

ANATOMICAL STUDIES WITHIN THE GENUS  
HYDRANGEA

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Rehder (6) describes the members of the Saxifragaceae, of which there are about 75 genera with 700 species widely distributed in both hemispheres, as herbs, shrubs, or small trees. The leaves, he states, are alternate or opposite and usually without stipules. The flowers, which are five-merous, regular, and either hypogynous or perigynous, are either axillary or in terminal corymbs or occasionally in panicles. The fruit is either a several seeded capsule or berry.

The genus *Hydrangea* represents 35 species of deciduous, upright shrubs, excepting *H. petiolaris* which climbs by aerial roots. The leaves are opposite as a rule but often are whorled in *H. paniculata*; *H. quercifolia* is the only member of the genus having lobed leaves, which are also the largest found in the genus.

The species of *Hydrangea* are natives of North and South America and east Asia as far south as Java. The following species are native to North America: *arborescens*, New York to Iowa and southward to Florida and Louisiana; *cinerea*, North Carolina and Tennessee to Georgia and Alabama; *quercifolia*, Florida and westward to Mississippi; and *radiata* in the Carolinas. From North China we have *Bretschneideri*; West China, *xanthoneura setchuensis*; and *paniculata* and *petiolaris* from Japan and China.

## LITERATURE

The work that has been published on the genus *Hydrangea* shows that very little has been done so far; however, numerous references are made relative to the value of certain species of *Hydrangea* in landscaping and gardening. Of the various species mentioned, *H. quercifolia* or the "Oak-leaved Hydrangea" as it is commonly called, seems to receive most attention in popular literature. This species is not only prominent because of its large panicles of flowers, Sargent says, but also for its beautiful habit of growth. In the South, which is the native habitat for this species, *quercifolia* often attains a height of fifteen feet. Almost as attractive as the flowers or the plant's growth are the large lobed leaves, which assume a beautiful red color in the fall.

In the Silva of North America reference is also made to the relative value of *H. petiolaris* as a climbing shrub. The flowers are not as attractive as those of other species of the group, but the plant is excellent as a cover for old walls, stones, etc.

Rehder (6) has published a detailed and useful account of the external features of the Hydrangeas. His descriptions have been very helpful in describing the general and external features of the group.

He also gives the distribution and original habitats of the various species.

Solreder (7) collected and published the literature on the Saxifragaceae, and in it refers quite often to the genus *Hydrangea*. Holle (4) also published an account giving the anatomical features of the Saxifragaceae.

Engler and Prantl distinguish the American and Asiatic forms by means of the ovary and seeds. The Asiatic forms, they say, have half-superior ovaries and round or broadly-elliptic, unstriated seeds while the American forms have inferior ovaries with elliptic, longitudinally striated seeds.

The various keys noted in the literature have been based entirely on external features. The writer has undertaken this study to discover anatomical characteristics common to a species and its varieties, and if possible, to make keys using only anatomical differences.

#### ANATOMICAL FEATURES OF THE STEMS AND LEAVES OF *HYDRANGEA ARBORESCENS* AND VARIETIES *URTICIFOLIA* AND *GRANDIFLORA*:

##### PRIMARY TISSUES

**Epidermis.** The epidermises of this species and two varieties are very similar. As seen in surface view the cells are rectangular in each case although the cell cavities of the variety *urticifolia* are slightly larger than those of the species *aborescens* and variety *grandiflora*. The vertical diameter of an epidermal cell, which in most cases is the greater, measures .06 mm., while the tangential diameter is about .035 mm. and the radial diameter about .018 mm. Trichomes of the simple-clothing-hair type, which characteristically point upwards, are found on the younger portions of the stems, but the stem soon becomes glabrate. The trichomes of the species and its two varieties are similar and about .16 mm. in length. As is characteristic of the genus, the trichomes are heavily encrusted with calcium carbonate.

Tannin bodies are found in the epidermis of the species and its varieties; and an especially large amount of tannin occurs in the epidermal cells of variety *urticifolia*.

A thin cuticle measuring .003 mm. in thickness is found on the epidermis of the younger stems. No cutinization is present.

**Primary Cortex.** The primary cortex has about the same thickness in the species and two varieties; in stems having a diameter of 5 mm. the primary cortices measure about .2 mm. in thickness in each case. The greater part of the cortex is taken up by the 6-7 cell layers of collenchyma.

