COMPARATIVE ANATOMICAL RESEARCH
WITHIN THE GENUS PYRUS

by

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GENUS PYRUS AND ALLIED GENERA

The Rosaceae, of which the genus Pyrus is a part, embraces about 100 genera and 2,500 species. The living Rosaceae are distributed over nearly the whole earth, but in varying frequency and with uneven representation of the various sub-families and groups. Fossil Rosaceae are found in the Tertiary and Quaternary deposits of Europe and America; and leaves in the chalk of America are attributed by Newberry to Pyrus. On account of their similarity to the corresponding parts of the living Rosaceae, many leaves and fruits found in the Tertiary deposits have been placed in the genera Spiraea, Prunus, Pyrus, Cotoneaster, and Crataegus.

This family includes a large group of trees, shrubs, herbs, and climbers of a very diverse habit which are widely distributed, but most abundantly in the temperate regions.

The following is Rehder's (1927) key to the sub-families:
A. Fr. consisting of 1-5, rarely to 12 dehiscent follicles, indehiscent only in No.12, or fr. a dehiscent caps.; stipules present or wanting..................1. Spiraeoideae.
AA. Fr. indehiscent: lvs. stipulate.

B. Ovary inferior; the 2-5 carpels more or less connate and adnate to the cup-shaped receptacle: fr. a pome, sometimes berry-like.........................2. Pomoideae.
BB. Ovary superior (apparently inferior in Rosa).
   c. Carpels usually many (if 1 or 2, not drupaceous); calyx persistent: lvs. often compound ........3. Rosoideae.
   cc. Carpel usually 1, rarely 2 or 5, drupaceous; calyx usually deciduous: lvs. always simple ...4. Prunoideae.

The following is a key to the sub-family Pomoideae of which Pyrus is a part:
A. Carpels bony at maturity; fr. with 1-5 stones.
   B. Lvs. entire or lobed.
   C. Lvs. entire or rarely serrulate: brs. unarmed.
   D. Fls. usually in several-to many-fld. corymbs, not more than 1 cm. across:
fr. about 1 cm. across or less: pistils 2-5........Cotoneaster.

DD. Fls. solitary, 3-5 cm. across: fr. 3-5 cm. across, brown with foliaceous calyx-lobes: pistils 5...... Mespilus.

CC. Lvs. crenate, dentate or lobed, rarely entire: brs. usually spiny.

D. Lvs. persistent, crenate or entire:
   pistils 5, with 2 fertile ovules....... Pyracantha.

DD. Lvs. deciduous, rarely subpersistent:
   pistils 1-5, with 1 sterile and 1 fertile ovule............ Crataegus.

BB. Lvs. pinnate; lfts. small, entire.... Osteomeles.

AA. Carpels with leathery or papery walls at maturity:
   fr. a 1-5-celled pane, each cell with 1 or more seeds.

B. Fls. in compound corymbs or panicles.
   c. Carpels partly free; styles 2-5, distinct or connate: fls. in corymbs or broad corymbose panicles.

D. Ovary in fr. free only at apex or 1/3 of its length; endocarp not dehiscent; styles 2-5.
E. Pedicels and infl. not verrucose:
  lfs. deciduous.

F. Styles 2-5: lvs. pinnate or
  simple and often lobed, usually
  with excurrent veins: calyx-
  lobes sometimes deciduous. Sorbus

FF. Styles 5, connate below: lvs.
  simple, with curving veins,
  glandular-denticulate, glandular
  on midrib above: calyx-lobes
  persistent. Aronia

EE. Pedicels and infl. verrucose, or
  smooth and lvs. persistent: lvs.
  simple, serrulate. Photinia

DD. Ovary in fr. (core) free to the middle
  and endocarp at full maturity dehiscent:
  lvs. persistent, entire or serrulate. Stranvaesia

CC. Carpels wholly connate; styles 5, distinct:
  fls. in panicles: fr. pear-shaped, yellow,
  3-4 cm. long: lvs. evergreen, with excurrent
  veins. Ericobotrya

BB. Fls. in umbels, racemes or solitary.

C. Carpels 4-many-seeded.

D. Styles connate at base: lvs. serrate or
crenate, rarely entire.
E. Ovules 4-10 in each cell; calyx tomentose outside. Docynia.
EE. Ovules many in each cell; calyx glabrous outside. Chaenomeles.
DD. Styles free: lvs. entire. Cydonia.
CC. Carpels 1-2-seeded.
D. Ovary and fr. 2-5-celled; cells 2-ovuled.
E. Lvs. evergreen: ovary 2-celled; lvs. in upright racemes, sometimes panicled; fr. black. Rhaphiolepis.
EE. Lvs. deciduous: ovary 2-5-celled; lvs. in umbel-like racemes.
F. Styles connate at base: fr. usually apple-shaped, without or with few grit-cells. Malus.
FF. Styles free: fr. usually pear-shaped; its flesh with numerous grit-cells. Pyrus.
DD. Ovary and fr. incompletely 6-10 celled; cells 1-ovuled.
E. Lvs. usually in racemes; styles usually 5: lvs. serrate or crenate. Amelanchier.
EE. Lvs. in few-fld. umbels; styles 2-3: lvs. entire or denticulate, narrow. Peraphyllum.
Within the genus Pyrus there are about 20 species, found mostly from Europe to East Asia and south to North Africa; and also common in Persia and the Himalayas.

According to Rehder a majority of the species of Pyrus in North America are found within zones IV and V. Zone IV includes the southern portion of Maine, lower half of New Hampshire and Vermont, the middle-third of New York, southern half of Michigan, a small portion of northern Ohio, Indiana and Illinois, dipping down into the northern part of Missouri, a small strip across northern Kansas, a strip across the middle of Nebraska, then down into northwestern Colorado, and including practically all of Wyoming, a portion of east Idaho and west Montana.

Zone V includes Massachusetts, Connecticut, lower portion of New York, Pennsylvania and Ohio, middle portion of Indiana, Illinois, and Missouri, practically all of Kansas, a tip off western Nebraska, a narrow strip through the middle of Colorado, eastern and southern portions of Utah,
a narrow strip through middle of Idaho and the southern and eastern portions of Washington.

The genus Pyrus includes deciduous, rarely half-evergreen sometimes thorny trees or rarely shrubs. The leaves are simple, serrate or entire, rarely lobed, involute in the buds, petiolate, stipulate; buds with imbricate scales. The white, rarely pinkish flowers appear with or before the leaves, in umbelliform racemes; sepals usually reflexed or spreading; petals clawed, suborbicular to broad-oblong; stamens 20-30, anthers usually red; styles 2-5, free, closely constricted at the base by the disk; ovules two in each locule.

Fruit usually a pyriform pome; flesh with copious grit-cells; walls of locules cartilaginous; seeds black or nearly black.

The following is a key to the various species of the genus Pyrus:

Fr. with persistent calyx.

A. Lvs. entire or crenate-serrulate, undivided.

B. Lvs. usually oblong and obtusish, papillose beneath, entire or slightly crenulate toward the apex, glabrescent...P.amygdaliformis.
BB. Lvs. not papillose beneath.
   C. Lvs. entire, cuneate, usually pubescent beneath.
   D. Lvs. linear-lanceolate to lanceolate, lustrous above........P. salicifolia.

DD. Lvs. broader.
   E. Lvs. lanceolate to narrow-elliptic.
       P. elseagrifolia.
   EE. Lvs. elliptic to obovate...
       P. nivalis.

CC. Lvs. crenate-serrulate all around, orbicular-ovate to oblong-ovate.
    P. communis.

AA. Lvs. at least partly pinnatifid..
    P. heterophylla.

AAA. Lvs. setosely serrate, generally ovate, glabrous...............P. ussuriensis.

Fr. with deciduous or partly deciduous calyx, brown.
   A. Lvs. dentate or sharply serrate.
   B. Lvs. sharply serrate or serrulate, often with appressed teeth; 6-12 cm. long.
   C. Fr. yellow: lvs. broad-cuneate at base; styles 5, rarely 4.......P. Bretschneideri.
CC. Fr. brown: lvs. usually rounded or subcordate.

D. Styles 5: lvs. setosely serrate or with appressed acuminate teeth. *P. serotina.*

DD. Styles 3-4; calyx occasionally partly persistent: lvs. serrulate with acute teeth. *P. serrulata.*

BB. Lvs. dentate-serrate with more or less spreading teeth: styles 2-4:

C. Lvs. glabrous, 6-10 cm. long: styles 3-4, rarely 2: fr. subglobose or pyriform, 1.5-2.5 cm. long. *P. phaeocarpa.*

CC. Lvs. pubescent, 4-7.5 cm. long: styles 2 or 3: fr. subglobose, about 1 cm. diam. *P. betulifolia.*

AA. Lvs. crenate or crenulate-serrulate.

B. Lvs. crenate-serrulate, orbicular-ovate to ovate, about 5 cm. long; styles 5. *P. longipes.*

BB. Lvs. crenate.

C. Styles 3-5; stamens 25-30: lvs. ovate to oblong. *P. pashia.*

CC. Styles 2-3; stamens 20: lvs. orbicular-ovate to oblong-ovate. *P. Calleryana.*
GEOGRAPHICAL DISTRIBUTION AND INTRODUCTION INTO CULTIVATION.

Giving only the Species Studied in this Thesis.

P. congesta.
This species is a hybrid of P. betulaefolia and P. elaegnofolia, and originated about 1890.

P. communis.
Originally found in Europe and western Asia. It is the common pear and has been long in cultivation, although often escaped and naturalized.

P. Bretschneideri.
Found in northern China and introduced into cultivation about 1880.

P. phaeocarpa globosa.
Introduced about 1882 from northern China.

P. betulaefolia.
Found in northern China and introduced into cultivation about 1865.

P. communis cotinifolia.
A variety of P. communis found in Europe.
P. pashia.
Found from the Himalayas to western China.
Introduced about 1908.

P. eleagnifolia.
This species was found in Asia Minor and western China and introduced into cultivation about 1800.

P. Michauxii.
Introduced and cultivated before 1816. Origin in Asia Minor. This species is a hybrid between P. amygdaliformis and P. nivalis.

P. P. amygdaliformis.
Originated in Southern Europe and Western Asia. Introduced about 1810.

P. persica.
Introduced into cultivation from Western Asia before 1810.

P. ussuriensis.
This species was found in North Eastern Asia and Western Asia. Was introduced about 1855.

P. nivalis.
Commonly called the snow pear. Originated in Eastern Europe and first cultivated in 1800.
SUMMARY OF THE PUBLISHED ANATOMICAL RESEARCH
ON THE POMOIDEAE AND THE GENUS PYRUS.

We find some literature on the anatomy of the genus Pyrus. Solereder (08) has summarized this in his book on the anatomy of the dicotyledons. He discusses the leaf structure, trichomes, structure of the axis, cork and structure of the wood of the stem. The outstanding anatomical features, which are characteristic of the genus are given by Solereder as follows:

1. Stomata on the lower surface of the leaf only.
2. The hairy covering consists of simple, unicalellular hairs and glandular hairs.
3. Superficial cork formation with the epidermis as the place of origin.
4. Outer portion of the primary cortex is frequently collenchymatous.
5. The secondary hard bast forms connected cylinders arranged concentrically.

Also Solereder found (Uber den Systematischen Wert der Holzstructur 3.111) simple perforations in the ends of the tracheal tube elements predominating,
but also scalariform perforations occur, excepting in the Chrysobalanoidaceae; the prosenchyma for the most part has bordered pits.

The Roman classicists, Virgil and Horace, called the pear tree "Pirus". The writing "Pyrus" arose in the middle ages.

According to Saniro ('63) the tracheal tubes of Pyrus communis show a spiral thickening. As compared with Pyrus communis, Malus communis has in general wider tracheal tubes, broader tracheids and wood parenchyma cells, and larger medullary rays; but these sizes are not absolutely distinctive features of the two woods.

All the investigated Pomeaceae show an essential similarity in the structure of the wood; but some genera (Cydonia Mespilus) or groups (Sorbus) can be distinguished by sections of the wood. Pyrus and Crataegus are hardly to be distinguished, also Amelanchier and Malus. Perhaps some species can be thus determined. This much is evident, that the species differ less in the structure of the wood than they do in the outer form of their members.
The characters that may be used are:

1. The presence or absence of tertiary thickening of the walls of tracheal tubes and tracheids.
2. The radial diameter of the tubes.
3. The height of the rays.
4. The number of rays per mm. in cross sections, or the distance apart of the rays.
5. The number of rows of ray cells seen in tangential sections.

A KEY TO THE GENERA OF THE POMACEAE.

1. Tracheal tubes without tertiary thickening.
   Rays 1-3-rowed, 1-rowed very frequently:
   2-rowed frequently; 3-rowed seldom.
   A. 10-13 rays per mm. in cross section.
      Tube radial breadth 0.030-0.040 mm. (In Malus communis sometimes more) Height of medullary ray cells 0.013 mm. Malus, Amelanchier.
   B. 13-16 rays per mm. in cross section.
      (a) Tube width 0.030-040 mm. (In Pyrus
communis up to 0.050 mm); height of ray cells 0.013-0.015 mm. *Pyrus.*

(b) Tube width mostly 0.040-0.045 mm seldom as small as 0.033 or larger than 0.050 mm; height of ray cells mostly 0.015-0.018 mm; seldom as small as 0.0146 mm, or as large as 0.0205 *Crataegus.*

(c) Tube width 0.035-0.041 mm; average height of the rays in the annual ring 0.020-0.021 mm; height of rays very unequal; along with the low (0.014 mm) occur also high (1-0.030 to 0.050 mm) rays, in which the radial length is smaller than or equal to the radial height. *Fyracantha.*

II Tracheal tubes with tertiary thickening.

A. Rays 1-2-rowed, more frequently 1-rowed.

Tracheids with spiral thickening. 15-17 rays per mm. in cross section. Tube radial width mostly 0.033-0.040 mm. Ray-cell distance 0.019-0.022 mm. *Cotoneaster*

B. Medullary rays 1-3-rowed (mostly 2, often, seldom 3-rowed.)
(a) 9-12 rays per mm. in cross section.
(a') Tube radial width 0.038-0.046 mm; (Markestrahl-
Zellenhohe) ray cells height 0.013-0.014 mm. Cydonia.
(b') Tube radial width 0.038-0.050 mm; ray-cell height
mostly 0.014-0.017 mm. (in Sorbus suecica 0.018-0.020 mm.)

Sorbus.

(b) 12-13 rays per mm. in cross section.
Tube radial width 0.034-0.044 mm;
ray-cells height 0.013-0.014 mm.

Aronia.

(c) 13-14 rays per mm. in cross section.
Tube width 0.030-0.035 mm. Ray-cells
height 0.013-0.014 mm. Chaenomeles.

C. Medullary rays 1-4-rowed.
Möller ('76) has described the wood of Pyrus
intermedia. Referring to this species he states
that the woods of Pyrus prunifolia, Amelanchier
Botryapium and Crataegus crisatalis agree with this
histologically.
P. Schulz ('83) has investigated the medullary rays of many woody plants. He remarks that essentially the same picture is presented by the medullary rays of Pyrus, Crataegus oxyacantha, Sorbus aucuparia and Cotoneaster vulgaris. Relative differences do occur, furnishing differentiating characters. He took data on the following characters:

a. The radial diameter (lumen and cell wall) of the tracheal tubes in the early growth.

b. The radial diameter (lumen and wall) of the tracheids.

c. The radial diameter of the wood parenchyma.

d. The height of the medullary ray cells.

e. The breadth of the medullary rays.

