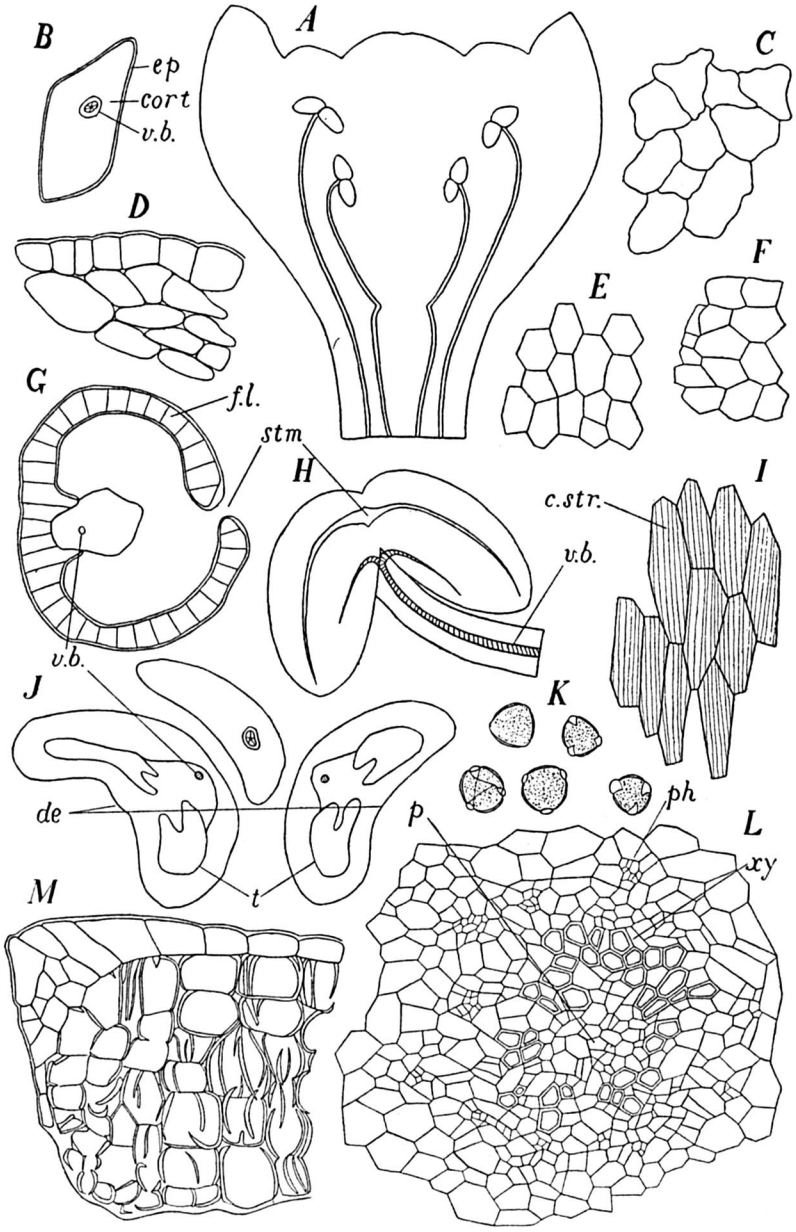

FIG. 4. *Digitalis purpurea* L. Androecium. A, Plan of corolla to show position of stamens × 2. B, Tissue plan of transverse section of filament × 25. C, Epidermal cells of anther lobes. D, Transverse section of filament—epidermis and cortex. E, Epidermal cells of filament near anther. F, Epidermal cells from region of stomium. All × 250. G, Tissue plan of transverse section of anther after dehiscence × 30. H, Anther lobes and filament × 10. I, Epidermal cells of filament from free portion × 250. J, Tissue plan of transverse section of anthers with filament × 25. K, Pollen grains × 250. L, Transverse section of vascular strand of filament × 425. M, Transverse section of anther including stomium × 250. *cort*, cortex; *c. str.*, cuticular striations; *de*, position of dehiscence lines; *ep*, epidermis; *f.l.*, fibrous layer; *p*, pith; *ph*, phloem; *stm*, stomium; *t*, tapetum; *v.b.*, vascular strand; *xy*, xylem.