The cortices of this group are almost identical. The collenchyma cells are rectangular as seen in cross section and have radial and tangential walls of about the same thickness. As seen in longitudinal sections, the cells of the collenchyma are rectangular in shape, have vertical diameters of .07 mm. and radial diameters of .025 mm. Since the radial walls are about as thick as the tangential walls the col-

lenchyma is not crushed as early as we find it in other species of the genus.

The cortical parenchyma consisting of 3-4 layers of thin-walled cells contains a small amount of starch and a few crystal sacs filled with raphide crystals of calcium oxalate. The crystal sacs are prominent because of their relatively great size, becoming .055 mm. wide and about .08 mm. in vertical length.

**Primary Xylem.** The primary xylem of this species and its two varieties consists of 20-22 protoxylem points with the metaxylem exterior and filling in between the points to complete a vascular cylinder.

The protoxylem points, each consisting of 6-7 radial rows of tracheal tubes, are subtended by a lignified medullary sheath 2-3 cell layers thick. Between these radial rows of primordial tracheal tubes is quite a large amount of unligified, thin-walled xylem parenchyma in which starch is found.

The metaxylem completing the vascular cylinder is very limited in radial extent, there being one to two layers of tracheal tubes and a very few scattered tracheids. Between the tracheal tubes is a small amount of xylem parenchyma containing a little stored starch.

In cross section the annular tubes measure .025 mm. and the slightly larger metaxylem tubes measure .035 mm. The length of an annular element is about .12 mm., while an element of a metaxylem tube is approximately .16 mm. long.

**Primary Phloem.** Since there is little difference between the primary and secondary phloem, the two are discussed together under the secondary tissues.

**Pith.** The unligified pith in this group is quite an outstanding feature, since lignification of the pith is a common character of the genus as a whole.

As seen in longitudinal sections, the majority of pith cells are hexagonal. The radial diameter measuring .19 mm. is much greater than the vertical diameter which measures about .05 mm.

The pith is relatively large, measuring about 5 mm. in cross section in stems having diameters of about 7 mm.

Crystal sacs, similar to those found in the primary cortex, are commonly found in the pith of the younger stems. No reserve foods are found in the pith other than the starch commonly found stored in the medullary sheath.

#### SECONDARY TISSUES

**Periderm.** As in the majority of the species, the cork cambium is formed in the outermost part of the cortical parenchyma. The periderm measures about .17 mm. in the species *arborescens* and variety *urticifolia* while that formed in variety *grandiflora* measures approximately .23 mm.; in all three cases the stems measured about 5 mm. in cross section. The cork cells, which have undulated tangential walls, have radial diameters of .02 mm., tangential diameters of .03 mm., and vertical diameters of .04 mm.

The collenchymatous phelloderm varies in thickness from 3-5 cell

layers. It is interesting to note that in variety *urticifolia* the phelloderm formed is thicker than the cork, the phelloderm measuring about .09 mm. and the cork about .07 mm.

An abundance of starch and protein are stored in the phelloderm.

**Phloem.** In cross section, the phloem, both primary and secondary, measures approximately .12 mm. radially. Quite an outstanding feature of this group is the unusual amount of starch stored in the parenchyma of the outer phloem region and almost as prominent as the stored starch is the protein found in the phloem tissues.

The few sieve tubes are rather large, measuring .03 mm. in cross section and the sieve tube elements have vertical diameters of .07 mm. The companion cells are made evident by the quantity of protein they contain. In cross section the companion cells are .02 mm. by .01 mm., and extend vertically approximately the length of a sieve tube element.

**Secondary Xylem.** Perhaps the most outstanding feature of the secondary xylem in this group is the great number of tracheids which are in definite radial rows. In these radial rows of tracheids is an occasional tracheal tube and on either side of the rows are xylem rays. Scattered wood fibers are sometimes found along the sides of tracheids. It is interesting to note that when wood fibers are found, the tracheids adjoining them are smaller than usual, suggesting that tracheid and fiber might have come from the same cambial initial.

Secondary tracheal tubes measure approximately .02 mm. in cross section, whereas the tubes of the metaxylem measure as much as .035 mm. across. However, the vertical diameter of a secondary tracheal tube element measures as much as .35 mm., which is more than twice the vertical diameter of a primary tracheal element.

In cross section an average-sized tracheid measures .02 mm. tangentially, .013 mm. radially and its length is about .06 mm. Wood fibers measure .01 mm. in cross section, with cavities half this breadth. The length of a wood fiber is approximately .9 mm.

An abundance of xylem parenchyma, the cells of which measure .02 mm. in cross section and have vertical diameters of .07 mm., contains a large amount of reserve starch.