He found that in Pyrus communis the medullary rays are one to three rowed.

Wiesner (1928) has described the wood structure of Pyrus communis.

Burgerstein ('95) states that the wood of the Pomaceae consists of the tracheal elements: tracheal tubes and tracheids and parenchymatous tissues:
wood parenchyma and medullary rays. The tracheal tubes are rather uniformly distributed; in the late growth they are fewer and smaller than in the early growth. The walls of the tracheids are relatively strongly thickened and have bordered pits placed at a slant with the vertical.

He reports average measurements on the xylem elements of several species of the genus *Pyrus*.

<table>
<thead>
<tr>
<th>Species</th>
<th>Width of vessels</th>
<th>Height of ray cells</th>
<th>Number of medullary rays</th>
</tr>
</thead>
<tbody>
<tr>
<td>cuneifolius</td>
<td>36.5u</td>
<td>15.2u</td>
<td>13.8u</td>
</tr>
<tr>
<td>heterophylla (a)</td>
<td>36.2</td>
<td>14.0</td>
<td>13.9</td>
</tr>
<tr>
<td></td>
<td>37.7</td>
<td>13.6</td>
<td>13.8</td>
</tr>
<tr>
<td>pasha</td>
<td>31.8</td>
<td>15.1</td>
<td>16.0</td>
</tr>
<tr>
<td>salviaefolia</td>
<td>31.6</td>
<td>14.6</td>
<td>13.9</td>
</tr>
<tr>
<td>sinensis</td>
<td>34.3</td>
<td>13.8</td>
<td>15.3</td>
</tr>
</tbody>
</table>

In summarizing his results, Burgerstein says that the distinguishing characters of the Pomaceae investigated, lay in the dimensions of the particular histological elements; in the presence or absence of tertiary thickening, in the varying distances apart of the medullary rays in cross section, and in the number of medullary ray cell rows in tangential sections.
METHODS USED IN PREPARING AND SECTIONING MATERIAL.

The material, for my comparative study of thirteen species of the genus Pyrus, was collected in the "Arnold Arboretum" by Professor W. C. Stevens. This material was cut during August, 1928 and sent to Lawrence where the species wrapped separately in cheese cloth and preserved in four percent formalin.

I have taken the material for sectioning from corresponding parts of the plant in each species studied, in order to keep the comparative study as uniform as possible. For the study of the leaves, average size leaves were taken and placed in 95 percent alcohol. The air was then pumped out and several leaves from each species were placed in a saturated solution of chloral hydrate to bleach, for the study of the venation. Other leaves were placed in equal parts 86 percent alcohol and glycerine. From this material I selected leaves, and took a portion about the middle of the leaf blade for sections of the midribs and margins. A portion,
of the petiole midway between the base and the blade, was taken for sectioning. Material for stem sections was taken within the first internode below the apical bud, and second internode from the base of the second year's growth. Material for the one-year stem sections were taken near the apical bud in order to obtain the epidermis, this soon being replaced by cork. This material was then placed in 95% alcohol and the air pumped out. A portion was set aside as reserve material and put into 70 per cent alcohol. The remaining material was placed in vials containing equal parts 80 per cent alcohol and glycerine.

Sections were cut on a Spenceer sliding microtome. Valet razor blades held in a special razor blade holder were used instead of an ordinary microtome knife. The razor blades could be removed and sharpened very quickly in a rotary safety razor blade hone and stropper. The microtome was set at ten microns for petiole, margin and midrib sections; and at ten or twelve microns for stems sections.

Because of the early cork formation and the hard bast in the stems, I had difficulty in
sectioning the stems taken from the alcohol-glycerine material. The stems were then vulcanized according to the Jeffrey method for softening woody material. The stem pieces were placed in small cheese cloth bags and put into air tight brass tubes. The tubes were filled three-fourths full with 95 per cent alcohol and the top screwed on tight in a vise. The tubes were then put into a Dentist's vulcanizer and heated at 315°F. for three hours. After this time the material was placed in equal parts hydrofluoric acid and 95 per cent alcohol for three days. This process softened the wood but the borkes would slip off when sectioning material enclosed with hard paraffin. So in order to obtain stem sections embedded them in celloidin. The stem pieces were placed in small bottles containing 2% celloidin dissolved in alcohol and ether. The bottles were loosely corked and the corks held in with wire; then they were placed in the paraffin oven for several days until the celloidin had evaporated to the consistency of 5 per cent celloidin.
The material was then carried through successively higher concentrations of celloidin according to the usual method, and then the stems were mounted on blocks with celloidin. The blocks were then placed in chloroform for a day and into a solution of equal parts 80 per cent glycerine and alcohol. However, the borke still slipped off. I omitted the vulcanizer treatment and used equal parts hydrofluoric acid and 95 per cent alcohol to soften the stems. The stems were taken directly from the material in formalin and placed in the hydrofluoric acid solution for several days. The pieces were then washed in running water for a day, then placed in a mixture of two parts normal butyl alcohol to three parts water and five parts ethyl alcohol. The stems remained in this solution until sectioned. They were then mounted on pine blocks enclosed in hard paraffin melted around them. I had very little difficulty in making transverse, tangential and radial sections taken from material treated in this way.

Macerations were made of the longitudinal sections of stem in order to study the various separate
elements of the xylem and bast fibers more minutely. A heated solution of nitric acid and a few crystals of potassium chlorate was used in making macerations of the wood. The cortex was macerated separately in a warmed solution of a concentrated solution of chromic acid.

In the study of the leaves, sections of the midribs, margins and petioles were made from material which had been mounted on a block and enclosed in hard paraffin melted around them. Sections were bleached by first, placing them in a saturated solution of bleaching powder for several hours, then washing with a five percent hydrochloric acid solution. The sections were then placed in 70 per cent alcohol, followed by 95 per cent alcohol, and finally mounted in sandara dissolved in butyl alcohol ready for photographing. The whole leaves which had been bleached in chloral hydrate did not bleach sufficiently to study the venation, so they were placed in a saturated solution of bleaching powder for a day. Then they were put into full strength hydrogen peroxide for a day.
From this solution they were again placed in chlora hydrate to clear them, and then mounted in glycerine. These bleached leaves were used in the study of the venation, surface view of the epidermal cells, trichomes, and in estimating the frequency of the palisade cells.

The ink drawings of the leaf epidermas, trichomes, leaf margins and cross sections; leaf tips showing venation; and stem epidermis were drawn by using a projecting microscope. Plates were then arranged on stiff sheets of large white card board 22" x 28". A time exposure of 25 seconds was made, using a large dry plate camera. 8" x 10" Cramer's Photo Dry plates, Emulsion No. 7944 were used in making the exposures. The diaphragm had been set at 16 after the object had been centered and focused. Sheets of No. 33 hard Kito paper were used in making the positive prints. A 400 watt lamp was used in making these exposures. The plates were reduced in making the positive prints.

Photomicrographs were obtained by projecting the image, by means of a microscope, upon 2 1/2"
x 2 1/2" or 3 1/4" x 4 1/4" Cramer's Photo Dry Plates, Emulsion No. 27820 and 27712. The time allowed for exposure was 8 seconds. A 100 watt lamp was the source of light used in making these exposures. The plates were developed from 5-10 minutes and then placed in hypo solution for 15 minutes. They were then washed for two hours and allowed to dry. Sheets of No. 31 hard Rito paper were used in making the positive prints.
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PYRUS CONGESTA

Primary Tissues.

Epidermis.

The trichomes of this species average .48 mm. in length and are approximately .015 mm. in width at the base, increasing slightly toward the middle, then decreasing toward the tip (Fig. 4).

The trichomes are of the simple clothing hair type, and are slender, wavy and slightly matted on the young stem. Their walls are relatively thin and the cavities are open the entire length of the trichomes. The epidermal cells are irregular in size and shape and slightly thick-walled, with the radial walls sometimes undulating, as seen in surface view (Fig. 1). The cells average .027 mm. longitudinally, as seen in surface view; .019 mm. in tangential diameter, .016 mm. in radial diameter as seen in cross section. The inner tangential wall and radial walls are approximately .0032 mm. thick. The outer wall is thicker and heavily cutinized.

Primary cortex.

The primary cortex of a stem 2.8 mm. in diameter, consists of a region approximately 42 mm. broad. The collenchymatous hypoderm varies.
from three to eight cell-rows in breadth, and all
the cells contain hemicellulose. This region is very
irregular, here and there dipping down into the
cortical parenchyma. An average collenchyma cell
measures .031 mm. tangentially, .019 mm. radially,
and .034 mm. in vertical length. The cortical
parenchyma consists of an outer region, lying next
to the collenchyma, composed of approximately ten
rows of thin-walled, isodiametric cells, measuring
.036 mm. in cross diameters, and .023 mm. in vertical
length. There are approximately three rows of small
inner, cortical parenchyma cells lying within the
primary sclerenchyma region next to the phloem.
These cells average .025 mm. in cross diameters and
.02 mm. in vertical length. There are numerous
octahedral crystals of calcium oxalate within the
inner cortex cells and grouped around the bast fibers.

There is a zone of primary sclerenchyma
approximately .06 mm. in breadth formed within the
inner cortex lying next to the phloem. The zone is
arranged in small rounded or occasionally elongated,
scattered patches, varying in breadth. The bast
fibers average 1.2 mm. in length, their pitted and
lignified walls average .006 mm. in thickness, and their cavities .0012 mm. across (Fig. 1a'). Small octahedral crystals are found in the cavities of many of the fibers. Numerous stone cells are found grouped at the ends of the fiber patches and scattered among the bast fibers. These cells are very irregular in shape and vary from .03 to .07 mm. in vertical length (Fig. 1 e). Their walls are approximately .0082 mm. in thickness and their cavities .018 mm. across. In all instances the stone cells contain tannin, completely filling the cell cavity, and the walls are lignified.

Phloem and Xylem.

There are approximately fourteen rows of phloem elements laid down radially in the current year's growth. The walls are thin, the cavities are elongated tangentially and narrow radially. In radial section numerous elongated phloem parenchyma cells, containing tannin and protein are found scattered throughout the phloem region. No secondary sclerenchyma tissue is formed within the primary phloem.

The primary xylem has developed from a continuous procambial cylinder. In my sections, there were eight protoxylem points extending slightly
into the pith. These points are made more distinct by the bordering small, thick-walled pith cells containing much tannin and starch. In the protoxylem are seven cell-rows of prominent spiral and annular tracheal tubes, averaging .027 mm. in cross diameter. There are approximately seven rows of these vessels in each protoxylem point. An abundance of xylem parenchyma cells occur within the protoxylem points. Metaxylem is produced in great abundance tangentially and laterally completing the xylem cylinder.

Pith.

The pith is composed of large inner cells and small outer cells, all with thick, pitted, and lignified walls. The inner cells average .035 mm. in cross diameters and .04 mm. in vertical length. (Fig. 1,g). Tanniferous bodies and starch are found scattered throughout the inner pith cells, excepting those that border the protoxylem points. The outer cells average .018 mm. in cross diameters and .065 mm. in vertical length.
(Fig. 1,f). These cells are all filled with tannin and starch.

Secondary Tissues.

Periderm.

Sections of a one-year stem of the second internode below the apical bud, taken in August, show a distinct periderm, consisting of cork, phellogen and phelloderm. Three to five cell-rows of thick-walled, sclerenchymatous, heavily suberized, tannin-bearing cork cells, comparatively uniform in size and shape are formed below the epidermis. The cells average .021 mm. tangentially, .018 mm. radially and .02 mm. vertically. A distinct row of phellogen, of epidermal origin, lies below the cork. Inside the phellogen two rows of parenchymatous, thin-walled phelloderm cells are formed.

Phloem.

In the outer part of the secondary phloem region, a continuous cylinder of secondary sclerenchyma is formed. This cylinder is narrow
consisting of two to four cells radially and averaging .04 mm. across. The secondary bast fibers some of them containing octahedral crystals, are similar in length and cell wall thickness to the primary fibers. A few tannin-bearing stone cells are scattered throughout the cylinder. The primary phloem tissue has become crushed and broken down as the secondary sclerenchyma is formed.

Xylem.

The rays are composed of large cells, which are very prominent in cross section due to the abundance of starch and tannin stored in them. They alternate with one to seven radial groups of xylem elements. They consist of from one to eighty-four cells vertically and are usually one cell broad. The walls are pitted. There are in cross section approximately seventy-five medullary rays per mm. tangentially. The radial rows of fiber tracheids are the most prominent features of the secondary xylem. These tracheids average .56 mm. in length and .0068 mm. in cross diameter (Fig. 1,c). The walls are densely marked
with pits often set at a slant. The tracheal tubes are scattered throughout the xylem area. They are composed of elements averaging .34 mm in length, with slanting walls completely dissolved out. These tubes average .038 mm in cross diameter. Their walls are marked with elongated elliptical pits reticulately arranged (Fig. 1,b). No wood fibers occur in the xylem area. Xylem parenchyma occurs in abundance, scattered amongst the fiber tracheids and tracheal tubes. These cells average .065 mm in length and .013 mm in cross diameters. The walls are strongly pitted. (Fig. 1,d).
PYRUS COMMUNIS

Primary Tissues.

Epidermis.

No trichomes are found upon the epidermis of this species.

The entire outer epidermal cell wall is cutinized as shown with Sudan III. The slightly angled-cells appear in quite regular vertical rows as seen in surface view (Fig. 2). The inner tangential wall, and radial walls are approximately .0025 mm. in thickness, and the cells measure .021 mm. vertically, as seen in surface view; .015 mm. radially, .013 mm. tangentially as seen in cross section.

Primary cortex.

In a stem with a radius of 2.2 mm. the primary cortex is .95 mm. in breadth. The collenchymatous hypoderm .08 mm. in width, is composed of six irregular cell-rows. The cells of the outer two rows of this tissue, are smaller in size than the inner collenchyma cells. The collenchyma cells average .032 mm. in tangential diameter, .025 mm. in radial diameter, and .04 mm. in vertical length. The walls are characteristically
thickened where three or four cells join. Tannin is found stored in all the collenchyma cells. The cortical parenchyma consists of approximately twenty-three cell rows. The cells are isodiametric, thin-walled, and tannin bearing. They measure approximately .043 mm. in cross diameter and .032 mm. in vertical length. The outer cortical cells are slightly different in shape and size from those bordering the phloem.

The primary sclerenchyma occupies a region .05 mm. in breadth, within the inner cortical parenchyma. The zone is arranged in elongated patches, practically forming a cylinder around the stem. The bast fibers average .5 mm. in length and taper bluntly; their walls average .0075 mm. in thickness and their cavities are minute and flattened, have numerous pits and contain frequent crystals. (Fig. 22a). A few stone cells are scattered among the bast fibers. These cells average .04 mm. in length; the cell wall being approximately .007 mm. thick and the cavity .02 mm. across (Fig. 22e). Tannin is stored within the stone cells.
Xylem and phloem.

In a section of the early growth of the stem the phloem is .12 mm. in width and is twenty-four rows of cells across. The phloem elements measure approximately the same in both radial and tangential diameters. Elongated, tannin-bearing, phloem parenchyma cells are scattered throughout the region.

Twenty-seven protoxylem points indent the pith. Numerous xylem parenchyma cells are grouped within the protoxylem points. These cells show no lignification when treated with phloroglucin and concentrated hydrochloric acid. Several rows of prominent spiral and annular tracheal tubes are arranged radially within the protoxylem region. Pitted tracheal tubes and fiber tracheids are produced in the metaxylem in radial rows.