Androecium. The filament is covered by a thin, uniform cuticle which is striated in the upper third of the free portion, the striations being parallel to the longitudinal axis of the filament (Fig. 4, I). The thin walled, polygonal, almost isodiametric epidermal cells at the base of the adherent portion are L and T, 20 to **48** to **58** to 80 μ; R, 19 to **27** to 34 μ. Over the remainder of the filament the cells are elongated in the direction of the longitudinal axis, L, 90 to **130** to 200 μ; T, 10 to **20** to 30 μ; R, 19 to **27** to 34 μ; this elongation is less apparent in the cells very near to the anthers where the measurements are L, 24 to **32** to 50 μ; T, 12 to **17** to 22 μ; R, 19 to **27** to 34 μ (Fig. 4, E). Neither stomata nor trichomes were found on the filaments examined.

The cortex consists of a loose tissue of 6 to 20 rows of ovoid, or irregularly ovoid, thin walled parenchymatous cells, with numerous intercellular air spaces. Apart from a few chloroplasts in the periphery the cells are devoid of contents (Fig. 4, D). Embedded in the cortex is the eccentric, rarely centric, vascular strand, consisting of a small central pith of partially collapsed cells surrounded by a ring of polygonal, lignified, xylem vessels, 4 to 12 μ in diameter, with spiral and annular thickening. Some medullary ray cells are visible. Surrounding the xylem is a ring of phloem tissue consisting of sieve tubes, 3 to 6 μ in diameter, companion cells and phloem parenchyma. The vascular strand divides in the connective, the two resultant stands supplying the two anther lobes (Fig. 4, B, H and L).

The anther lobes are covered by a thin cuticle, the epidermal cells are polygonal with slightly wavy walls, L, 28 to **50** to 65 μ; T, 20 to **29** to 50 μ; R, 18 to **22** to 30 μ (Fig. 4, C). In the region of the stomium the cells have straight walls and are slightly smaller, L and T, 16 to 24 μ; R, 8 to **12** to 20 μ (Fig. 4, F). No contents were seen in these epidermal cells. Beneath the epidermis there are about five rows of almost isodiametric fibrous cells with ligno-cellulosic thickening in spiral and annular bands, L and T, 20 to **26** to **37** to 50 μ; R, 20 to **36** to 50 μ (Fig. 4, G and M). At the stomium these cells are absent and adjacent to the stomium the number of rows is less, the cells are also smaller, the fibrous tissue therefore forms a pair of slightly tapering blunt pincers which close upon the stomium (Fig. 4, G and M). The fibrous cells adjacent to the stomium are more heavily lignified than the others. Remains of the collapsed tapetum is sometimes visible within the fibrous layer. Stomata and trichomes are absent from the anther lobes.

The pollen grains (Fig. 4, K), are subspherical bodies, 19 to **26** to 32 μ in diameter, with three equally placed germinal pores, 7 to 10 μ in diameter, situated at the widest part of the three germinal furrows which taper towards the poles but do not meet. The intine is smooth, the exine slightly pitted. Starch and oil were not found in the grains examined, in iodine the grains stained a deep yellow.

Gynoecium. The ovary is covered by a thin, smooth cuticle. The polygonal epidermal cells with thin straight walls measure, L and T, 12 to **17** to 29 μ; R, 12 to **18** to 24 μ (Fig. 5, G and H). Anomocytic stomata occur (Fig. 5, G), the guard cells lie in the same plane as the surrounding

epidermal cells. The stomata measure, L, 24 to **30** to 40 μ; B, 20 to **22** to 24 μ. The Stomatal Index has a mean value of 2. Only glandular trichomes occur, they are very numerous and are similar to those of the calyx, 54 to **300** to **450** to 1000 μ long; 12 to **25** to **30** to 60 μ wide at the base; 1 to **1** to **3** to 6 cells per pedicel; 170 to **195** to **230** to 270 trichomes per sq. mm. The cells of the inner epidermis of the ovary are elongated at right angles to the longitudinal axis and have thin straight walls, T, 20 to **55** to 67 μ; L, 5 to **7** to 9 μ; R, 6 to **9** to 12 μ (Fig. 5, M). Neither trichomes nor stomata were found on this inner surface.