Both uniseriate and multiseriate rays occur in this group. The multiseriate rays, 3-4 cells wide, are found adjoining the protoxylem points and extend to the outer edge of the phloem. The uniseriate rays as stated above, are found on either side of the radial rows of tracheids; these, too, extend to the outer edge of the phloem.

An average-sized cell of the ray (those nearer the lower and upper extremities have greater vertical diameters) measures .019 mm. in cross section and .06 mm. vertically.

As in the xylem parenchyma, much starch is stored in the rays.

#### LEAVES

**General Features.** The leaves of this group are very similar, but vary in minor features. The leaves of variety *urticifolia* are more sharply acuminate and the tips of the leaves of *arborescens* are less sharp and sometimes rounded. The leaves of *arborescens*, which are

the largest, are from 6-20 cm. long, while the leaves of *urticifolia* are from 4-10 cm. long. The leaves of *arborescens* and variety *urticifolia* are somewhat crenate, and the bases round to cordate. The leaves are glabrous above but slightly pubescent on the under surface along the veins; they are of uniform texture and average about .21 mm. in thickness.

**Epidermis.** The lateral walls of the upper epidermal cells of *arborescens* are slightly undulated, a feature lacking in the varieties. (Fig. 31). The cells as seen from the surface are irregular in shape, averaging .055 mm. in diameter. The cells of the lower epidermis are similar (Figs. 27, 28, 34); however, those of variety *grandiflora* are slightly larger than those of *arborescens* and variety *urticifolia*. The trichomes found along the veins on the lower surface have quite thick walls which are somewhat roughened by encrustation with calcium carbonate. A cuticle measuring .001 mm. in thickness is found on the upper epidermis, but cutinization is absent.

**Mesophyll.** One layer of palisade cells .04 mm. in length and .017 mm. in cross section occupies about one third the mesophyll volume. The cells of the spongy parenchyma are irregular with large intercellular spaces between them. Large crystal sacs are commonly found in the spongy layer.

**Midrib.** The midribs are ovate as seen in cross section and project slightly above the leaf surface. The projection is composed largely of collenchyma, which is also found on the lower surface of the midrib. The vascular tissue is in the form of an arc which is surrounded by thin-walled parenchyma cells. (Figs. 19, 21, 22.)

**Margins.** The margin of *arborescens* species is the only one studied which is incurved. Collenchyma is also lacking in the margin of this species. The normal leaf structure of variety *urticifolia* continues to within .17 mm. of the margin where collenchyma is found. Collenchyma extending .3 mm. from the margin is found in variety *grandiflora* and here the outer walls of the epidermal cells are slightly thicker than farther back in the leaf surface. (Figs. 7, 8, 9.)

**Petioles.** The petioles are relatively large as seen in cross section, measuring from 2-2.5 mm. from the lower to the upper surface and 2-3 mm. in breadth. Three vascular bundles enter the petioles but they soon divide and redivide so that midway of the petiole there are 11-12 small bundles arranged in a semicircle. Near the leaf blade the bundles fuse to form a vascular arc which continues into the midrib. Three to four cell layers of thick-walled collenchyma are found below the epidermis. The vascular tissues are surrounded by thin-walled parenchyma cells which contain tannin, and among which are crystal sacs filled with crystals of calcium oxalate.

**Venation.** The midrib passes upward into the leaf apex; from the midrib branch veins which pass outward and upward along the margin. The veinlet meshes are relatively large, with a frequency of from 2 to 3 meshes per sq. mm. Free vein endings occur only in the larger meshes where from 2-3 are usually found. (Figs. 36, 40, 41.)

*HYDRANGEA BRETSCHEIDERI* AND VARIETIES  
*LANCIFOLIA* AND *GLABRESCENS*:

PRIMARY TISSUES

**Epidermis.** The epidermal cells of the stem of this species and its two varieties are very much alike. As seen in surface view the cells are so very irregular that it is difficult to distinguish the tangential from the longitudinal diameters. The longer diameter of an average-sized cell is .04 mm. and the shorter diameter about .02 mm. (Figs. 16, 17, 18.)

The trichomes found on the young stems are very interesting, there being trichomes of the simple-clothing-hair type and also longer ligulate ones in great abundance. We would expect to find fewer trichomes on variety *glabrescens*; however, from the material I have used in my study I was not able to note an appreciable difference in size or numbers.

As in the species *arborescens*, the trichomes of the simple clothing-hair type are heavily encrusted with calcium carbonate; however, the ligulate trichomes show very little of such encrustation, although we do find an occasional projection of the cuticle from the cell wall.