Pith.

The pith cylinder is composed of inner, large-cavited cells and small, elongated, outer cells bordering the xylem. All cells are thick-walled, lignified and strongly pitted. The outer
cells contain an abundance of starch and tannin. These cells average .01 mm. in cross diameter and .06 mm. in vertical length. (Fig. 22f).

The inner pith cells average .03 mm. in cross diameter and .048 mm. in vertical length (Fig. 22g). Starch and tannin are stored within some of the cells.

Secondary Tissues.

Periderm.

As is characteristic of all the species studied, the periderm appears early during the first season's growth. There are four cell-rows of cork present in the one and two year stems. The cells average .02 mm. in tangential diameter, .015 mm. in radial diameter and .017 mm. in vertical length. All the cells contain tannin. The cell walls are thickened and heavily suberized. Two cell rows of thin-walled phelloderm is formed inside the phellogen. These cells measure approximately .02 mm. in both tangential and radial diameters. Tannin is scattered throughout the phelloderm cells.

Phloem.

A comparatively large amount of secondary phloem is produced by the cambium in regular radial rows. In the outer secondary phloem region a continuous cylinder is formed of secondary...
sclerenchyma, .049 mm. in width. This cylinder is interrupted at intervals by the rays. The cells are like the primary fibers in length and cell wall thickness. There is a continuous longitudinal row of simple crystals within the cavities of the fibers. A very few tannin-bearing secondary stone cells are scattered throughout the secondary bast fibers.

Xylem.

Abundant fiber tracheids are formed in radial rows within the xylem area. These fibers average .39 mm. in length, and the cavities .003 mm. in cross diameter (Fig. 22c). There are approximately 240 fiber tracheids per square mm. Vertically elongated xylem parenchyma cells are very abundant within the protoxylem points and scattered among the fiber tracheids and tracheal elements. These cells average .058 mm. in vertical length, and the cavity measures approximately .01 mm. in cross diameter (Fig. 22c). The cell walls are heavily pitted. The large cavitated tracheal tubes are scattered throughout the xylem
area but are condensed at the beginning of each year's growth. The elements of the tracheal tubes average .24 mm. in length and .028 mm. in cross diameter (Fig. 22 f). The end walls are set obliquely and are completely dissolved out. The pitting is scalariform. The xylem elements are arranged radially, having medullary rays alternating with approximately four radial rows of xylem elements. In tangential section the rays are seen to be uniformly one cell broad and occur up to fifty-one cells vertically. The walls are strongly pitted.
PYRUS BRETSCHNEIDERI

Primary Tissues.

Epidermis.

There are no trichomes borne upon the stem epidermis of this species.

The epidermal cells are irregular, thin walled, and the radial walls more or less straight, seen in surface view. (Fig. 3). The outer epidermal wall is heavily cutinized. These cells average .021 mm. in tangential diameter and .008 mm. in radial diameter, as seen in cross section. The length of the cells vary greatly, but an average cell is approximately .026 mm. in length, as seen in surface view.

Primary cortex.

The primary cortex occupies a region .18 mm. in breadth of a stem 2.3 mm. in diameter. This region is composed of from fifteen to twenty cell layers. The collenchymatous hypoderm immediately below the epidermis is five cell layers broad. The collenchyma cells are smaller in cross diameter than those of Pyrus congesta.
and Pyrus communis. They average .023 mm. in tangential diameter, and .016 mm. in radial diameter. Much tannin is stored within the cell cavities. The outer cortical parenchyma has become slightly stretched and broken tangentially. There is a relatively small amount of tannin stored in these cells. The inner cortical parenchyma cells, lying within the primary sclerenchyma region and next to the phloem has become crushed.

The primary sclerenchyma tissue is formed in irregular patches, almost making a complete cylinder in some portions of the stem, where the stone cells are grouped at the ends of the bast fiber patches, joining these patches (Fig. 121). The primary sclerenchymatous zone varies in breadth, but averages .04 mm. There are from two to six cell layers of bast fibers of approximately the same size and shape. These fibers average .79 mm. in length with strongly pitted and lignified cell walls (Fig. 23a0. A few bast fibers contain simple octahedral crystals. Stone cells are concentrated in groups at the ends of the bast fiber patches, and a few are scattered among the fibers (Fig. 23 e). These
large-cavitated stone cells appear very prominent in cross section due to the abundance of stored tannin.

**Phloem and protoxylem.**

The phloem elements are radially arranged as seen in cross section (Fig. 121). There are approximately twenty cell rows of phloem elements uniform in size and cell wall thickness. In radial section, elongated, tannin bearing cells are found scattered throughout the phloem region.

There are twenty protoxylem points which extend very slightly into the pith. The thin-walled cells concentrated within the protoxylem points do not react to a lignin test. These cells are made more prominent by the abundance of stored starch in all the smaller outer pith cells bordering these areas. Radially-grouped spiral tracheal elements make up a large portion of the protoxylem area. Metaxylem elements are laid down centrifugally and laterally, completing the primary xylem cylinder.

**Pith.**

Nearly all the pith cells contain starch
and tannin stored within the cell cavities. The inner cells average .032 mm. in cross diameter and .042 mm. in length (Fig. 23 g). The pith cells lying next the vascular bundles average .016 mm. in cross diameter and .06 mm. in length (Fig. 23f). All the pith cells give a strong lignin reaction and the cell walls are thick and pitted.

Secondary Tissues.

Periderm.

The cork cylinder, formed below the epidermis, is six cell layers broad, in sections taken within the second internode of the first seasons growth. Its cell walls are thick, with the tangential walls more heavily suberized than the radial walls. The cells measure approximately the same as stated for the previous species. The size of the cork cells seems to be a very constant feature in all the species of Pyrus studied and all the cork cells contain tannin. Approximately two cell layers of thin-walled, isodiametric phelloderm are formed inside the phellogen.
Phloem.

The entire phloem area appears stretched tangentially and the primary phloem becomes crushed as the secondary sclerenchyma is formed. A great amount of tannin is stored within the phloem area as is seen in Fig. 122. Secondary sclerenchyma is formed in elongated, narrow patches within the secondary phloem. These patches alternate with the primary sclerenchyma groups. These secondary fibers are slightly larger and the groups of them are not so compact as in the case of the primary bast fibers. They average about the same length as the primary fibers and contain a few crystals within their cavities. A few small, tannin-bearing stone cells are scattered among the fibers. The secondary sclerenchyma is more heavily lignified than the primary.

Xylem.

Radial groups of fiber tracheids and xylem parenchyma cells of from one to seven rows lie between prominent starch and tannin-bearing xylem ray cells. In tangential section the rays are seen to be from one to two cells broad and up to forty-four cells vertically. The cell
walls are heavily pitted. The fiber tracheids average .42 mm. in length, and the cavities .0093 mm. in cross diameter (Fig. 23c). The walls are heavily thickened and have numerous inclined bordered pits. Cross sections show large tracheal tubes, densely scattered within the second season's growth. These elements are marked with elliptical pits, reticulately arranged and the oblique end walls are completely dissolved out (Fig. 23b). The elements vary in size and shape but average .24 mm. in length and .032 mm. in cross diameter. The xylem parenchyma cells thickly scattered among the fiber tracheids average .052 mm. in length and .009 mm. in cross diameter. The end walls are slightly slanting and the entire cell wall is strongly pitted (Fig. 23d).
PYRUS PHAEOCARPA GLOBOSA.

Primary Tissues.

Epidermis.

The trichomes of this species average .72 mm. in length. These are the longest trichomes found upon the stems of any of the species studied (Fig. 7). They are slender, tapering, simple-clothing hairs. Occasionally the tip is curved in a distinct crook. The walls of the trichomes are relatively thin, and the cavity is open the entire length. The young stem is tomentose with the trichomes somewhat matted.

The outer epidermal wall is heavily cutinized as is characteristic of the epidermis of the stems. The cells are very irregular in size and shape and contain an abundance of tannin (Fig. 6). The epidermal cells average .021 mm. longitudinally, .023 mm. tangentially and .0078 mm. radially.

Primary cortex.

The primary cortex is approximately .65 mm. broad in a stem with a diameter 2.4 mm. The collenchymatous hypoderm is .09 mm. in breadth and consists of approximately eight cell-layers,
containing an abundance of tannin. These cells average .03 mm. tangentially, .017 mm. radially and .04 mm. vertically. The thin-walled, isodiametric cortical parenchyma cells make up the greatest portion of the primary cortex. These cells average .032 mm. in cross diameter and .036 mm. in vertical length. An abundance of small, octahedral, polyhedral and rosette crystals of calcium oxalate are found scattered throughout the cortical parenchyma and especially in those cells surrounding the primary sclerenchyma patches.

In a section of the second internode below the apical bud, there are small patches of a few bast fibers and stone cells scattered among the bast fibers. The cell wall of the bast fibers is thick and the cavity comparatively small. But in a section taken near the base of the first season's growth, the primary sclerenchyma appears in short, comparatively widened patches and the bast fibers are more compactly grouped and numerous stone cells appear at the ends of the patches, and occasionally scattered among the fibers. The bast fibers vary greatly in length, from 1.78 mm. to 7 mm. (Fig. 24 a). The cavities are now much smaller.
Small octahedral crystals are scattered throughout the bast fiber cavities. The stone cells are slightly elongated radially, and average 0.013 mm. in vertical length (Fig. 21e). They contain an abundance of tannin.

Phloem and xylem.

The phloem is approximately twenty-one cells layers in radial breadth. The cells are very thin-walled and a few contain small crystals. The large tannin-bearing rays alternate with from one to eleven phloem groups.

The xylem area is small compared to the diameter of the stem. It is 0.28 mm. broad in a stem having a diameter of 2.6 mm. (Fig. 123). The procambium is a cylinder and approximately nineteen protoxylem points slightly indent the pith. Numerous, large cavitated, spiral tracheal tubes compose the protoxylem. A few thin-walled xylem parenchyma cells are grouped within the protoxylem points. Metaxylem consisting of pitted tracheal tubes, fiber tracheids and xylem parenchyma is produced tangentially and radially in the procambium cylinder.

Pith.

The pith cells average approximately
.04 mm. in cross diameter and .033 mm. in vertical length. There is very little difference in size between the inner and outer cells. All the cell walls are thick and pitted. In a section stained with K II, the cells containing starch appear scattered throughout the cylinder. Only a few pith cells contain tannin and a few rosette crystals occur in the cells surrounding the xylem area.

Secondary Tissues.

Three to six cell layers of sclerenchymatous cork are formed during the first season's growth. These cells average .021 mm. tangentially, .018 mm. radially and .02 mm. vertically. The tangential walls appear more heavily suberized than the radial walls. No distinct phelloderm is present but two cell layers of relatively thin-walled cells, lying below the cork can be seen in the two year stem, the inner cell layer being the phellogen and the outer cell layer the newly formed cork where the cell walls stain slightly with Sudan III (Fig. 124).

Phloem.

The secondary phloem cylinder consists of approximately fifteen irregular cell layers.
The primary phloem has become crushed. The secondary sclerenchyma is formed in narrow, elongated bands within the secondary phloem. These patches alternate with the primary sclerenchyma groups, and here they are more numerous than in the primary sclerenchyma ring. These cells are very irregular in size and shape but in all cases contain tannin. The secondary bast fibers are on the whole shorter in length than the primary. These fibers have tapering ends and the cell walls are pitted.

**Xylem.**

Approximately the same amount of secondary xylem has been formed as primary xylem of the previous season. Tracheal tubes, approximately the same size, are uniformly scattered throughout the secondary xylem. The elements average .02 mm. in cross diameter and .22 mm. in vertical length (Fig. 24b), and the slightly slanting end walls are completely dissolved out. In a few instances the end walls are nearly perpendicular to the side walls. Fiber tracheids and xylem parenchyma cells are fewer in number than in precious species studied. Fiber tracheids average .016 mm. in
cross diameter and .67 mm, vertically (Fig. 24c). There are approximately 176 per sq. mm. The walls are strongly pitted. The xylem parenchyma cells average .014 mm. in cross diameter and .09 mm. in length (Fig. 24 d). There are approximately 103 xylem parenchyma cells per sq. mm. The rays appear very prominent within the xylem area, as seen in cross section, due to the abundance of stored starch (Fig. 124). The rays alternate with from one to eleven radial rows of xylem elements. The rays are uniserate as seen in tangential section and average twenty-six cells in height.
Primary Tissues.

Epidermis.

The young portion of the one-year stems is slightly tomentose and bears short trichomes averaging .23 mm. in length and .015 mm. in breadth at the base (Fig. 9). The cell wall of the trichome is relatively thick, being .005 mm. in thickness. The cavity is open the full length but is very narrow at the tip. The trichomes are of the simple clothing-hair type and the majority are short, curved and bluntly tapering to a point.

The cells of the epidermis are uniform in size and shape with relatively thin undulating radial walls (Fig. 5). These cells average .023 mm. in vertical diameter, .022 mm. tangentially, and .012 mm. radially. Few of the cells contain tannin. The entire outer epidermal cell wall and approximately one-fourth of the radial wall is cutinized.

Primary cortex.

The primary cortex region occupies
approximately one-third of the diameter of the stem. A collenchymatous hypoderm of seven irregular cell layers, composing a region .032 mm. in breadth, occupies approximately one-half of the primary cortex region. The cells average .027 mm. tangentially, .015 mm. radially and .029 mm. in vertical length. In the two-year-old stem sections the cortex has become stretched tangentially and more definitely arranged in rows (Fig. 126). Tannin is abundant within the cavities of the collenchyma cells. The cortical parenchyma region is composed of slightly thick-walled cells of uniform size and shape. These cells average .037 mm. in cross diameter, and .036 mm. longitudinally. Tanniferous bodies and a few octahedral crystals are scattered throughout the cortical parenchyma cells. The inner cortical cells have become crushed by the primary sclerenchyma tissue. The primary sclerenchyma is formed in small, very irregular patches. These patches vary greatly in the number of fibers and breadth of the zone. The best fibers average .24 mm. in length with the ends bluntly tapering (Fig. 25 a). The wall of the fibers is approximately
.009 mm. in thickness and densely pitted. The width of the cavity varies greatly. Chains of elongated octahedral crystals are present within the cavities of some of the bast fibers, as seen in radial section. Scattered throughout the bast fibers, are tannin-bearing stone cells (Fig. 25e). Their walls are approximately .005 mm. in thickness and the cavities .013 mm. in cross diameter.

Phloem.

The phloem region is approximately .18 mm. in breadth and consists of twenty-five tangential cell layers. The phloem elements are regularly arranged in radial rows, one to three cell rows alternating with the large, elongated, tannin-bearing phloem ray cells (Fig. 125). The phloem elements are very small, thin-walled, and irregular in size and shape. In radial section the tannin-bearing cells appear scattered throughout the phloem area.

Xylem.

The primary xylem occupies a region .28 mm. in breadth and approximately fifteen protoxylem points indent the pith. The protoxylem points appear very prominent, when the section is tested with phloroglucin and hydrochloric acid. Unlignified, thin-walled xylem parenchyma occupies
approximately one-third of the primary xylem area. There are relatively few, small-cavitated, spiral and annular tracheal vessels in the protoxylem. Metaxylem consisting mostly of fiber tracheids, is formed both radially and laterally by the procambial cylinder.

Pith.

The pith cells are very irregular in size and shape. The cell walls are very thick and densely pitted. The pith cylinder is homogenous as all the cells contain tannin and starch stored within their cavities. The outer small cells average .013 mm. in cross diameter and .04 mm. longitudinally (Fig. 25f). The inner large cells average .031 mm. in cross diameter and .034 mm. longitudinally (Fig. 25g).