The mesophyll is formed of polygonal cells with thin, straight, or slightly wavy walls, some small intercellular air spaces are present. The cells contain chloroplasts with which are associated small, round starch grains of diameter 3 to 5 μ (Fig. 5, O). About 40 vascular strands are embedded in this mesophyll, the polygonal vessels, 4 to **7** to 10 μ in diameter, have lignified thickening of the spiral and annular type; the phloem is composed of very small elements. The cells of the placenta are similar to those of the mesophyll (Fig. 5, K), except that they appear devoid of contents. About eight vascular strands, similar to those of the mesophyll, supply the placenta. Numerous anatropous ovules with one integument are borne on the placenta, when mature these parenchymatous bodies are 12 to **16** to 19 μ long and 10 to **11** to 14 μ wide. The cells of the septum are also similar to those of the mesophyll (Fig. 5, J).

The style is covered by a thin, striated, cuticle, the striations are parallel with the longitudinal axis of the style. The epidermal cells are polygonal, with thin, straight walls and are elongated in the direction of the axis (Fig. 5, N). They measure L, 350 to **450** to 600 μ; T, 16 to **19** to 24 μ; R, 12 to **16** to 22 μ. Beneath the epidermis is the cortex, composed of thin walled cells which surround a small central canal. Two vascular strands are embedded in the cortex, opposite to each other and near to the epidermis (Fig. 5, E), each strand consists of a ring of lignified, polygonal xylem vessels, 3 to 9 μ in diameter; the xylem is surrounded by a ring of very small celled phloem tissue (Fig. 5, I). These two strands supply the two diverging lobes of the parenchymatous stigma (Fig. 5, C).

Fruit. The outer surface is covered by a thick, smooth, cuticle. The polygonal epidermal cells, L and T, 20 to **32** to **49** to 68 μ; R, 17 to **25** to 32 μ, have straight walls and, except for an occasional small rounded starch grain, are devoid of contents (Fig. 6, E). Stomata, similar to those on the ovary wall, are present on this surface (Fig. 6, E). The trichomes are also similar to those on the ovary wall (Fig. 6, E), but they measure only 80 to **220** to 480 μ in length and only 10 to **25** to 40 per sq. mm. The cells of the inner epidermis are similar to those on the inner surface of the ovary wall except that the elongation, T, 68 to **190** to 340 μ; L, 7 to **12** to 17μ; R, 7 to **11** to 14 μ, has become more pronounced (Fig. 6, C). Trichomes and stomata are absent on this inner surface.

The mesocarp (Fig. 6, F), is formed of five to seven rows of cells, the row adjacent to the endocarp is sclerenchymatous, the remainder are parenchymatous. These latter consist of closely packed polygonal, straight walled cells, containing a few chloroplasts. The sclerenchymatous