The simple clothing-hair type of trichome measures approximately .35 mm. in length, where as those of the ligulate type are much longer, exceeding 2 mm. in some cases.

**Primary Cortex.** Rehder describes *Bretschneideri* as having "chestnut-brown bark peeling off in thin flakes." In the youngest material which I studied, I found this distinctive brown color; however, I find the dark-brown color due to the dead epidermis and collenchyma tissues. The cortex of a one-year old stem measuring 2 mm. in cross section has a thickness of .1 mm.; of this cortex the stretched, dead collenchyma occupies about .06 mm. The cortical parenchyma, which contains a few crystal sacs, measures about .04 mm. in thickness.

Because of the early formation of internal cork, the cortical tissues soon die, and become crushed, making it impossible to give the dimensions of the individual cells at this time.

**Primary Xylem.** The primary xylem is about the same in the species and two varieties, there being from 16-20 protoxylem points at the second internode of the current year's growth.

The tracheal tubes of the protoxylem in the species and its two varieties are in definite radial rows as in *arborescens*. Between the radial rows of tracheal tubes is a large amount of unligified wood parenchyma containing much starch.

Around each protoxylem point is a partially lignified bundle sheath, slightly thicker than the sheath found in the varieties of *arborescens*. In this thick-walled bundle sheath is found a large quantity of oil, an especially large amount being found in *Bretschneideri* species.

In cross section the tracheal tubes of the protoxylem are approximately .02 mm., the tangential and the radial diameters being approximately the same. The vertical diameter of the tracheal elements is about .3 mm.

**Metaxylem.** Very little metaxylem is formed exterior to the protoxylem; however, the protoxylem points are connected by the metaxylem. A few thick-walled fibers are found adjoining the tracheal elements of the metaxylem. The tracheal elements of the metaxylem are very similar to those of the second xylem and measure .03 mm. in cross section and have vertical diameters of .09 mm.

**Pith.** The pith of *Bretschneideri* species and its varieties is lignified, whereas that of *arborescens* and its varieties showed no lignification.

There are very few crystal sacs in the pith of *Bretschneideri* and none were found in the pith of the two varieties.

An outstanding characteristic of the pith of the species *Bretschneideri* and its varieties is the large amount of oil stored in the pith; especially was this noticeable in variety *glabrescens*.

#### SECONDARY TISSUES

**Periderm.** One of the most outstanding features of this group is the early formation of a phellogen and the large amount of cork formed. In the species and two varieties the phellogen is formed by the innermost row of cortical parenchyma. In the table below are given the number of rows of cork cells, the thickness of the periderm, stem, etc.

	Thickness of stems.	Rows of cork cells.	Thickness of phellogen	Thickness of periderm
<i>H. Bretschneideri</i>	2 mm.	11-12	.08 mm.	.32 mm.
Var. <i>lancifolia</i> ...	2 mm.	12-13	.06 mm.	.24 mm.
Var. <i>glabrescens</i> .	5 mm.	14-15	.1 mm.	.4 mm.

The cell walls of the parenchymatous phellogen are slightly thickened. Schizogenous intercellular spaces are very common in the phellogen; especially large spaces are found in the variety *glabrescens*.

A large amount of starch is stored in the phellogens of this group; variety *lancifolia* has the least amount of starch but perhaps a little more protein. Very little oil is found in the phellogen of the two varieties but quite a large amount was noticed in that tissue of *Bretschneideri* species.

**Phloem.** The phloem in the species and its two varieties show little differences. Little phloem is formed in any of the species studied, but there are no indications of the phloem being crushed in a two-year-old stem.

The phloem measures approximately .07 mm. in thickness. Sieve tubes measure about .0275 mm. in cross section and the vertical diameters of the elements average .06 mm. The companion cells, which are slightly smaller than the sieve tubes in cross section, measure .02 by .01 mm. but may have vertical diameters of .06 to .08 mm.

In the phloem of *Bretschneideri* a great amount of oil is stored, but very little is found in the varieties. The amount of protein in the phloem is about the same in the species and varieties.

**Secondary Xylem.** The secondary xylem shows no great differences from that described for *arborescens*. There is a slight difference in the amount of secondary xylem formed in this group, which may be caused by slightly more favorable growing conditions.

The medullary rays are either uniseriate or biseriate. Those found in *Bretschneideri* species are mostly biseriate. The rays vary from 6 to 12 cells in depth and extend from .3 mm. to .48 mm. vertically. Individual cells of the rays are approximately .03-.04 mm. vertically and .03 mm. radially.