Secondary Tissues.

Periderm.

A distinct periderm is formed early during the first season's growth, by a subepidermal phellogen. There are approximately five cell-layers of cork, occupying a region .065 mm. in breadth. The cells are uniform in shape and in regular cell rows. They average .023 mm.
tangentially, .016 mm. radially and .02 mm. longitudinally. The cell wall is sclerenchymatous and uniformly suberized. All the cork cells contain tannin. No distinct phelloderm is present within the periderm of this species.

Phloem.

The primary phloem has become crushed and stretched tangentially. A very small amount of secondary phloem has been formed by the cambium. Numerous tannin-bearing cells are scattered throughout the phloem area.

The primary sclerenchyma patches have become stretched tangentially. The secondary sclerenchyma is formed within the secondary phloem. This tissue occurs in elongated, narrow patches, alternating with the primary sclerenchyma patches (Fig. 126). The secondary bast fibers are compactly grouped, forming a region approximately .04 mm. in breadth. These bast fibers are shorter on the average than the primary fibers. Numerous large tannin-bearing stone cells are grouped at the ends of the patches and scattered among the bast fibers.

Xylem.
Approximately twice the amount of secondary xylem is formed in the two year stem as of primary xylem. There are relatively few tracheal tubes in the primary xylem area in comparison to the number present in the secondary xylem. The tracheal tubes are uniformly scattered throughout the secondary xylem. The elements of the tubes average .16 mm. in length and .022 mm. in cross diameter (Fig. 25b). The walls are densely pitted. The end walls are slanting and completely dissolved out. Fiber tracheids are more abundant in the late growth of the primary xylem than in the secondary xylem. They average .53 mm. in length and .004 mm. in cross diameter (Fig. 25c). The cell wall is relatively thickened with numerous oblique pits. The entire cell wall is heavily lignified and strongly pitted. The secondary rays are composed of narrow, radially elongated cells, containing starch. There are approximately forty-one xylem rays per mm. in cross section. The rays are composed of from three to thirty-five cells vertically and average .23 mm. in this direction. They are usually uniseriate, but vary from uniseriate to triseriate in tangential breadth. The xylem
rays alternate with one to ten cell-rows of radially arranged xylem groups. The cell walls are thick and strongly pitted. The xylem parenchyma cells average .049 mm. in vertical length and .01 mm. across (Fig. 25d).
PYRUS COMMUNIS COTINIFOLIA.

Primary Tissues.

Epidermis.

The epidermal cells are small and very irregular in shape as seen in surface view (Fig. 8). These cells average .023 mm. in vertical diameter, .021 mm. in tangential diameter, and .015 mm. in radial diameter. The cell walls are slightly thickened and the entire outer cell wall is heavily cutinized.

No trichomes are found upon the stem epidermis of this species.

Primary cortex.

The primary cortex consists of a region .62 mm. in breadth in a stem 3.2 mm. in diameter. In this species, the outer four to six cell rows of the primary cortex are parenchymatous collenchyma. The cells are elongated tangentially, being approximately .037 mm. in this direction; narrow radially, .014 mm; and short vertically, .024 mm. The cell walls are characteristically thickened with occasional pits. All the collenchyma cells contain
tannin. This collenchymatous hypoderm is not very distinct in the one-year stem sections taken at the second internode below the apical bud.

The thin-walled, isodiametric, cortical parenchyma cells appear in very irregular rows with numerous large intercellular spaces. There are approximately twenty-seven cell layers of cortical parenchyma cells which average .034 mm. across and .039 mm. in vertical length. This region becomes stretched tangentially as secondary thickening occurs. Numerous rosette crystals are found within this tissue.

The primary sclerenchyma zone, bordering the inner cortical parenchyma occupies a region .06 to .08 mm. in breadth, consisting of approximately ten cell-layers. This tissue is formed in short, compact patches of quite varying breadth. The bast fibers vary in length from .5 mm. to 1.3 mm. (Fig. 26a). The cell wall measures approximately .008 mm. in thickness and the cavity .003 mm. across. A few crystals are scattered among the bast fibers. Numerous stone cells are massed about the ends of the bast fiber patches. These cells are prominent in cross section as they
are very much larger than the best fibers and contain tannin. The stone cells are quite irregular in size and shape, and average approximately .04 mm. in vertical length. (Fig. 26 e).

Phloem and xylem.

The primary phloem elements are arranged in irregular radial rows as seen in cross section, (Fig. 127). The cells are small and the cell walls are very thin. A few tannin-bearing phloem parenchyma cells are scattered throughout the phloem region.

There are fourteen protoxylem points very irregular in tangential width, indenting the pith cylinder very slightly. Within the protoxylem points there are groups of unlignified thin-walled xylem parenchyma cells. The protoxylem are made more evident by the small thick-walled starch-bearing, outer pith cells surrounding them. A few spiral and annular tracheal tubes are scattered throughout this region. Metaxylem, consisting mainly of fiber tracheids, and pitted tracheal tubes, has been formed by the procambial cylinder.

Pith.

The pith cells are very uniform in size
and shape. The cell walls are thin in the very young stem, but later become thickened, pitted and heavily lignified. The inner cells average .039 mm. across and .032 mm. in vertical length (Fig. 26g). Tannin and starch are scattered throughout these cells. The outer cells are relatively smaller in cross diameter being approximately .02 mm. across and .041 mm. in vertical length. (Fig. 26f). All of these cells contain starch.

Secondary Tissues.

Periderm.

Approximately six cell-layers of cork are formed below the epidermis, occupying a region .063 mm. in breadth. These cells are sclerenchymatous and the cell walls are very heavily suberized. All the cork cells contain tannin. These cells average .023 mm. tangentially, .013 mm. radially, and .02 mm. vertically. The phellogen is very distinct in cross section. Two cell layers of thin-walled, isodiametric, tannin-bearing, phelloderm are formed inside the phellogen.

Phloem.

Secondary phloem has been formed in
regular radial rows by the cambium. The phloem rays are very prominent in cross section due to the abundance of tannin and protein stored within them (Fig. 128). The primary phloem has become crushed.

Within the secondary phloem region, three distinct zones of secondary sclerenchyma have been formed. The primary sclerenchyma has become stretched tangentially so that the patches occur far apart. The two outer secondary sclerenchyma zones are formed in elongated, alternating bands. The inner zone is in a cylinder, interrupted only by the rays (Fig. 128). These zones are uniformly approximately .04 mm. in breadth. The secondary bast fibers appear larger in cross diameter and the cavities wider than those of the primary fibers. Secondary tannin-bearing stone cells are scattered among the secondary cavities of some of the fibers.

Xylem.

In a section taken to show secondary growth, several annual rings are prominent. The most characteristic feature of this section is the abundance of large-cavities tracheal tubes.
These are quite uniformly scattered but appear more condensed and larger cavitated at the beginning of each season's growth. These cells average .038 mm. across and .22 mm. in vertical length. (Fig. 26b). The end walls are slanting and completely dissolved out. Xylem parenchyma cells average approximately .017 mm. in cross diameter and .034 mm. vertically (Fig. 26d). These cells have thickened cell walls strongly beset with pits. Fiber tracheids occur scattered throughout the secondary xylem area. These tracheids average .0094 mm. in cross diameter and .32 mm. vertically (Fig. 26c). The bordered pits are set at a slant along the wall.

The xylem rays alternate with approximately nine radial rows of xylem elements. They are uniseriate as seen in cross and tangential sections. They vary greatly in height and the number of cells in height.
Primary Tissues.

Epidermis.

No clothing hairs occur on the stem epidermis of this species. The epidermis observed from surface view is seen to be made up of cells that are uniform in size with thickened, angled radial walls (Fig. 10). These cells average .028 mm. vertically, .02 mm. tangentially, and .012 mm. radially. The entire outer cell wall is cutinized.

Primary cortex.

The collenchymatous hypoderm is .064 mm. broad consisting of four to six irregular cell layers. The two outer layers of collenchyma are smaller in cross diameter than the inner layers. These cells are typically prosenchymatous collenchyma. The collenchyma cells average .034 mm. tangentially, .021 mm. radially and .04 mm. vertically. A majority of these cells contain tannin. The cortical parenchyma is unusually well developed, being .92 mm. broad.
where the stem has a diameter of 4.6 mm. (Fig. 129). Approximately thirty-two cell layers make up this tissue. The cells average .038 mm. across and .04 mm. vertically. The cell walls are thin. Tannin is found scattered throughout this region. Moderate-sized, thick-walled primary bast fibers, with occasional tannin-bearing stone cells are evident within the inner cortical parenchyma region. This sclerenchymatous tissue is formed in small, scattered, short, compact patches which average .052 mm. in breadth. The bast fibers average 5 mm. vertically with pitted walls and small, compressed cavities (Fig. 27a).

Phloem and Xylem.

The phloem region of a one-year stem is approximately twenty-five cell layers broad, being made up principally of tangentially elongated, thin-walled cells with no definite arrangement. The phloem rays are very large, being approximately as wide as two rows of phloem elements, as seen in cross section.

The primary xylem is in a continuous cylinder, with but very little indentation into the pith. Small groups of xylem parenchyma cells
are concentrated within these points. There are several rows of radially arranged tracheal vessels which have the typical spiral markings. Approximately eighteen protoxylem points are found in the section studied. Metaxylem is produced laterally and tangentially by the procambium cylinder.

Pith.

The pith is composed of lignified heavy-walled, pitted, central cells and a region of un lignified outer cells. There is very little difference in the size of these cells, the chief difference being in the thickness of the cell walls and amount of lignification. Numerous octahedral crystals of calcium oxalate are found scattered throughout the outer region. A few of these cells contain tannin and starch. The inner sclerenchymatous cells average .041 mm. across and .048 mm. vertically (Fig. 27g). All the inner cells contain starch.

Secondary Tissues.

Periderm.

The periderm of this species is very prominent. The cork region, .078 mm. in width, consists of approximately five cell-layers.
These cells are thick-walled, with somewhat undulating radial walls. They average .021 mm. tangentially, .016 mm. radially and .024 mm. vertically. The cell walls are equally suberized. A very distinctive phelloderm of four irregular cell layers is formed next to the collenchyma. These cells are uniform in size and shape and thin-walled. All the cells contain tannin.

Phloem.

An abundance of secondary phloem has been formed in quite regular radial rows. The primary phloem has become crushed and stretched tangentially (Fig. 130). Within the secondary phloem a cylinder of secondary sclerenchyma has been formed. The zone is uniformly about .048 mm. wide. It is interrupted only by the phloem rays. Numerous tannin bearing stone cells and crystals are scattered among the bast fibers. There is very little difference between the primary and secondary fibers.

Xylem.

The secondary xylem has numerous fiber tracheids and xylem parenchyma cells. The fiber tracheids average .59 mm. in length and .017 mm. across (Fig 27c). The cell walls are densely
pitted. Xylem parenchyma cells are very short, being approximately 0.042 mm. in length, and 0.012 mm. in cross diameter (Fig. 27b). Tube elements, as seen in radial section, are typically like those found in other species. Their end walls are oblique and completely dissolved out. Walls of the tracheal elements are densely pitted with large elliptical pits. Elements of the xylem are radially arranged in groups varying from one to six rows wide, alternating with the xylem rays. The rays as seen in tangential section are several cells high and one to two cells wide.
PYRUS ELAEAGNIFOLIA

Primary Tissues.

Epidermis.

The stem epidermis of this species has an unusual number of the simple, clothing-hair type of trichomes. They are elongated, narrow, pointed and twisted, and average 0.42 mm. in length (Fig. 11). The cavity is open the entire length of the trichome, but is comparatively narrow because of the thick walls.

A surface view of the epidermis shows cells that are quite regular in size and shape (Fig. 18). Some of the cells, however, are irregular in shape. The epidermal cells average 0.02 mm. vertically, 0.017 mm. tangentially and 0.008 mm. radially. The entire outer cell wall is heavily cutinized.

Primary cortex.

The primary cortex occupies an average of 0.32 mm. in a stem with a diameter of 3.4 mm. The collenchymatous hypoderm consists of four to six irregular cell layers, dipping down, here and there, into the cortical parenchyma. The cells are very irregular in size and shape. The outer cell layer is composed of uniformly small cells.
All of the cells contain tannin, making this collenchyma region appear very distinct in a section stained with FeCl₃.

There are approximately nine cell-layers of cortical parenchyma cells. These cells are quite uniform in size, averaging 0.036 mm. across and 0.04 mm. vertically. The cells are compactly arranged, with the cell walls thickened and somewhat angled. A few of the cells contain tannin and starch.

The primary sclerenchyma tissue is arranged in an interrupted cylinder, varying greatly in breadth and the number of cell layers. The cell walls are very thick and pitted with the cavities nearly obliterated. These fibers are comparatively short, averaging 0.44 mm. in length (Fig. 28a). A few small, tannin-bearing stone cells are scattered among the fibers.

Phloem and xylem.

The phloem region consists of approximately twenty-seven cell-layers in radial breadth, being made up of tangentially elongated, thin-walled cells arranged in more or less radial rows.
The large tannin-bearing phloem ray cells are very distinct as seen in cross section (Fig. 131).

There are twenty protoxylem points indenting the pith. These points vary greatly in tangential width. As is characteristic of the species studied, numerous xylem parenchyma cells are grouped within the protoxylem points. There are several rows of small-cavitated, spiral and annular tracheal tubes uniformly scattered throughout the protoxylem area. Metaxylem, consisting on numerous fiber tracheids, tracheal tubes with elliptical pits and xylem parenchyma is laid down radially and tangentially by the procambial cylinder.

Pith.

The pith is composed of lignified heavy-walled, pitted cells of nearly uniform size and shape. In this species there is very little difference in size between the inner pith cells and the outer cells bordering the vascular bundles. The cells of the pith average .034 mm. across and .065 mm. vertically. Comparatively few of the pith cells contain tannin and starch.

Secondary Tissues.

Periderm.
As is characteristic of all the species studied, a cork cylinder is formed below the epidermis. It is approximately three cell layers broad. The cell walls are thick and heavily suberized. The cells are practically isodiametric, measuring approximately 0.021 mm. tangentially, 0.02 mm. radially and 0.032 mm. vertically. All the cork cells contain tannin. There is no distinct phelloderm in the sections studied.

Phloem.

A relatively large amount of secondary phloem has been formed. The entire secondary phloem area appears stretched tangentially and the primary phloem has been crushed. Within the secondary phloem elongated, narrow, alternating bands of secondary sclerenchyma tissue have been formed. (Fig. 132). These bands are about 0.035mm, wide consisting of one to three cell-layers. The secondary bast fibers are comparatively short and heavily lignified. A few of the fibers contain small crystals within their cavities. Secondary, tannin-bearing stone cells are sparsely scattered among the fibers.
Xylem.

Tracheal tubes, quite uniform in size, are equally distributed throughout the secondary xylem area. The tracheal elements are approximately .27 mm. in vertical length and .023 mm. across (Fig. 28b). Their walls are densely marked with elliptical pits reticulately arranged. Their end walls are slightly at a slant and completely dissolved out. There are numerous fiber tracheids formed in radial rows in the secondary xylem. These tracheids average .47 mm. in vertical length and .017 mm. across (Fig. 28c). A few oblique pits appear in the cell walls. The ends of the tracheids taper to a decided point. Xylem parenchyma is not so frequent in the secondary as in the primary xylem. These cells average .035 mm. in vertical length and .01 mm. across (Fig. 23d). The cell walls are relatively thin with only a few pits. The medullary rays alternate with from one to six cell rows of xylem elements. The rays, as seen in tangential section, are mostly uniseriate, but occasionally they are biseriate; and vary from three to eighty-three cells in height.
PYRUS MICHAUXII

Primary Tissues.