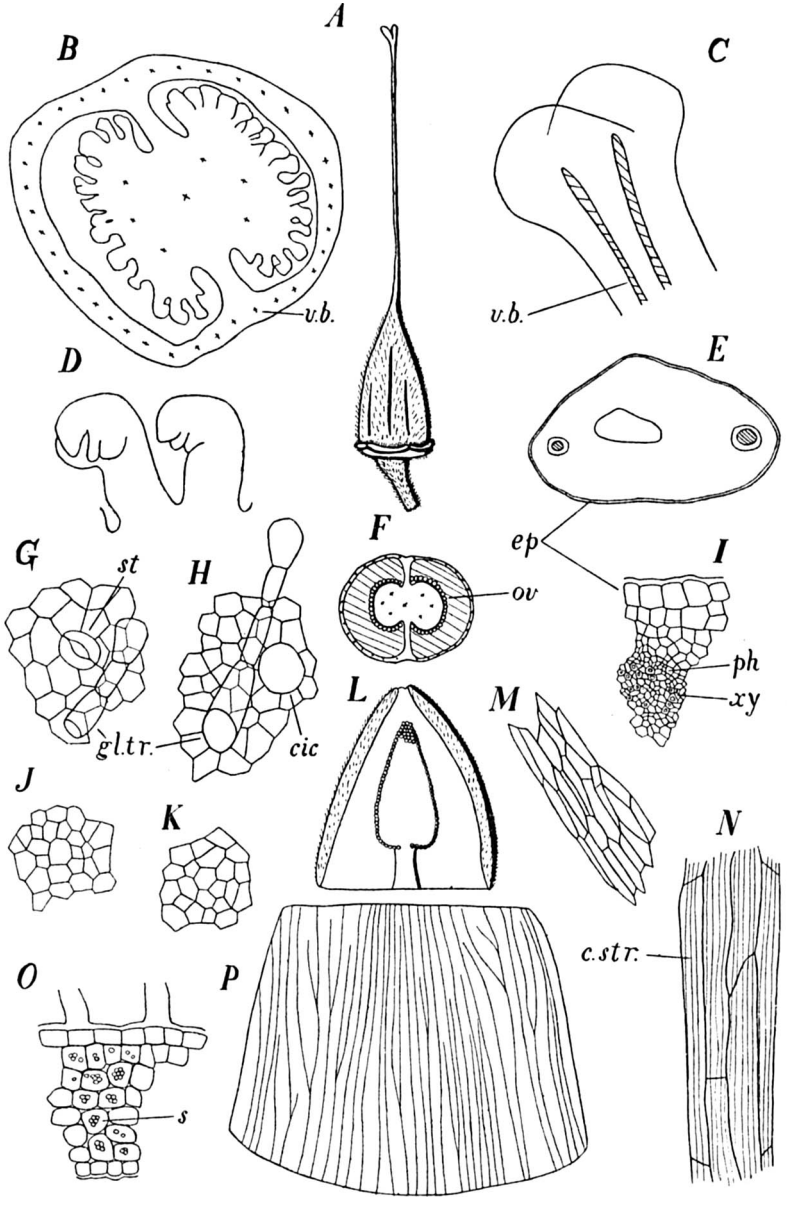

FIG. 5. *Digitalis purpurea* L. Gynoecium. A, Gynoecium × 1·5. B, Transverse section of ovary × 8. C, Stigma with vascular strands × 10. D, Ovules × 100. E, Transverse section of style × 20. F, Transverse section of ovary × 3. G, Outer epidermal cells from central region of ovary. H, Outer epidermal cells from base of ovary. I, Transverse section of style through vascular strand. J, Cells of septum. K, Cells of placenta. All × 180. L, Longitudinal dissection of ovary × 3. M, Inner epidermal cells of ovary. N, Epidermal cells of style. O, Transverse section of ovary wall. All × 180. P, Ovary wall, plan of venation × 5. *cic*, cicatrix; *c.str.*, cuticular striations; *ep*, epidermis; *gl.tr.*, glandular trichome; *ov*, ovules; *ph*, phloem; *s*, starch; *st*, stoma; *v.b.*, vascular strand; *xy*, xylem.