Starch is stored in all the rays of this group; an exceptionally large amount being found in the primary rays of variety *glabrescens*. Oil is found in the rays of *Bretschneideri* only.

#### LEAVES

In discussing the leaves, I shall describe the leaves of *Bretschneideri* species and then point out how the varieties differ from the species.

**General Features.** The leaves of *Bretschneideri* are 7-12 cm. long, elliptic to oblong-ovate and have serrate margins. The apices are acute to acuminate and the bases cuneate. The leaves are glabrous above, but villous beneath. The leaf blade has a thickness of about .28 mm. and the petioles, which are not winged, are from 1-3 cm. long.

The leaves of variety *glabrescens* are smaller, being from 4-10 cm. long, more elliptic, more coarsely serrate and sparingly pubescent beneath.

As the name of the variety suggests, the leaves of *lanceifolia* are lanceolate and have serrate margins. Their lower surfaces are covered with short, fine trichomes which are more numerous and finer than those found on the variety *glabrescens* or the species. The leaves of *lanceifolia* are from 10-20 cm. long.

**Epidermis.** As seen from the surface, the leaf epidermises of this group are very much alike, the cells being irregular in outline and variable in size, but those of the lower epidermises are distinctly smaller than those of the upper. The cells of the upper epidermises vary from .05-.06 mm. in diameter, while those of the lower epidermis average .04 mm. The radial diameters average .03 mm. (Figs. 26, 28, 29, 30, 32, 33.)

The trichomes found on the lower surface of the leaves vary greatly, both in size and in numbers. Those found on the leaves of *Bretschneideri* measure 1.5 mm. in length and are also quite numerous. The trichomes are rather sparse on leaves of variety *glabrescens* and are about the same size as those of *Bretschneideri* species. Trichomes occur most abundantly on the leaves of variety *lanceifolia*, but they are smaller and finer than those found on the other members of this group, averaging only 1 mm. in length. In all cases the trichomes are encrusted with calcium carbonate.

A thin cuticle is found mainly on the upper surface, with only traces on the lower. Very little difference in the thickness of the outer and inner walls of the epidermal cells was noted.

A count of the stomata shows that there are from 200-275 per sq. mm.

**Mesophyll.** The number of palisade cells varies from 5,000 per sp. mm. in *glabrescens* to 6,210 in *Bretschneideri*. They are .1-.12 mm. long and about .02 mm. wide and occupy about one half the mesophyll

volume. The cells of the spongy parenchyma as in *arborescens* are very irregular and have large intercellular spaces between them.

Crystal sacs lying parallel to the leaf surface and averaging .16 mm. in length are very common in the spongy mesophyll, and are quite outstanding in bleached leaves.

**Leaf Margins.** As seen in cross section the leaf margins are very blunt. The margin of *Bretschneideri* differs from the other two (Figs. 10, 11, 12) by having two rows of palisade cells while back from the margin there is only one row.

Next to the margin is a small amount of collenchyma, and here the outer and inner walls of the epidermal cells are thicker than those farther in from the margin. The cuticle is thicker at the margin and is somewhat serrate. It measures .003 in thickness.

**Midribs.** The midribs of the species and varieties show a marked similarity when seen in cross section. (Figs. 20, 23, 24.) The midribs of *Bretschneideri* species and variety *glabrescens* are the larger, measuring 1.5 mm. in thickness while the midrib of variety *lancifolia* measures about 1 mm. in thickness.

In each case there is a slight projection of the midrib above the leaf blade composed of 4-5 cell layers of collenchyma extending entirely around the midrib. In the ground tissue around the vascular arc is found a notable amount of tannin. The vascular tissues compose a concentric bundle, the phloem entirely surrounding the xylem.

**Petiole.** Other than the petiole of variety *lancifolia* being slightly smaller than those of *Bretschneideri* and variety *glabrescens*, there is little difference in the petioles of this group. In cross section they are ovate wing-like projections at either side of the upper surface.

Beneath the epidermis are 4-5 cell layers of collenchyma cells with prominent walls which measure as much as .03 mm. in thickness.

The ground parenchyma of rather loose structure contains numerous crystal sacs and quite a large amount of tannin. At the base of the petioles are three bundles, one below the middle and one above either side of the lower. As the bundles pass through the petiole they gradually fuse to form a concentric bundle, the phloem surrounding the xylem as in the midrib mentioned above.