Epidermis.

In surface view the epidermal cells are seen to be elongated vertically, averaging .038 mm. in this direction (Fig. 12). The cells are irregular in shape radial walls straight and appear in more or less regular rows. The cell walls are thin. All the epidermal cells contain tannin. In cross section these cells average approximately .017 mm. tangentially and .013 mm. radially. The entire outer cell wall is cutinized. A few short, stubby, slightly curved trichomes are sparsely scattered over the epidermis near the apex. These trichomes average .31 mm. in length and .02 mm. in width at the base (Fig.13). They are heavy-walled with a very narrow cavity open the entire length of the trichome.

Primary cortex.

The primary cortex occupies a region .43 mm. in breadth in a stem 3.2mm. in diameter. The collenchymatous hypoderm consists of five to six cell-layers. The cells average .038 mm. tangentially, .023 mm. radially and .048 mm. vertically. They are quite uniform in shape and all contain tannin. The cell walls are characteristically
thickened where several cells join.

The cortical parenchyma region consists of approximately eleven cell layers of isodiametric, thickened-walled cells. These cells are approximately .037 mm. across, and .04 mm. in vertical length. Tannin is stored within the cavities of the majority of the cortical parenchyma cells.

The primary sclerenchymatous tissue is formed in small patches of greatly varying breadth within the inner cortical parenchyma. The bast fibers in this species have relatively thinner cell walls and large cavities. The cell walls average .005 mm. in thickness. Average cross diameter of the cavities is .014 mm., the largest not exceeding .02 mm. at the greatest cross diameter. In macerated material the fibers extend over 7 mm. in length. They are straight, coming to a blunt point at the end (Fig. 29a). The walls are pitted. A good lignin reaction was evident.

Phloem and Xylem.

The primary phloem elements have been laid down without definite arrangement, making it very difficult to approximate the cell layers. The cells composing a region of approxi-
mately 1.3 mm. in radial breadth, are small, nearly idodiometric with very thin cell walls. The phloem ray cells are very large, containing an abundance of starch and protein.

In the sections of one year's growth studied, the xylem area is very irregular in arrangement and breadth. There are approximately thirteen protoxylem points varying greatly in tangential width. In a few of these points, approximately one-half of the area consists of thin-walled, small, xylem parenchyma cells. These cells show lignification in older stem sections tested with phloroglucin and concentrated hydrochloric acid. The procambium has developed in a continuous cylinder. The spiral and annular tracheal tubes are arranged in radial rows but are scattered within the protoxylem points. The metaxylem consists of numerous fiber tracheids arranged in radial rows, scattered xylem parenchyma cells and large-cavited bordered tracheal tubes.

Pith.

The pith cylinder is composed of cells being very irregular in size and shape. There
is very little difference, however, between the outer and inner cells. The cell walls are comparatively thick and heavily lignified and pitted. The cells average 0.032 mm. across and 0.041 mm. in vertical length. Practically all the cells contain an abundance of tannin and starch. A few very small octahedral crystals of calcium oxalate are found within the pith cells.

Secondary Tissues.

Periderm.

The cork cylinder, consisting of from three to four tangentially flattened rows of cells, occupies a region approximately 0.04 mm. in radial breadth. The cells average 0.027 mm. tangentially, 0.01 mm. radially, and 0.026 mm. vertically. The cell walls are relatively thin and equally suberized. These cork cells appear very prominent in sections tested for tannin, due to the great abundance of tannin present in all these cells. There is no phelloderm in this stem.

Phloem.

The primary phloem has become crushed. An abundance of secondary phloem has been formed, but the entire area as seen in (Fig. 134) appears stretched tangentially and the outermost rows
seem crushed. The cells appear in very irregular radial rows.

The primary sclerenchyma patches have become stretched apart tangentially. Several alternating layers of secondary sclerenchyma have been formed in narrow, elongated bands, alternating with the primary sclerenchyma. The secondary bast fibers, some of them containing chains of octahedral crystals, are short, bluntly tapering, with thick, pitted cells walls more heavily lignified than the primary. A few, tannin-bearing secondary stone cells, of varying size and shape are scattered among the bast fibers.

Xylem.

The tracheary tissues and xylem parenchyma are radially arrange, with xylem rays alternating with from one to seven cells rows of xylem elements. Xylem parenchyma, fiber tracheids, and tracheal tubes seem to be almost equally distributed throughout the xylem area, as seen in radial section. In cross section, the tracheal
tubes appear densely but quite uniformly scattered throughout the secondary xylem (Fig. 134). The elements of these vessels average .17 mm. vertically and .023 mm. across (Fig. 29 b). Their walls are marked with slanting, elongated, elliptical pits reticulately arranged or with numerous bordered pits. Fiber tracheids average .27 mm. in length and .0072 mm. across (Fig. 29c). A single row of pits, with slitlike crossed openings in the border mark the cell walls. Xylem parenchyma cells, densely pitted, average approximately .08 mm. vertically and .011 mm. across (Fig. 29 d). The xylem rays are much shorter than those of precious species as seen in tangential section. They average twenty-two cells in height. These rays, as seen in tangential section, vary somewhat in the number of cell rows broad. The majority are uniseriate. Some are uniformly biseriate, while a few are two cells broad at the center, tapering to one cell at the ends.
Primary Tissues.

Epidermis.

No trichomes are found upon the stem epidermis of this species.

The cells of the epidermis seen in surface view are very irregular in size and shape with undulating thin cell walls (Fig. 14). These cells average .02 mm. vertically, .021 mm. tangentially and .0037 mm. radially. The outer cell wall is not cutinized but a cuticle .003 mm. in thickness covers the stem epidermis.

Primary cortex.

The primary cortex, consisting of a collenchymatous hypoderm and cortical parenchyma tissue, is .27 mm. broad in a stem with a diameter 2.6 mm. The collenchymatous hypoderm makes up the greatest portion of the primary cortex. This tissue consists of five to six regular cell-layers. These cells average .028 mm. tangentially, .02 mm. radially and .034 mm. vertically. The cell walls are characteristically thickened at the corners. Most of the cells contain tannin. The
cortical parenchyma region consists of approximately ten irregular cell-layers. The cells are quite irregular in size and shape with somewhat thickened cell walls. They average .021 mm. across and .036 mm. in vertical length. There are occasional intercellular spaces between the parenchyma cells. Tannin is scattered throughout the cortical parenchyma region.

An interrupted cylinder of selerenchyma is formed within the inner cortex, lying next to the phloem. This cylinder is approximately .06 mm. in breadth and is composed of compactly arranged best fibers and scattered stone cells, more or less clustered at the ends of the fiber groups. The best fibers are somewhat angled, as seen in cross section. The cell wall is pitted and approximately .005 mm. in thickness; and the cavity averages .0002 mm. across. In macerated material these fibers are found to average .39 mm. in length with bluntly tapering ends. (Fig. 30a). Continuous chains of simple crystals are found within the cavities of a few of the fibers. The stone cells average .02 mm. across.
They are large-cavitated and contain an abundance of tannin.

Phloem. and Xylem.

The elements of the phloem are arranged in radial rows. The phloem region consists of approximately fifteen cell layers in radial breadth. The innermost layers are composed of tangentially elongated thin-walled cells, while the outermost layers bordering the sclerenchyma are thin-walled and quite isodiametric. The phloem ray cells appear prominent in cross section due to the abundance of starch and protein stored in them (Fig. 135).

There are twenty-eight protoxylem points indenting the pith cylinder. The protoxylem consists of a few rows of scattered spiral and annular tracheal tubes. Numerous xylem parenchyma cells are grouped within the protoxylem points making them appear very distinct (Fig. 135). Metaxylem consisting of numerous scattered tracheal tubes, fiber tracheids and xylem parenchyma cells, is formed laterally and tangentially by the procambial cylinder.
Pith.

The most characteristic feature of the pith cylinder of this species, is the very small amount of stored food present. Only an occasional cell contains tannin or starch. There is very little difference in size and shape between the inner and outer pith cells. An average pith cell measures \(0.036\) mm. across and \(0.038\) mm. vertically. The cell walls are very thick, pitted and heavily lignified. Frequent, small intercellular spaces occur where three or four cells join.

Secondary Tissues.

Four cell-layers of thick-walled, sclerenchymatous, suberized, tannin-bearing, cork cells are formed below the epidermis. These cells average \(0.023\) mm. tangentially, \(0.015\) mm. radially and \(0.02\) mm. vertically. Two cell-rows lying just inside the cork region, appear to be phellogen and a cell row of newly formed cork.

Phloem.

Secondary sclerenchyma has been formed bands in tangentially elongated, alternating with the primary sclerenchyma. The primary sclerenchyma
tissue has become stretched apart tangentially (Fig. 136). The secondary bast fibers, some of them containing crystals, are similar in length and cell wall thickness to the primary fibers. Occasional tannin-bearing secondary stone cells are found scattered among the fibers. The primary phloem has become crushed as the secondary sclerenchyma is formed. An abundance of secondary phloem has been formed, but the entire area appears stretched tangentially, and the phloem elements are very irregular in size and shape.

**Xylem.**

The large number of uniformly scattered, large-cavitated, tracheal tubes as seen in cross section is the most characteristic feature of this species (Fig. 136). Their elements average .28 mm. in length and .026 mm. across and are marked with elliptical pits, reticulately arranged with the oblique end walls completely dissolved out. (Fig. 30b). Radial groups of from one to eight rows of xylem elements lie between the tannin and starch-bearing xylem rays. In
tangential section the rays are seen to be from one to two cells broad and up to twenty-eight cells in vertical height. The cell walls are thick and densely pitted. The fiber tracheids average .25 mm. in length and the cavities are approximately .0092 mm. across (Fig 30c). The walls are somewhat thin, lignified, with few inclined pits. The xylem parenchyma cells thickly scattered among the fiber tracheids, average .06 mm. in length and .0085 mm. across. The walls are thickened and densely pitted. (Fig. 30d).
Primary Tissues.

Epidermis.

The trichomes of this species average .30 mm. in length and are .02 mm. wide at the base (Fig. 16). They are of the simple clothing-hair type, being slender, elongated and curved. Their walls are comparatively thin. The cavity is open the entire length of the trichome, becoming narrow at the tip.

The cells of the epidermis, as seen in cross section are very irregular in size and shape (Fig. 15). The cell walls are thin and somewhat indubulating. The entire outer wall is cutinized. The epidermal cells average .038 mm. vertically, .023 mm. tangentially and .012 mm. radially.

Primary cortex.

The primary cortex region appears very prominent in sections stained with FeCl₃, due to the abundance of tannin present in the collenchyma and cortical parenchyma cells.
This region, consisting of approximately six outer cell layers of collenchyma-like cells and twelve cell rows of cortical parenchyma, is .48 mm. in diameter.

In this species the outer cell rows of the primary cortex are parenchymatous collenchyma. The cells are elongated tangentially, narrow radially and short longitudinally. They average .04 mm. tangentially, .021 mm. radially and .027 mm. vertically.

The cortical parenchyma cells vary greatly in size and shape and have numerous, large, intercellular spaces. The smaller cells average .019 mm. across, while the larger average .04 mm. The cells however, are quite uniformly about .034 mm. vertically.

Within the inner cortical region an interrupted cylinder of scleranchyma is formed. This zone is irregular in breadth and the number of cell rows composing it. The bast fibers are .96 mm. in length, staff-like with thick pitted walls, and tapering ends (Fig.31a). Their cell walls are approximately .009 mm. thick; with cavities averaging .0018 mm. across. The fibers give a
good lignin reaction and some contain crystals. Elongated, narrow, tannin-bearing stone cells are scattered throughout the bast fibers (Fig. 31e).

**Phloem.**

Approximately twenty cell-layers of phloem elements constitute the primary phloem of the stem. These elements are radially arranged, interspersed with prominent, tannin and protein-bearing ray cells. The cells are thin walled, and nearly isodiametric (Fig. 137).

There are approximately twenty-nine protoxylem points indenting the pith. These points are small and made more prominent by the grouping of xylem parenchyma cells within them. Several rows of tracheal elements are uniformly arranged in these points. The walls have spiral and annular thickenings typical of the protoxylem elements. An abundance of metaxylem has been formed by the procambial cylinder. This region consists mainly of radially arranged fiber tracheids and xylem parenchyma cells with a few bordered tracheal tubes scattered throughout.

**Pith.**

The inner pith cells have slightly
larger cavities than the outer cells. They average .04 mm. across while the outer cells average .028 mm. across. The pith cells vary from .037 to .043 mm. in vertical length. All the cells are thick walled, pitted, and lignified. Starch and tannin is scattered throughout the cells.

Secondary Tissues.

Periderm.

A cylinder of cork, consisting of from four to five cell-layers, occupies a region .06 mm. in breadth. The sclerenchymatous cell walls are heavily suberized. The phelloderm, lying just beneath the cork cylinder, is composed of three cell-layers of cells of relatively the same size and shape as the cork cells. The cells are, however, more isodiametric, and have thin, non-suberized cell walls. There is an abundance of tannin stored in the cork and phelloderm cells.

Phloem.

The primary phloem has become crushed. The secondary phloem elements are elongated tangentially and produced in more or less radial rows. Within the outer portion of the secondary phloem region a continuous cylinder of secondary
solerenchyma has been formed (Fig. 133). This cylinder, occupying a region .073 mm. in breadth, consists of approximately four cell-layers of secondary bast fibers and scattered, large-cavited, secondary stone cells. The secondary fibers are relatively larger in cross diameter than the primary and on the average they are slightly longer than the primary, being 1.3 mm. long. Their walls are more heavily lignified than the cell walls of the primary fibers.

**Xylem.**

As seen in cross section the secondary xylem elements are in compact radially-arranged groups. Fiber tracheids compose a greater percent of the elements. The radial groups of xylem elements from one to six cell rows wide are interspersed by the prominent starch-bearing xylem rays as seen in tangential section. A large proportion of the rays are usually two cells broad, the entire height of the ray excepting the single cell at either end. The remaining rays are uniseriate. The rays average thirty-four cells in height. The walls of the ray cells are densely pitted. Tracheal tubes, formed in radial rows, are numerous in the early season's growth,
but in the later growth, the tubes become fewer and more scattered. The tracheal elements average .27 mm. in vertical length, .032 mm. across; and have decidedly oblique end walls which are completely dissolved out. Reticulately arranged bordered pits mark the cell walls. (Fig. 316). The fiber tracheids are approximately .39 mm. in length and .013 mm. across (Fig. 31c). The walls contain scattered pits placed at a slant. The numerous, scattered xylem parenchyma cells average .084 mm. in length and .012 mm. across. The walls are strongly pitted (Fig. 31d).
Primary Tissues.

Epidermis.

No trichomes are present on the stem epidermis of this species. The epidermis in surface view exhibits cells quite uniformly .021 mm. in vertical length. These cells are irregular in outline and have thin undulating walls. All of the cells contain tannin (Fig 17). As seen in cross section these cells average approximately .02 mm. tangentially and .013 mm. radially. A cuticle, .0027 mm. thick, covers the outer epidermal walls.

Primary cortex.