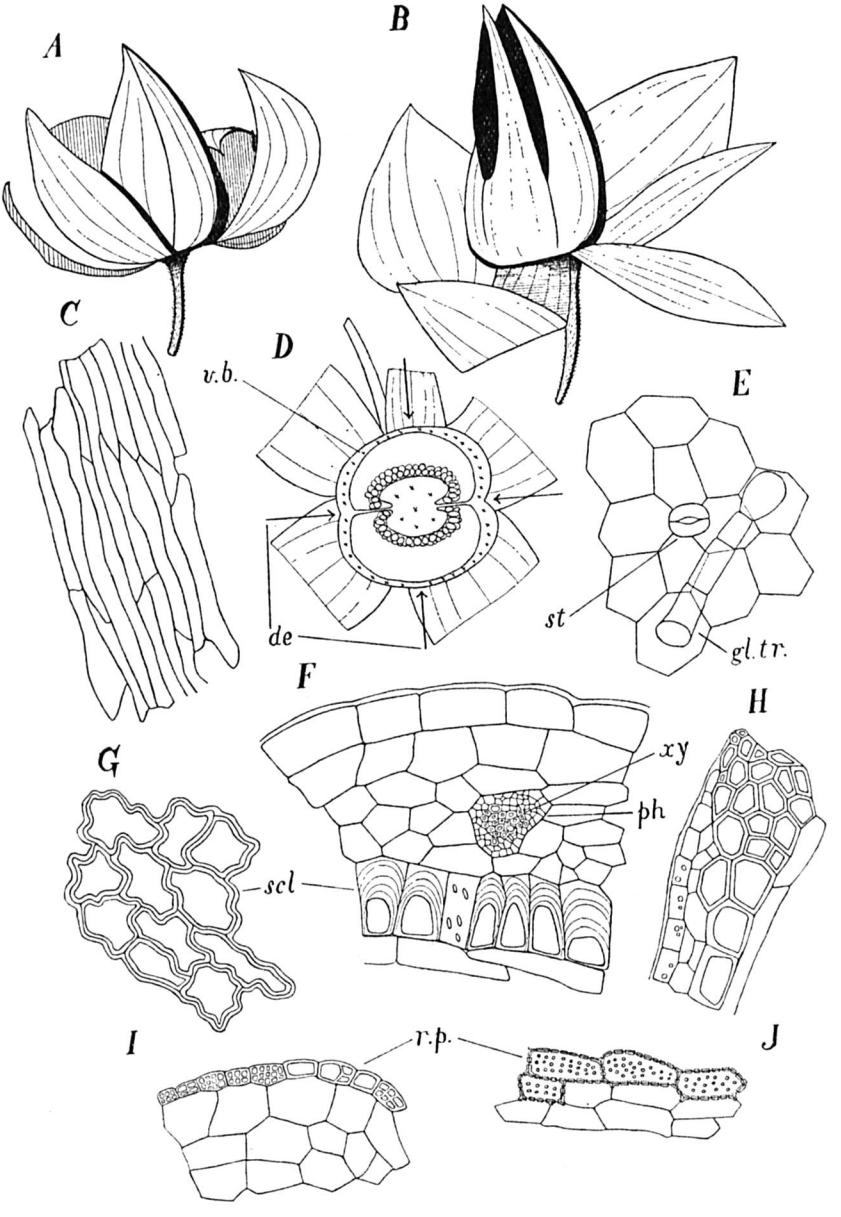

FIG. 6. *Digitalis purpurea* L. Fruit. A, Fruit × 6. B, Fruit showing lines of dehiscence × 6. C, Inner epidermal cells of fruit wall × 180. D, Transverse section of fruit × 6. E, Outer epidermal cells of fruit wall. F, Transverse section of mesocarp. G, Sclerenchymatous layer in surface view. H, Transverse section of mesocarp at point of loculicidal dehescence. I, Transverse section of placenta. J, Covering cells of placenta in surface view. All × 180. *de*, position of dehiscence lines; *gl.tr.*, glandular trichomes; *ph*, phloem; *r.p.*, reticulate parenchyma; *scl.* sclerenchyma; *st*, stoma; *v.b.*, vascular strand; *xy*, xylem.