**Venation.** The leaves of this group have prominent midribs from the base to the apex. From the midrib lateral veins are alternately given off which pass outward and upward along the margin. In bleached leaves, at a distance of 2 mm. from the apex we find the midrib and two lateral veins along the margin. As is characteristic of all the leaves, the meshes are relatively large, there being an average of 4.5 meshes and 4 free vein endings per sq. mm. (Figs. 37, 38, 39.)

#### SUMMARY

This brief study shows that there is a close anatomical relation between the species and their varieties, and also that there are anatomical differences among the various species.

As a result of this study, I have noted several outstanding differences.

1. The pith of *Bretschneideri* and varieties *lanceifolia* and *glabrescens* is lignified, whereas the pith of *arborescens* and varieties *grandiflora* and *urticifolia* shows no lignification.

2. Oil, as evidenced by Sudan III, is present in large amounts in the *Bretschneideri* group but was absent in the other group studied.

3. Multiseriate rays are common in *arborescens* and its varieties but are not found in the other species mentioned.

4. Cork is formed earlier and more abundantly in *Bretschneideri* and its varieties.

5. The stem epidermises of *Bretschneideri* and its varieties have cells that are elongated and somewhat rectangular but those of *arborescens* and its varieties are very irregular and with little differences in the tangential and vertical diameters.

6. On the stem epidermises of *Bretschneideri* and its varieties are found two kinds of trichomes, those of the simple clothing-hair type and also longer ones of the ligulate type.

7. The phelloderm of *arborescens* and its varieties is also different from that of *Bretschneideri* by being collenchymatous while that of the *Bretschneideri* is parenchymatous.

8. Crystal sacs are common in the pith of the *arborescens* group but are lacking in the *Bretschneideri* group.

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The drawings used in this paper were made with the aid of a right-angle, arc-light, microprojection apparatus.