The primary cortex occupies a region .183 mm. in breadth in a stem 3.04 mm. in diameter. The collenchymatous hypoderm consists of five to seven cell-layers dipping down here and there into the cortical parenchyma. The cell walls are heavily thickened at the corners. The collenchyma cells average .037 mm. tangentially, .02 mm. radially and .04 mm. vertically. Tannin is stored in all
the cells. The cortical parenchyma region is very narrow in breadth and consists of approximately seven cell-layers of relatively thick-walled cells very irregular in size and shape. An average cortical parenchyma cell measures approximately .038 mm. in cross diameter and .04 mm. in length. Most of the cells contain tannin.

Within the inner cortical parenchyma region an interrupted cylinder of sclerenchyma is formed (Fig. 139). This cylinder is approximately .058 mm. in width. The bast fibers of this cylinder have thick lignified pitted cell walls, averaging .006 mm. in thickness. The cavities are approximately as wide as the cell wall is thick. These long, stafflike tapering fibers average 1.2 mm. in vertical length and occasionally contain crystals. (Fig. 32a). Many tannin-bearing stone cells are scattered among the fibers. The stone cells are more numerous and have larger diameters, as seen in cross section than any other species studied.

Phloem and xylem.

Seventeen cell-layers of phloem elements have been formed with the cells in radial rows in the current year's growth. The primary vascular tissues have developed from a continuous procambial
cylinder. The inner rows of cells are elongated tangentially and narrow radially. The outer cell-rows consist of isodiametric cells. The cell walls are very thin. Numerous, elongated phloem parenchyma cells, containing tannin and protein are found scattered throughout the phloem region. There are approximately twenty-four protoxylem points indenting the pith. Small groups of xylem parenchyma cells are present within the protoxylem points. The protoxylem consists of ten cell-layers of spiral and annular tracheal tubes; the tubes averaging .024 mm. across. These tracheal tubes are quite uniformly scattered throughout the protoxylem points. Metaxylem consists mainly of an abundance of fiber tracheids, interspersed with radial rows of xylem parenchyma cells, and scattered pitted tracheal tubes.

Pith.

The pith of this species is homogeneous. All the cells contain starch or tannin. The central pith cells are slightly larger cavitated, while those cells bordering the vascular bundles are smaller. Their cross diameters, however, very considerably, the outer cells averaging .021 mm.
and the central cells .045 mm. across. The inner cells are approximately .033 mm. in vertical length, (Fig. 32g) and the outer cells .04 mm. (Fig. 32f). All the cells have heavy, lignified cell walls, with a few intercellular spaces.

Secondary Tissues.

Periderm.

A distinct periderm is formed early during the first season's growth. Four cell-layers of sclerenchymatous, tanning-bearing cork cells of comparatively uniform size and shape, are formed below the epidermis. The tangential walls are more heavily suberized than the radial walls. These cells average .021 mm. tangentially, .013 mm. radially and .019 mm. vertically. Two to three cell layers of thin walled isodiametric, parenchymatous phelloderm cells lie below the cork cylinder. They contain an abundance of tannin.

Phloem.

The outer portion of the secondary phloem region is a continuous cylinder of secondary sclerenchyma. The primary phloem lying outside the cylinder is much crushed, while the secondary phloem elements lying within are in definite radial rows. The secondary phloem cells are isodiametric
and thin walled. The sclerenchyma cylinder is approximately 0.08 mm. in breadth and consists of compactly grouped secondary bast fibers with secondary tannin-bearing stone cells scattered among them. These fibers average approximately the same in length and cell wall thickness as the primary fibers but secondary stone cells are not as numerous as the primary stone cells. The secondary sclerenchyma is more completely lignified than the primary.

Xylem.

Radially arranged fiber tracheids is the most prominent feature of the secondary xylem. These fibers are very abundant and average 0.23 mm. in length, and 0.013 mm. across, with crisscross, slitlike openings in the borders of the pits, scattered within the cell wall (Fig. 32c). The ends taper to very fine points. Tracheal tubes are scattered throughout the xylem area but are more condensed at the beginning of the season's growth. The tracheal elements average 0.054 mm. across and 0.283 mm. in length (Fig. 32b). The end walls are oblique and completely dissolved out.
The side walls are reticulately pitted with dense rounded or elliptical bordered pits. Xylem parenchyma cells average .081 mm. in length and .02 mm. across (Fig. 32d). The cell walls are densely pitted. One to six cell rows of xylem groups alternate with prominent tannin- and starch-bearing xylem rays. These rays are very numerous as seen in tangential section and average fifteen cells in height. They are usually uniseriate but are occasionally two cells broad at the middle.
PYRUS NIVALIS.

Primary tissues.

Epidermis.

The trichomes, of this species, are densely matted upon the epidermis and become twisted and tangled together. They are of the simple clothing-hair type with very thick cell walls as compared with those found on other species studied. The cavities are very narrow but open the full length of the trichome. These trichomes are slender, and average .67 mm. in length and .02 mm. across at the base, slightly increasing in diameter toward the middle, then decreasing toward the end, tapering to an apical point (Fig. 28).

The epidermal cells, as seen in surface view are very irregular in size and shape (Fig. 19). They have thin, undulating cell walls. They average .026 mm. vertically, .019 mm. tangentially, and .0097 mm. radially. The outer cell wall is covered with a cuticle .002 mm. in thickness. The majority of the cells contain tannin.

Primary cortex.

The primary cortex is .62 mm. broad in a stem with a diameter of 4.2 mm. The
collenchymatous hypoderm consists of four to five regular cell layers. The cells average .032 mm. tangentially, .027 mm. radially and .052 mm. vertically. The cell walls are very thick, particularly at the corners. The collenchyma cells contain an abundance of tanniferous bodies. Approximately fifteen cell-layers of cortical parenchyma lie below the collenchyma. These cells are thin-walled and irregular in size and shape. They average .039 mm. across and .042 mm. in length. A few scattered octahedral and rosette crystals are found within the cortical parenchyma region.

In a section of the second internode below the apical bud, there is an interrupted cylinder of sclerenchyma formed within the inner cortex region (Fig. 141). This cylinder, consisting of from two to nine cell layers, occupies a region .08 mm. in breadth. The bast fibers average .53 mm. in length; the cell wall is approximately .009 mm. thick and the cavity .0027 mm. across (Fig. 33a). The cell walls are lignified and pitted. Scattered, large-cavitated, tannin-bearing
stone cells are present within the sclerenchyma cylinder.

Phloem and xylem.

The phloem is approximately thirteen cell-layers in radial breadth. The cells are very thinwalled and elongated tangentially, and arranged in radial rows. Large tannin-bearing parenchyma cells overreach the phloem, and connect adjacent phloem rays.

The procambium is a cylinder and approximately thirty-one protoxylem points indent the pith slightly. Several rows of annular and spiral tracheal tubes are arranged in more or less radial rows. Small groups of xylem parenchyma cells are present within the protoxylem points making them appear quite prominent in cross section. Metaxylem is produced tangentially and laterally as is characteristic of all the stems studied. Radial rows of numerous fiber tracheids, xylem parenchyma; and scattered tracheal tubes compose the metaxylem.

Pith.

The entire pith cylinder is lignified.
The cells are nearly uniform in size and shape, appearing somewhat angled. These cells average .037 mm. across and .04 mm. vertically. The cell walls are thick and densely pitted. Tannin and starch are sparsely scattered throughout the pith cells.

Secondary Tissues.

Periderm.

Four to five cell-layers of sclerenchymatous cork are formed during the first season's growth. The cork cells average .02 mm. tangentially, .016 mm. radially and .033 mm. vertically. The walls are equally thickened and suberized. No phelloderm is formed in this species.

Phloem.

The secondary phloem elements are arranged in radial rows. The primary phloem has become stretched tangentially and in some portions of the stem it is crushed. Approximately twenty-five cell-layers of secondary phloem have been formed. The secondary sclerenchyma is formed in a continuous cylinder within the outer secondary phloem region. The secondary bast fibers
vary greatly in size and length, being approximately .73 mm. The ends are tapering, and the walls pitted and heavily lignified. Secondary stone cells are scattered throughout the cylinder.

Xylem.

Tracheal tubes approximately uniform in size are well scattered throughout the secondary xylem. The elements average .031 mm. across and .30 mm. in length (Fig. 33 b). The slanting end walls are completely dissolved out. Small elliptical or rounded pits, reticulately arrange, mark the cell walls. Radially arranged fiber tracheids are numerous. These tracheids average .37 mm. in length and .015 mm. across (Fig. 33c). The majority of the fibers are relatively short with long tapering ends. A few oblique pits occur in the walls. Xylem parenchyma cells are approximately .075 mm. vertically and .018 mm. across (Fig. 33d). The walls are densely pitted. The xylem rays alternate with from one to six radial rows of xylem elements. The xylem rays, as seen in tangential section, average .63 cells in height. Many of the rays are two cells broad at the middle tapering to one cell at each end, the remaining rays are uniseriate.
ANATOMICAL KEY TO THE STEM.

Based on the anatomical structures of the one and two year stems.

A. Trichomes present.
   1. Longest trichomes, averaging .72 mm. 
      *phaeocarpa globosa* (Fig. 7).
   2. Trichomes varying .38-0.67 mm. in length and frequent in number.

B. Primary sclerenchyma in an interrupted cylinder.
   C. Secondary sclerenchyma in elongated patches alternating with the 
      primary sclerenchyma. *elaeaginfolia* (Fig. 132).
   CC. Secondary sclerenchyma is formed in a compact cylinder. *persica* 
      (Fig. 138).

BB. Primary sclerenchyma in elongated patches. *nivalis* (Fig. 141).
   3. Trichomes are short, (.23 - .31 mm. in length) and sparse.

B. Secondary sclerenchyma is formed in a continuous cylinder. *congesta* 
   (Fig. 117).
BB. Secondary sclerenchyma is formed in elongated bands... *Betulaefolia* (Fig. 126).

BBB. Secondary sclerenchyma is formed in elongated patches alternating with the primary sclerenchyma... *Michauxii* (Fig. 134).

AA. Trichomes absent.

B. Primary sclerenchyma formed in elongated patches... *Communis* (Fig. 119).

BB. Primary sclerenchyma formed in small patches.

C. Collenchyma parenchymatous.

*Communis cotinifolia* (Fig. 127).

CC. Collenchyma prosenchymatous.

D. Entire pith cylinder lignified.

*Bretschneideri* (Fig. 121).

DD. Inner pith cells lignified; outer pith cells not lignified... *Pashia* (Fig. 129).

BBB. Primary sclerenchyma an interrupted cylinder.

C. Secondary sclerenchyma formed in elongated bands alternating with the primary sclerenchyma... *Amygdaliformis* (Fig. 136).

CC. Secondary sclerenchyma formed in a compact cylinder... *Ussuriensis ovoidea* (Fig. 140).
SUMMARIZED DISCUSSION OF THE ANATOMICAL FEATURES OF THE ONE AND TWO YEAR STEMS.

In my study of the stems of thirteen species of Pyrus, I have observed certain features which are characteristic or distinctive. The following features are quite constant for the several species:

A. Bark.

1. Trichomes are found on the epidermis of seven species.

2. Periderm is formed during the first season.

3. Primary cortex region consists of a collenchymatous hypoderm and a relatively wider region of parenchyma.

4. An interrupted cylinder, or irregular patches of primary sclerenchymatous tissue is formed within the inner cortex.

5. Secondary sclerenchymatous tissue is formed, in a cylinder or elongated patches, within the secondary phloem.

6. The phloem region is relatively narrow in radial breadth, usually becoming crushed
as the secondary sclerenchyma is formed.

B. Wood.

1. Occurrence of numerous xylem parenchyma cells within the protoxylem points.

2. Numerous fiber tracheids present in the metaxylem and secondary xylem.

3. Absence of wood fibers.

4. Reticulately-pitted tracheal tubes scattered throughout the xylem area.

5. Prominent xylem rays, alternating with from one to eight radial rows of xylem elements.

C. Pith.

1. Pith lignified in all species except one.

2. Abundance of stored tannin or starch.

The above anatomical features vary somewhat among the species. The various anatomical structures will be discussed and the several species compared or grouped together.

Trichomes are found upon the epidermis of the following species: Congesta, phaeoarspa, globosa, betulaefolia, elaeagnifolia, Michauxi, persica and nivalis. In all these species there was very little variation in shape of the
trichomes. These are of the simple clothing hair type and vary from short, curved, unicellular hairs of .23 mm. in length in betulaefolia, to elongated, slender, wavy, somewhat twisted hairs of .72 mm. in length in phaeocarpa globosa. P. elaeagnifolia has trichones twisted and densely matted on the stem, while the trichomes of P. Michauxii are short, stubby, and thinly scattered over the young stem. No glandular hairs were found on the stems of the species studied.

No trichomes are found on the stem epidermis of the following species: communis, Bretschneideri, communis cotinifolia, passia, amygdaliformis and ussuriensis ovoidea.

The epidermal cells are quite irregular in size and shape, varying but little in vertical length. In the majority of the species the epidermal cells average .02-.023 mm. vertically. In Michauxii and persico these cells average .038 mm. vertically. The cell walls are relatively thin and occasionally undulating. The entire outer epidermal cell wall is heavily cutinized in all but the species amygdaliformis and ussuriensis ovoidea.
where a distinct cuticle covers the outer epidermis and no cutinization of the outer wall has taken place.

Sections of a one-year stem of all thirteen species of the second internode below the apical bud, taken in August, have a distinct periderm. The periderm consists of from three to seven cell-rows of thick-walled, sclerenchymatous, heavily suberized cork cells, comparatively uniform in size and shape; one cell layer of phellogen, which has been produced sub-epidermally; and in some of the species a phelloderm tissue. A very distinctive phelloderm of four irregular cell rows is formed in pashia. These cells are isodiametric and thin walled.

The primary cortex consists of a collenchymatous hypoderm followed by cortical parenchyma. The collenchymatous hypoderm of from one to eight irregular cell layers, occurring below the periderm, is characteristic of all but two species studied. A typical collenchyma cell averages .032 mm. tangentially. The cell walls are characteristically thickened where three or four cells join. In communis cotinifolia, and persica the outer four to six cell layers of the primary cortex are
parenchymatous collenchyma whose cells are elongated tangentially, narrow radially and short longitudinally. In pashia, elaeagnifolia and Michauxii the two outer rows of collenchyma are very small in cross diameter as compared to the inner rows. The cells, however, are typical collenchyma. Pits were found in the walls of some of the collenchyma cells. Practically all of the collenchyma cells contain tannin.

The outer cortical parenchyma cells are relatively large, thin-walled, and usually contain tannin or starch. The cortical parenchyma region is usually quite broad in all the species. The inner cortical parenchyma cells, lying inside the primary sclerenchyma region next to the phloem area, are slightly smaller in cross diameter and uniformly contain tannin.

The primary sclerenchyma is the most outstanding and distinctive feature of the several species. This tissue is formed within the inner cortical parenchyma of all species. There are variations in the breadth of the zone and the number of cell rows of which it is composed, but the distinctive feature is in the formation of a cylinder composed of interrupted bands or of irregular patches. In congesta, Bretschneideri,
phaeocarpa-globosa, betulaefolia, communis-cotinifolia, pashia, and Michauxii, the primary sclerenchyma is formed in small, irregular, or elongated patches. In eleagnifolia, persica, amygdaliformis, and ussuriensis-ovoides, this tissue is laid down in an interrupted cylinder of nearly uniform width. In nivalis and communis the primary sclerenchyma is formed in elongated patches.