cells have lignified U-shaped thickening and measure L, 34 to **48** to 69 μ; T, 17 to **26** to 34 μ; R, 20 to **29** to 38 μ; viewed tangentially these cells appear wavy (Fig. 6, G), occasional slit-like pits are visible in the thickening. The vascular strands are similar in all respects to those in the ovary wall. The placenta is also similar, except that the surface has become irregular and covered by reticulate parenchymatous cells (Fig. 6, I and J), which measure L and T, 14 to **20** to **42** to 68 μ; R, 14 to **19** to 22 μ. At the fruit stage the septum is bounded on both sides by the sclerenchymatous layer and inner epidermis. The dehiscence is septicidal and loculicidal (Fig. 6, D). At the septum, splitting occurs in the central parenchyma; the loculicidal splits occur opposite the median part of the placenta, at these points the mesocarp is reduced, the sclerenchyma is wider, and the inner epidermis is absent; the dehiscence occurs in the sclerenchyma.

Seed. The histology of the seed has been described[15], but in addition the following characters have been noted. The epidermal cells measure L, 34 to **59** to 72 μ; T, 30 to **42** to 54 μ; R, 34 to **51** to 64 μ. From the layer of collapsed cells adjacent to these epidermal cells it would appear that a diffuse reddish-brown pigment originates, this spreads over part of the anticlinal walls of the epidermis.

Pedicel. The surface is covered by a thick, striated cuticle, the striations of which are parallel to the longitudinal axis of the pedicel. The polygonal, elongated, epidermal cells have thin and straight, or slightly wavy walls (Fig. 7, E). Their dimensions are L, 36 to **80** to 115 μ; T, 11 to **16** to 21 μ; R, 11 to **15** to 22 μ. Stomata, similar to those on the calyx, are present (Fig. 7, E); the Stomatal Index varies from 3 to **5** to 7. Both non-glandular and glandular trichomes are numerous on all parts of the pedicel, the former, similar in appearance to those on the calyx, are 105 to **320** to 790 μ long, 18 to **27** to 36 μ wide at the base, with 2 to **4** to 6 cells per trichome and 35 to **80** to 120 trichomes per sq. mm. The glandular trichomes, also similar in appearance to those on the calyx, are 70 to **153** to 350 μ long, 11 to **21** to 28 μ wide at the base, with 1 to **3** to 5 cells per stalk and 10 to **30** to 60 trichomes per sq. mm. (Fig. 7, E).

The cortex consists of about eight rows of loosely packed polygonal cells with thin, straight, or rounded walls. The cells are filled with chloroplasts and associated starch grains which are small and rounded, 1 to 3 μ in diameter. The inner periphery of the cortex is delimited by the starch sheath, a ring of subrectangular cells distinct in shape from the cortical cells. The concentration of starch in these cells does not appear to differ markedly from that in the cortex. Within this starch sheath the pericycle occurs as 8 to 10 rows of polygonal, thick walled, lignified fibres, 7 to 24 μ in diameter. They have numerous slit-like pits on their walls, and the outer walls, of those fibres situate on the periphery of the pericycle, are wavy (Fig. 7, H). At the time of the fall of the corolla these fibres are not lignified, the lignification proceeds during the development of the fruit. The pericycle surrounds a narrow band of phloem tissue, with

thin walled sieve tubes 6 to 10 μ in diameter. Cambial tissue is not distinct. The ring of xylem tissue is entirely lignified, the polygonal vessels, with straight and thickened walls, are 10 to 18 μ in diameter. The thickening is of the annular or spiral type. The central pith consists of cells with thin, straight walls and a few starch grains are present. Fibres, single and in groups, similar to the pericyclic fibres, occur in this region (Fig. 7, B and D).