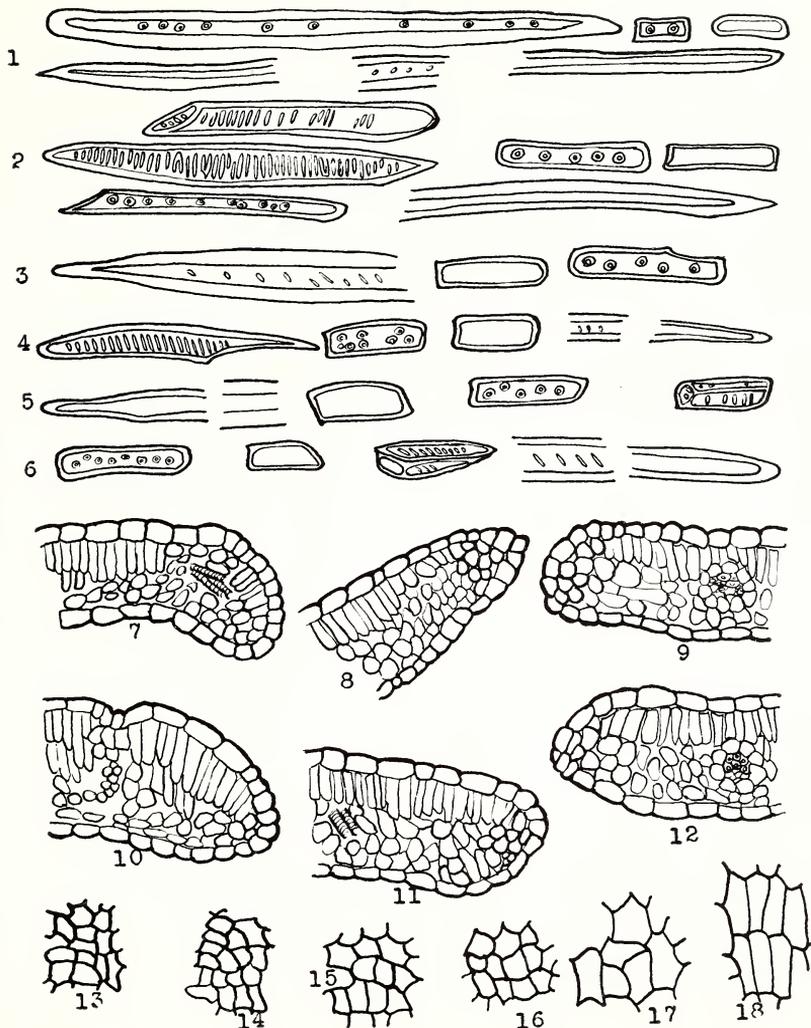


PLATE I

Figures 1-6, drawings of the xylem elements. x 162

Fig. 1. *Hydrangea arborescens*

Fig. 2. *Hydrangea arborescens grandiflora*

Fig. 3. *Hydrangea arborescens urticifolia*

Fig. 4. *Hydrangea Bretschneideri*

Fig. 5. *Hydrangea Bretschneideri glabrescens*

Fig. 6. *Hydrangea Bretschneideri lanceifolia*

Figures 7-12, drawings of the leaf margins. x 125

Fig. 7. *Hydrangea arborescens*

Fig. 8. *Hydrangea arborescens grandiflora*

Fig. 9. *Hydrangea arborescens urticifolia*

Fig. 10. *Hydrangea Bretschneideri*

Fig. 11. *Hydrangea Bretschneideri glabrescens*

Fig. 12. *Hydrangea Bretschneideri lanceifolia*

Figures 13-18, drawings of stem epidermises. x 162

Fig. 13. *Hydrangea arborescens*

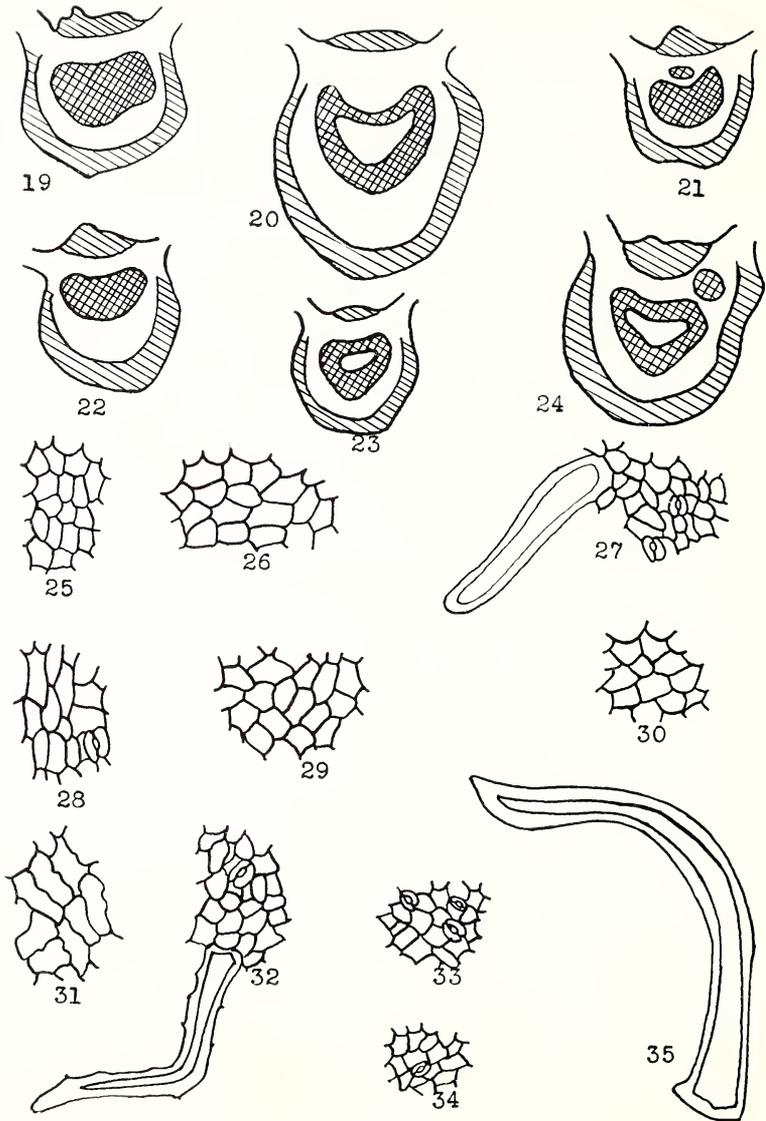
Fig. 14. *Hydrangea arborescens grandiflora*