Macerations were made of the bark of all the species in order to determine the lengths of the bast fibers. These fibers varied in length from short, blunt fibers of .24 mm. in length in betulaefolia, to fibers averaging .7 mm. or more in phaeocarpa globosa and Michauxii. The fibers were straight, staff-like, tapering to blunt ends. The cell walls were thick, averaging .008 mm., pitted and lignified. The cavities, as seen in cross section are slit-like. Many of the fibers contain small, octahedral crystals of calcium oxalate. Tannin-bearing stone cells, very irregular in size and shape, are usually grouped at the edges of the bast fiber patches and scattered amongst them.
Secondary sclerenchyma is formed within the secondary phloem region of all the species studied. The primary phloem becomes stretched tangentially and, in most species crushed in the two year sections. Several layers of secondary sclerenchyma may be formed in elongated, narrow patches, alternating with the primary sclerenchyma patches, as in Bretschneideri, paeocarpa-globosa, elaeagnifolia, Michauxii and amygdaliformis. In congesta, communis, communis-cotinifolia, pashia, persica, ussuriensis-ovoidea, and nivalis the innermost layer of secondary sclerenchyma is formed in a continuous cylinder. In betulaefolia, this tissue is formed in irregular, elongated bands. The secondary fibers average approximately the same in length as the primary fibers; but in all species the secondary fibers were more heavily lignified than the primary. Secondary stone cells are fewer than the primary, but contain tannin, the same as the primary.

There were no outstanding variations in comparing the xylem areas of the various species. In cross section the elements are seen to be arranged in radial strips of from one to seven cell-rows wide, alternating with relatively prominent xylem rays. The primary xylem has
developed in a continuous procambium cylinder, and areas of protoxylem extend slightly into the pith. These points appear quite prominent in sections stained with KII, due to the small, thick-walled pith cells containing much tannin and starch, surrounding them. The most outstanding feature of the primary xylem region is the occurrence of numerous xylem parenchyma cells grouped within the protoxylem points. Tracheal tubes are well scattered throughout the xylem area, being more concentrated at the beginning of each year's growth. Metaxylem, consisting of numerous fiber tracheids, xylem parenchyma, and scattered tracheal tubes, is produced tangentially and laterally by the procambial cylinder.

In all the species, fiber tracheids are numerous and formed in radial rows. They are usually short, slender, tapering to elongated points. They range very little in length, within the different species, varying from .25 mm. in length in amygdoliformis to .67 mm. in phaeocarpa globosa. The average length was .39 mm., while the average width was .009 mm. Their walls show
few inclined pits, and are relatively thickened. In macerated mounts of the wood of the species, the fiber tracheids were always the most prominent xylem elements. No wood fibers were found in any of the species studied.

The tracheal tubes are composed of elements averaging 0.24 mm. in length. These are, of course, usually bluntly tapering, with the end walls completely dissolved out. The walls of the elements have dense, reticulately arranged pits. The size of the tracheal tube cavities varies little, being 0.035 mm. to 0.04 mm. across.

Xylem parenchyma is found in abundance in all species. The cells have relatively thick, densely pitted walls. They average 0.06 mm. in length and 0.01 mm. across.

Xylem rays as seen in tangential sections vary considerably within a species in the number of cells in height, the range being from two to eighty-four cells within all the species. In congesta the rays are uniformly uniseriate. In the remaining species they are usually uniseriate, only occasionally biseriate or triseriate. The biseriate rays become single celled at the ends.
The ray cells are strongly pitted and contain an abundance of starch and tannin.

The most characteristic feature of the pith is the arrangement of the cells. It is common to find smaller-cavitated cells, elongated vertically, bordering the vascular ring and uniformly containing starch and tannin. The cells at the center are slightly larger cavitated and shorter vertically, with tannin and starch scattered throughout the cylinder.

The pith is composed of heavy-walled, pitted cells, and is lignified in all but one of the species. In pashia the central inner pith region is lignified but the outer smaller cells are not lignified.
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PYRUS CONGESTA

General Features.

The leaves of this species are ovate to elliptic lanceolate, sharply serrulate, short acuminate, and average 4 cm long, 1.8 cm. broad and .19 mm. in thickness. Petioles average 1.35 cm. in length.

Epidermis.

As seen in surface view, the upper epidermal cells appear somewhat rectangular and uniform in size and shape (Fig. 34). The cells of the upper epidermis average .025 mm. across and .016 mm. in depth. The outer cell walls are very slightly thicker than the inner walls. The cell walls average approximately .0018 mm. in thickness. The outer cell wall is cutinized. Trichomes are thinly scattered over the upper epidermis. They average .53 mm. in length and are slender and twisted. (Fig. 41).

The trichomes on the lower epidermis are
well scattered along the midrib and veins. They are simple, unicellular clothing-hairs, thin-walled and greatly twisted (Fig. 40). They average .6 mm. in length. The lower epidermal cells are smaller than the upper epidermal cells, averaging .019 mm. across and .009 mm. in depth (Fig. 37). The cell walls are approximately .0023 mm. in thickness. The outer cell walls are cutinized. There are approximately 135 stomata per sq. mm. occurring in the lower epidermis.

Mesophyll.

There are two cell layers of palisade cells (Fig. 79). The upper layer is composed of compactly grouped cells averaging .0092 mm. across and .033 mm. in vertical length. The cells composing the second layer are loosely arranged, and are approximately .03 mm. in vertical length and .008 mm. across. There are approximately 12,525 palisade cells per sq. mm. of the leaf's area.

The spongy mesophyll is composed of six cell layers of irregularly arranged cells. These cells average .021 mm. across. The spongy mesophyll
region is 0.078 mm. in depth.

Venation.

As seen in the surface view the leaf blade has a strong main vein with several lateral veins. There are approximately fifty-four meshes and twenty-three free vein endings per sq. mm. (Fig. 104).

Midrib.

The midrib in cross section is nearly circular in outline, with the outer surfaces appearing roughened. (Fig. 143). The midrib extends slightly more below the lower surface than above the upper surface. A group of approximately four cell-layers of collenchyma cells lies below the upper epidermis, directly above the vascular arc. One to two cell layers of tannin-bearing small, sclerotic or collenchymatous cells are present below the epidermis of the lower surface. The vascular arc consists of a single prominent, collateral bundle, which is bordered dorsally and ventrally by a region of bast fibers. The bast fibers lying at the top of the bundle have slightly larger cavities and are not so heavily-
lignified as those fibers surrounding the phloem region. The fibers occasionally contain crystals. Only a few cell layers of ground parenchyma surround the vascular arc.

Margin.

The margin tapers slightly and is more or less rounded (Fig. 78). The epidermal cells are comparatively uniform in size and shape. A group of collenchyma cells lies below the lower epidermis, approximately 0.09 mm. from the end. The entire outer cell wall and a portion of the radial walls are cutinized. A small vein terminates within 0.07 mm. of the limit of the margin.

Petiole.

The petiole cross section in general outline is somewhat semi-circular, averaging 0.93 mm. in width and 0.34 mm. in depth and 23.5 mm. in length. (Fig. 156). The epidermal cells average 0.018 mm. across. The outer epidermal cell walls and a portion of the radial cell walls are cutinized. A few trichomes are massed at the upper portion of the petiole. They are similar in
length and shape to those present on the blade. A collenchymatous hypoderm of from two to four cell layers, dipping here and there into the parenchyma, occurs uniformly around the petiole.

The single, collateral fan-shaped vascular arc is almost completely bordered with a zone of bast fibers. These fibers are thick-walled and heavily lignified.
PYRUS COMMUNIS

General Features.

The leaves are simple orbicular-ovate to elliptic, acute or short acuminate, subcordate to broad cuneate, 2 to 8 cm. long, crenate, serrulate, glabrous or villous when young. The petioles are very slender and average from 1.5 cm. to 5 cm. in length. The blade has an average thickness of .24 mm.

Epidermis.

The upper epidermis is composed of cells quite irregular in size and shape, having an average diameter of .03 mm. and an average depth of .0225 mm. (Fig. 35). The outer walls are somewhat thicker than the inner, being approximately .00137 mm., while the inner wall averages .00124 mm. in thickness. The outer cell walls are cutinized. There are no trichomes or stomata present on the upper epidermis.

The cells, composing the lower epidermis average .032 mm. in diameter and .0178 mm. in depth (Fig. 36). Only a few simple clothing-
hairs are found on the lower epidermis. These are found within the serrations of the margin. They are elongated, slender trichomes averaging .62 mm. in length (Fig. 43).

Mesophyll.

There are two layers of palisade cells present below the upper epidermis (Fig. 31). The upper row is composed of cells averaging approximately .04 mm. in vertical length and .01 mm. across. The lower layer is composed of cells having the same cross diameter but an average vertical length of .03 mm. An average of 14,000 palisade cells in the upper layer per sq. mm. of leaf surface or approximately 154 per stoma.

The cells of the spongy mesophyll are loosely arranged and have an average cross diameter of .021 mm.

Midrib.

The midrib is practically circular in form as seen in cross section (Fig. 144). Its surfaces extend on both upper and lower surfaces of the blade about equally. No
collenchymatous tissue is formed below the epidermis. The ground parenchyma cells have cavities averaging .02 mm. The vascular arc is composed of a collateral bundle which is bordered dorsally and ventrally by a region of bast fibers which is from two to five cell-layers wide.

Margin.

The structure of the leaf margin is quite different from that of other portions of the blade. The margin tapers slightly (Fig. 80). The epidermal cells are elongated radially with the outer wall much thicker than the inner. The outer portion of the margin is composed of collenchyma cells. The outer epidermal walls are heavily suberized.

Venation.

When viewed from the surface the leaf is seen to have numerous prominent veins and a network of smaller veins embedded within the spongy mesophyll. There are approximately 18 meshed
and 8 free vein endings per sq. mm.

Petiole.

The petioles average 3 cm. in length, 1.3 cm in width and .9 mm. in thickness and in general outline they are fan-shaped in cross section (Fig. 157). A collenchymatous hypoderm of from two to three cell-layers extends uniformly around the petiole.

The vascular arc is composed of a single collateral bundle. The convex side is bordered with a zone of bast fibers, which are thick-walled and heavily lignified. The concave side of the petiole is partially bordered with thinner-walled, bast fibers which do not react very strongly to a lignin test.
PYRUS BRETSCHNEIDERI.

General Features.

The leaves are ovate to elliptic-ovate, acuminate, broad cuneate, sharply serrate with acuminate setose teeth usually slightly appressed. The leaves I measured varied in length from 2.5 cm. to 7 cm., but Rehder gives the range from 5-11 cm. An average leaf was approximately 4.9 cm. in length, 4.5 cm. broad and .188 mm. in thickness. The petiole averaged approximately 3.5 cm. in length.

Epidermis.

There are no trichomes present on the leaves of this species. As is characteristic of the genus both epidermis are cutinized outer walls.

As seen in surface view the upper epidermis consists of large cells, sometimes elongated, with thin more or less straight radial cell walls. The cells average .039 mm. across, as seen in surface view (Fig 39). In cross section the cells are approximately .027 mm. tangentially and .019 mm.
radially. The cell wall is uniformly approximately .0017 mm. thick.

The cells composing the lower epidermis are more or less isodiametric, with thin undulating radial walls (Fig. 38). Subsidiary cells surround the stomata. The epidermal cells average .023 mm. tangentially and .013 mm. radially. The stomata are scattered over the lower epidermis and average 132 per sq. mm.

Mesophyll.

There are two compact cell layers of palisade cells (Fig. 86). The upper layer is composed of cells averaging .022 mm. in vertical length and .0036 mm. across. The second layer is composed of cells of the same approximate size.

The spongy mesophyll composes a region slightly wider than the two palisade layers. The cells are small, rounded, and very irregular in size and arrangement. They average .0078 mm. across.

Venation.

Toward the leaf tip there is one large vein, the midrib; with two strong veins, one on either side of the midrib, and practically parallel with it (Fig. 103). There are several lateral veins, however, back from the tip. There are
approximately twenty meshes and thirteen vein endings in one sq. mm. of leaf surface, viewed from the surface.

Midrib.

The midrib cross section is elliptical in general outline, as seen in surface view, projecting very little on the lower surface, but slightly convexly protruding on the upper surface (Fig. 145). The epidermal cells are smaller in cross diameters than those of the other portions of the leaf blade. A collenchymatous tannin-bearing hypoderm of two irregular cell layers is present below both epidermises. A single oblong vascular bundle is embedded within the fundamental tissue. An irregular band of bast fibers lies above the xylem area. The bast-fiber region encircling the phloem area is interspersed with large parenchyma cells. The bast fibers are lignified. Numerous crystals are grouped within the parenchyma cells surrounding the bast fibers. Tannin-bearing phloem ray cells and occasional tannin-bearing cells scattered throughout the phloem region appear very prominent in cross section.
Margin.

The leaf becomes slightly narrower toward the margin and the margin tapers to a short crook as seen in cross section (Fig. 82). The epidermal cells are approximately the same size as those of the other portions of the leaf. The epidermal cell walls are thin, and the outer walls are heavily cutinized. A small group of sclerotic cells are grouped near the end. There are numerous irregular cells within the margin.

Petiole.

As seen in cross section the petiole is rounded, with the upper surface flattened and has two slightly projecting wings (Fig. 158). The petiole is approximately 1.3 mm. broad and 1.14 mm. thick. The epidermal cells are very small, averaging a little more radially than tangentially in thickness. A collenchymatous hypoderm of two to three cell layers, dipping here and there into the parenchyma, completely encircles the petiole. A crescent-shaped vascular arc, consisting of a large collateral bundle and a small bundle, is embedded in the fundamental tissue. It occupies the bulk of the petiole.
Three to five small groups of large-cavitated parenchyma cells lie above the xylem area. These cells are slightly lignified. Irregular patches of bast fibers, interspersed with parenchyma cells, surround the phloem region. These fibers are heavily lignified.
PYRUS PHAEOCARPA GLOBOSA.

General Features.

An average leaf of this species was approximately 5.6 cm. long, 4 cm. wide, and .152 mm. thick. The leaves ovate, rounded at the base, acuminate and serrated. The petiole averages 4 cm. in length.

Epidermis.

No trichomes are present upon the epidermises of this leaf. The outer walls of both epidermises are cutinized.

As seen in surface view, the upper epidermal cells are large, very irregular in shape with relatively thin cell walls, and average .04 mm. across (Fig. 44). In cross section these cells average .038 mm. tangentially and .022 mm. radially. The cell wall is approximately .002 mm. in thickness.

The lower epidermis, as viewed from the surface, is seen to be composed of cells irregular in size and shape with somewhat undulating cell walls (Fig. 49). These cells average .031 mm. tangentially, as seen in cross section, and are approximately .036 mm. tangentially, and .023 mm.
radially. The cell wall is approximately 0.0028 mm. in thickness. There are approximately 103 stomata per sq. mm. occurring only in the lower epidermis.

Mesophyll.

The palisade region consists of two cell layers (Fig. 87). The upper layer is composed of cells approximately 0.04 mm. in vertical length and 0.0095 mm. across. There are approximately 6,825 of the upper palisade cells per sq. mm., as seen from the surface view of the upper surface of a bleached leaf. The cells making up the second cell layer are more loosely arranged and average 0.036 mm. in vertical length and 0.008 mm. across.

The spongy mesophyll consists of approximately five, irregular, loosely arranged cell-layers. The cells are more or less rounded averaging 0.02 mm. across.

Venation.