Inflorescence axis. The histology of the inflorescence axis is similar in many respects to that of the pedicel, the differences only will be noted. The cuticle is smooth (Fig. 7, F). Stomata are 36 to **43** to 48 μ long and 25 to **28** to 36 μ wide. The glandular trichomes are 90 to **216** to 450 μ long, 10 to **22** to 43 μ wide at the base, there are 50 to **75** to 140 such trichomes per sq. mm. There are 0 to **8** to 20 non-glandular trichomes per sq. mm. The cortex consists mainly of collenchymatous cells (Fig. 7, C). This is a variable factor, the collenchyma is minimal, two or three rows, at the apex of the young axis, and maximal, occupying the entire cortex, at the base of mature fruit axes. The pericyclic fibres, 11 to **25** to 36 μ in diameter, have thick walls without pits (Fig. 7, C and G). The pith, surrounding a central cavity, consists of large lignified cells with simple pits (Fig. 7, C). The ring of vascular tissue is nearer the periphery of the organ in the axis than in the pedicel (Fig. 7, A and B).

Discussion

The diagnostic characters which are the most valuable in identifying the inflorescence, when in admixture with the leaf, are as follows:

Calyx. Glandular trichomes with a uniseriate, multicellular stalk and a unicellular head: striated cuticle: epidermal cells with thickened cellulosic walls: pericyclic fibres.

Corolla. Glandular trichomes as on the calyx, some of which are very long: anthocyanin and flavone pigments.

Androecium. Elongated epidermal cells with striated cuticle from the filament: fibrous cells from anther wall: pollen grains.

Gynoecium. Glandular trichomes as on the calyx: elongated epidermal cells with striated cuticle from the style: anatropous ovules with one integument.

Fruit. Glandular trichomes as on the calyx: fibrous cells with U-shaped thickening.

Seed. Lignified reticulate cells of the testa: storage tissue containing oil and protein.

Pedicel. Glandular trichomes as on the calyx: elongated epidermal cells with striated cuticle: pericyclic fibres.

Inflorescence axis. Glandular trichomes as on the calyx: pericyclic fibres: lignified pith cells.