Fig. 15. *Hydrangea arborescens urticifolia*

Fig. 16. *Hydrangea Bretschneideri glabrescens*

Fig. 17. *Hydrangea Bretschneideri lanceifolia*

Fig. 18. *Hydrangea Bretschneideri*



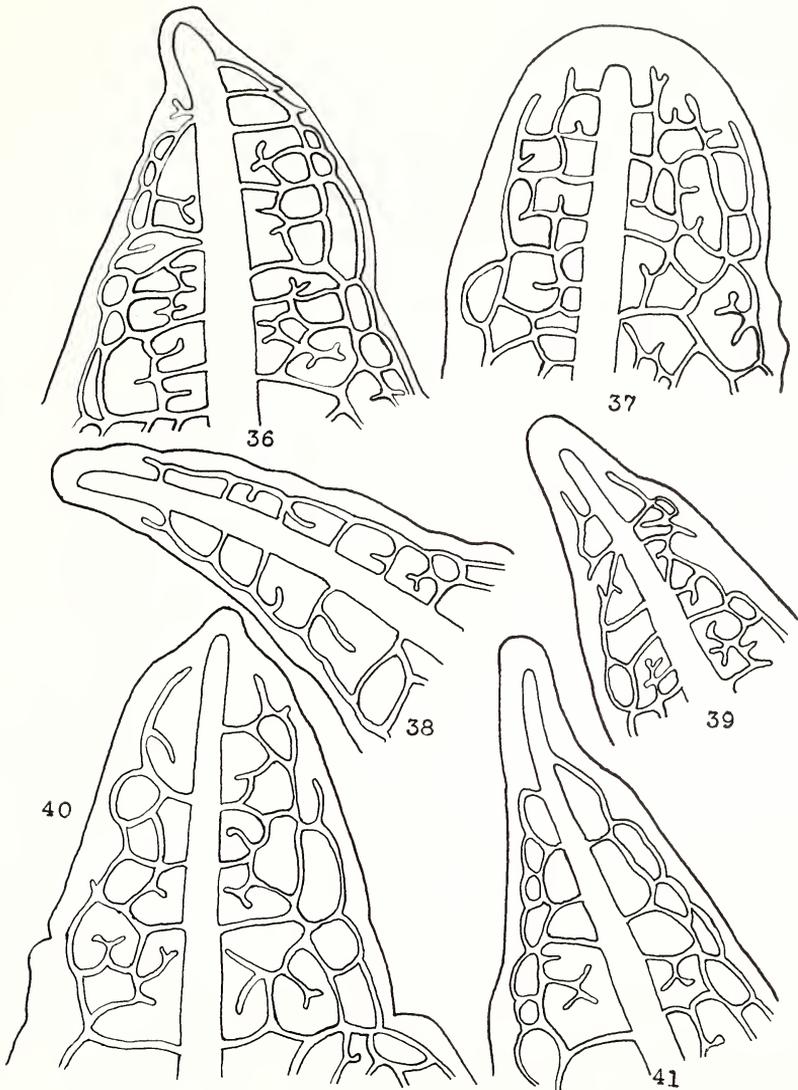
## PLATE II

Figures 19-24, drawings of cross sections of the midribs. (Vascular tissues solid; collenchyma shaded.) x 28

- Fig. 19. *Hydrangea arborescens grandiflora*  
 Fig. 20. *Hydrangea Bretschneideri glabrescens*  
 Fig. 21. *Hydrangea arborescens urticifolia*  
 Fig. 22. *Hydrangea arborescens grandiflora*  
 Fig. 23. *Hydrangea Bretschneideri lancifolia*  
 Fig. 24. *Hydrangea Bretschneideri*

Figures 25-35, drawings of the upper and lower epidermises. x 182

- Fig. 25. Upper epidermis of *H. arborescens grandiflora*  
 Fig. 26. Upper epidermis of *H. Bretschneideri*  
 Fig. 27. Lower epidermis of *H. arborescens grandiflora*  
 Fig. 28. Lower epidermis of *H. Bretschneideri*  
 Fig. 29. Upper epidermis of *H. Bretschneideri lancifolia*  
 Fig. 30. Upper epidermis of *H. Bretschneideri glabrescens*  
 Fig. 31. Upper epidermis of *H. arborescens*  
 Fig. 32. Lower epidermis of *H. Bretschneideri glabrescens*  
 Fig. 33. Lower epidermis of *H. Bretschneideri glabrescens*  
 Fig. 34. Lower epidermis of *H. arborescens*  
 Fig. 35. Trichome on stem of *H. Bretschneideri* x 182



## PLATE III

Figures 36-41, venation drawings of leaf tips. x 28

- Fig. 36. *Hydrangea arborescens*  
 Fig. 37. *Hydrangea Bretschneideri*  
 Fig. 38. *Hydrangea Bretschneideri glabrescens*  
 Fig. 39. *Hydrangea Bretschneideri lancifolia*  
 Fig. 40. *Hydrangea arborescens grandiflora*  
 Fig. 41. *Hydrangea arborescens urticifolia*