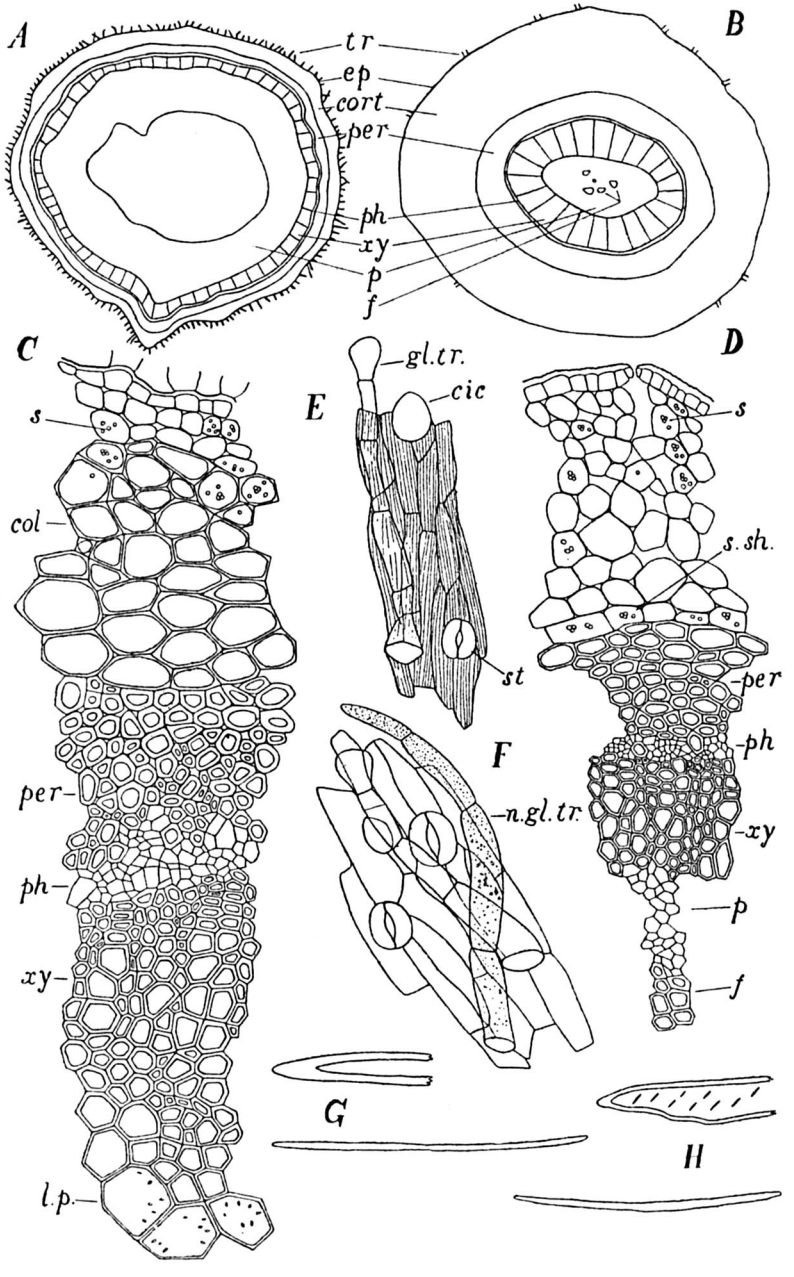

FIG. 7. *Digitalis purpurea* L. Pedicel and Inflorescence Axis. A, Tissue plan of transverse section of inflorescence axis × 8. B, Tissue plan of transverse section of pedicel × 50. C, Transverse section of inflorescence axis. D, Transverse section of pedicel. E, Epidermal cells of pedicel. F, Epidermal cells of inflorescence axis. All × 180. G, Pericyclic fibre from inflorescence axis × 45, and part of same × 180. H, Pericyclic fibre from pedicel × 45, and part of same × 180. *cic*, cicatrix; *col*, collenchyma; *cort*, cortex; *ep*, epidermis; *f*, fibres; *gl.tr.*, glandular trichome; *l.p.*, lignified pith; *n.gl.tr.*, non-glandular trichome; *p*, pith; *per*, pericycle; *ph*, phloem; *s*, starch; *st*, stoma; *tr*, trichomes; *xy*, xylem.

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DISCUSSION

The paper was presented by MR. P. S. COWLEY.

THE CHAIRMAN. It was the experience of some of those handling large quantities of commercial digitalis, that only on rare occasions were flowers present. In the authors experience did the quantity of flowers ever exceed the B.P. permitted limit of 2 per cent of foreign matter? Could the B.P. method for estimating foreign matter be applied and what microscopical characteristics were recommended for determining the inflorescence in the powdered drug?

DR. J. W. FAIRBAIRN (London). There could be no possibility of flowers in digitalis grown in this country, since this is now grown as an annual. Was the material examined by the Authors either foreign or wild? Was the contamination serious? Were there glycosides in the flowers? Was there a microscopic method for estimating the flower in the drug?

DR. T. E. WALLIS (London). Prepared digitalis might contain lucerne which has numerous flowers and the corolla of these would need to be compared with that of digitalis.

MR. V. REED (London). Are there instructions that leaves of commercial samples should be washed?

MR. COWLEY replied. No quantitative estimations of commercial samples had been made. In powders they could detect 0·2 per cent of added powdered corolla in powdered leaf using only one slide. It was possible to detect 0·1 per cent of matured fruits in the leaf. The B.P. did not direct that the leaves should be washed.

DR. ROWSON replied. He agreed that the majority of English digitalis was first-year biennial, continental material was frequently second year.

His experience was that contamination with flowers or mature fruit could easily occur when harvesting second-year biennial. Chemical tests showed the flowers to be moderately active, but not more than the leaf and he believed the glycosides in the seed differed from those in the leaf. No doubt the B.P. Appendix method could be applied to determine the corolla as the epidermis was characteristic. To estimate the entire inflorescence axis would be more difficult. He agreed that the characters of lucerne flowers would have to be investigated before it was possible to determine the amount of inflorescence in Prepared Digitalis B.P.