In the study of a bleached leaf-tip, the number of meshes were estimated to be 32 per sq. mm.; and there were approximately ten free vein endings, per sq. mm. There was one main vein with a few large lateral veins, and numerous small meshes (Fig. 107).
Midrib.

As seen in cross section the midrib is broadly elliptical in outline, with the upper side projecting to a peak above, and the lower surface slightly extending below the leaf blade (Fig. 146). Two irregular cell layers of collenchyma lie inside the upper surface, while there are one to two cell layers of smaller collenchyma cells lying inside the lower epidermis. All the collenchyma cells contain tannin. A single, rounded, collateral vascular bundle lies embedded within the fundamental tissue. The phloem rays are very large and all contain an abundance of protein and tannin. Irregular groups of bast fibers lie above the xylem. A continuous band of from one to four cell layers of bast fibers subtends the phloem region. These fibers are more heavily lignified than those above the xylem area. A few simple octahedral crystals are found scattered throughout the parenchyma cells.

Margin.

The margin cross section tapers somewhat and is rounded (Fig. 83). The epidermal cells are smaller in cross diameter than those found on the other portions of the leaf. A layer of
large, rounded, collenchyma cells lies just inside the epidermis, contributing to the strength of the margin. Palisade cells are found .06 mm. from the margin. The outer epidermal cell walls and a portion of the lateral walls are heavily cutinized.

Petiole.

As seen in cross section, the petiole is more or less round, with a rather deep groove in the upper surface with wings extending equally on each side (Fig. 159). The petiole is approximately .76 mm. wide and .94 mm. deep. There are a few trichomes averaging .38 mm. in length, massed at the base of the petiole. The entire outer cell wall and a portion of the radial walls are heavily cutinized. The collenchymatous hypoderm is one cell layer deep at the upper surface, becoming three to four cells deep at the lower surface. Tannin is found in all these cells. There is a large bean-shaped vascular bundle, and two small round, vascular bundles, one in each wing. A layer of bast fibers from one to five cells in breadth subtends the phloem region of the vascular
arc. A patch of bast fibers is found above each small bundle. There is a region of thin-walled prosenchymatous cells lying next to the xylem of the vascular arc. These cells stain, when tested for lignin, but not as heavily as these fibers subtending the phloem.
PYRUS BETULAEFOLIA.

General Features.

The leaves are rhombic to oblong-ovate, acuminate, broad-cuneate, sharply and rather coarsely serrate. An average leaf measures approximately 4 cm. in length; 1.9 cm. in breadth and .15 mm. in thickness. The petiole is approximately 3.7 cm. long.

Epidermis.

The cell cavities of the upper epidermal cells vary from .02 mm. to .043 mm. in cross diameters, as seen in surface view. The cells composing the upper epidermis are comparatively large, with somewhat straight radial cell walls (Fig. 45). As seen in cross section the upper epidermal cells average .032 mm. tangentially and .018 mm. radially. The outer cell wall is .0018 mm. thick and the inner wall is .00165 mm. in thickness. The outer cell walls are cutinized.

The lower epidermis is composed of relatively small cells but sometimes are elongated up to
.036 mm. vertically. In surface view they are very irregular in size and shape with slightly undulating cell walls (Fig. 50). An average cell, as seen in cross section, measures .032 .023 mm. tangentially and .017 mm. radially. The cell wall is uniformly .0015 mm. in thickness. The outer cell walls are cutinized. According to Rehder the leaves appear tomentose beneath, but the mature leaves I studied were practically glabrous, with only an occasional short, trichome scattered along the midrib. These trichomes were .32 mm. long, very slender, and unicellular (Fig. 46). Approximately 167 stomata are found per sq. mm.

Mesophyll.

Two cell layers of palisade cells occupy approximately one-third the thickness of the leaf (Fig. 88). The upper cell layer is composed of cells averaging .033 mm. in vertical length and .0087 mm. across. The upper row of cells is quite compact, there being approximately 10,342 of these cells per sq. mm. The lower cell layer is composed of loosely arranged cells approximately .021 mm. in vertical length and .01 mm. across.
The spongy mesophyll is composed of cells very irregular in size and shape and loosely arranged. There were numerous veins embedded within the spongy mesophyll, in the cross sections of the leaf studied.

Venation.

As seen in surface view the leaf blade has a prominent midrib, extending to the tip, and occasional, irregularly-branching lateral veins, forming a fine network of small veins (Fig. 106). Within an area 2 mm. back from the apex, there are approximately twenty-six meshes and twelve free veinlet endings per sq. mm. of leaf surface.

Midrib.

In general outline the midrib cross section is an ellipse, projecting slightly above the upper surface, but considerably projecting below the lower surface (Fig. 147). One to three rows of small tannin-bearing collenchyma cells are found beneath both epidermises. Then follow isodiametric parenchyma cells with slightly thickened cell walls. Those cells, bordering the bast fiber region, which surrounds the vascular arc, occasionally
contain small octahedral crystals. A single vertically elongated, elliptical, vascular bundle is embedded within the fundamental tissue. The bast regions, lying above the xylem and below the phloem are practically uniform in number of cell layers, and cell wall thickness. The bast fibers are all lignified. Tannin is found in some of the parenchyma cells and all the phloem rays and occasional phloem parenchyma cells. The xylem rays contain tannin and starch.

Margin.

The margin cross section is slightly tapering (Fig. 84). The epidermal cells surrounding the margin are comparatively elongated radially. One cell layer of tannin-bearing collenchyma cells lies inside the epidermis, lining the margin. The palisade cells are present practically to the end of the margin. The entire outer wall and a portion of the radial walls of the epidermis is cutinized.

Petiole.

The petiole cross section is round, in general outline, with the upper surface slightly flattened. It is .79 mm. wide and .762 mm. thick (Fig. 160).
Simple, single-celled, curving, clothing hairs, approximately 0.30 mm. in length, are scattered along the petiole and massed at the base. A collenchymatous hypoderm of two to three cell layers completely encircles the petiole. All the collenchyma cells contain tannin. The parenchyma cells are thin-walled and occasionally contain tannin. In cross section a large kidney-bean shaped vascular bundle and two very, small rounded bundles, lying at the ends of the large bundle are embedded within the parenchyma tissue. A narrow belt of small, thin-walled prosenchyma cells lies above the xylem region of the large bundle. These cells are faintly lignified. A bast fiber zone uniformly three to four cell rows wide, subtends the phloem region of the large vascular bundle. A single patch of bast fibers lies below the phloem of each small bundle. These fibers are heavily lignified.
General Features.

Leaves of this species average 5 cm. in length, 3.5 cm. in width and .173 mm. thick. They are oblong, ovate, broadly acuminate, with dentate margins. The petiole averages 3 cm. in length.

Epidermis.

A few, narrow, twisted, simple clothing-hairs are found upon the upper epidermis, sparsely scattered along the midrib and main veins (Fig. 52). They average .41 mm. in length. The outer epidermal cell walls are cutinized. As seen in surface view the upper epidermis is composed of cells more or less uniform in shape but varying in size and averaging approximately .025 mm. across (Fig. 42). The cells have relatively thin cell walls, appearing in quite regular rows, appearing sometimes almost rectangular in shape. In cross section the cells average .023 mm. tangentially and .02 mm. radially. The cell wall is .0018 mm. thick.
The lower epidermis, as seen in surface view, is composed of more or less isodiametric cells approximately .03 mm. across, with lateral walls not at all undulating (Fig. 47). The cells average .02 mm. tangentially and .014 mm. radially as seen in cross section. The cell walls are seen to be approximately .002 mm. in thickness. The outer walls are cutinized. A few elongated narrow, twisted trichomes are scattered along the midrib. These are approximately .49 mm. in length (Fig. 54). An average of 111 stomata per sq. mm. is found in the lower epidermis.

Mesophyll.

There are two layers of palisade cells, as is common in the previous species. The upper row is composed of cells averaging .02 mm. vertically and .01 mm. across. The cells of the lower layer are approximately the same in cross diameters but average .037 mm. in vertical length (Fig. 88). The spongy mesophyll is composed of irregularly arranged, somewhat vertically elongated thin-walled cells averaging .032 mm. vertically and .02 mm. across.
Numerous veins are embedded in the spongy mesophyll.

Venation.

Many lateral veins branch from the midrib and ultimately consist of a fine network of veins (Fig. 109). Approximately thirty-six meshes and fifteen freevein endings per sq. mm. of leaf surface.

Midrib.

The midrib cross section is an elongated ellipse in outline. It projects very little on both surfaces. (Fig. 148). Three layers of large-cavitied, collenchyma cells lie inside the upper epidermis and one to two irregular cell-layers of smaller-cavitied, tannin-bearing collenchyma cells lie inside the lower epidermis. Following the collenchyma come three to four cell layers of relatively thin walled, isodiametric parenchyma cells. The parenchyma cells bordering the bast fiber zone occasionally contain simple octahedral crystals of calcium oxalate. A single elongated collateral vascular bundle whose xylem
is immediately bordered by two to three cell layers of slightly large-cavitated, lignified, bast fibers, and a hard bast zone, approximately two to five cell layers, interspersed with tannin-bearing parenchyma cells, subtends the phloem region. These fibers are slightly thicker walled and more heavily lignified than those bordering the xylem region.

Margin.

The leaf tapers but very little at the margin, which is rounded (Fig. 85). The epidermal cells appear the same in size and shape, in cross section, as on other portions of the leaf blade and the outer walls are heavily cutinized. A single cell layer of isodiametric, relatively thin-walled cells lie inside the epidermis. Following immediately inside these thin-walled cells is a group of cells irregular in size and shape. Palisade cells are found .05 mm. from the outer limit of the margin.

Petiole.

The petiole cross section is round in outline with the upper surface slightly depressed and
with wings projecting equally on each side (Fig. 161). The cross section is approximately 1.13 cm. broad and 1.02 mm. deep. Trichomes, thickly scattered along the petiole, are of the simple clothing-hair type, small tapering to a point, and not much curved or twisted. (Fig. 51). These average .424 mm. in length. The epidermal cells are small cavitated, with relatively thick cell walls making them stand out in cross section. The outer epidermal cell walls and approximately a third of the radial walls are cutinized. A collenchymatous hypoderm of from two to six cell layers encircles the petiole. There are uniformly two cell-layers of collenchyma cells below the upper surface, while the number of cell layers at the sides and lower surface varies greatly. The collenchyma cells contain tannin. A single, vascular bundle, kidney-bean shaped in cross section and two very small bundles, one at each end of the larger bundle are embedded in the fundamental tissue. One small group of lignified, bast fibers lies above the middle of the xylem of the large bundle, and a compact, bast fiber zone, irregular in the number of cell-layers and breadth, subtends
the phloem area of the large bundles. These fibers are heavily lignified. A single patch of lignified fibers lies beside the phloem of each small bundle. Tannin is stored in the phloem rays and in abundance in the parenchyma cells ensheathing the phloem.
PYRUS PASHIA.

General Features.

The leaves of this species average 4.3 cm. in length, 2.5 cm. in width and .151 mm. in thickness. They are ovate to oblong-ovate, or oblong, acuminate, usually rounded at the base, crenate or crenate-serrulate. The petioles average 2.5 cm. in length.

Epidermis.

The upper epidermis is composed of cells, irregular in size and shape with more or less straight radial walls, making the cells appear rectangular, as seen in surface view (Fig. 53). The outer cell wall is cutinized. The upper epidermal cells average .037 mm. longitudinally, .035 mm. tangentially, and .02 mm. radially. The cell wall is uniformly about .00193 mm. thick.

As seen in surface view, the lower epidermal cells are more or less isodiametric, irregular in arrangement, with undulating radial walls. (Fig. 56). A few simple clothing-hairs are sparsely scattered over the blade, being more numerous along the midrib and margin of the leaf. These
hairs are slender, slightly curved, and average .62 mm. in length (Fig. 58). The outer cell walls are cutinized. The lower epidermal cells average .029 mm. longitudinally, .021 mm. tangentially, and .0185 mm. radially. There are approximately ninety-seven stomata per sq. mm. of leaf surface, occurring only on the lower epidermis.

Mesophyll.

There is one compact cell layer of palisade cells and a second layer of small, loosely arranged palisade cells (Fig. 93). The cells composing the upper cell layer are approximately .038 mm. long and .012 mm. broad. There are approximately 15,875 upper palisade cells per sq. mm. The lower layer is composed of cells averaging .02 mm. in length and .013 mm. in breadth.

The spongy mesophyll is composed of thin-walled isodiametric cells, averaging .018 mm. across. These cells are formed in irregular chains enclosing large air spaces. There are many small veins embedded in the spongy tissue.

Venation.

The midrib of this leaf is very prominent with several small lateral veins branching from it
There is a fine network of veins throughout the leaf blade but the meshes are comparatively large. Approximately seventeen meshes and six vein endings are found within a sq. mm. of leaf surface.

Midrib.

As seen in cross section the midrib is quite circular in outline, projecting equally on both surfaces of the leaf (Fig. 149). The epidermal cells covering the midrib are very small in cross diameter. One to two cell layers of collenchyma cells are found below the upper epidermis. A single row of collenchyma cells lines the lower epidermis. Next follow larger cavitated parenchyma cells on the lower side as compared to those at the upper side. These cells are relatively thick-walled. Those parenchyma cells lying next to the bast fibers contain rhombohedral or rosette crystals of calcium oxalate. A single oblong vascular bundle lied embedded in the fundamental tissue. A bast fiber zone, relatively uniform in cross section lies above the xylem region and subtends the phloem region. The bast fibers are thick-walled and heavily lignified. The
mesophyll tissues of the leaf blades extend practically to the edges of the vascular arc.

Margin.

The leaf margin tapers to a blunt point in cross section. No collenchymatous tissue is found within the margin of this leaf but a group of irregularly arranged parenchyma cells composes the marginal tissue. (Fig. 90). The palisade tissue is present within .06 mm. of the end.

Petiole.

The petiole of this species appears in cross section nearly circular in outline, with a slightly depressed upper surface (Fig. 162). The petiole in cross section is approximately 1.28 mm. broad and 1.22 mm. in thickness. The epidermal cells are very small in all dimensions. The entire outer cell wall and a portion of the radial walls are heavily cutinized. A collenchymatous hypoderm of three irregular cell-layers encircles the petiole. All the collenchyma cells contain tannin. The parenchyma tissue consists of large-cavitated, thin-walled, isodiametric
cells. Embedded in this tissue is a large
lunar shaped vascular bundle and a small rounded
bundle at each end of the larger. A thin layer of
from one to two cell layers of relatively large-
cavitated prosenchyma cells lie above the xylem
region of the large bundle. An interrupted
bast fiber zone of approximately three cell
layers subtends the phloem region of the large
bundle and extends above the phloem region of
each small bundle. The fibers of this zone are
thick-walled and lignified. The fibers lying above
the xylem region are relatively thin-walled and
faintly lignified.
PYRUS ELAEAGNIFOLIA

General Features.

The leaves are lanceolate to obovate-lanceolate or narrow elliptic, short acuminate, greyish or whitish on both sides. The margin is entire. An average leaf measures approximately 5.2 cm. in length, 1.5 cm. wide and 1.149 mm. in thickness. The petiole averages 1.5 cm. in length.

Epidermis.

As seen in surface view, the cells of the upper epidermis appear large-cavitated with relatively thin walls (Fig. 55). The cells are more or less irregular in arrangement, with straight lateral walls. The upper epidermal cells average 0.038 mm. longitudinally, 0.036 mm. tangentially and 0.02 mm. radially. The cell walls are approximately 0.0019 mm. thick. The outer cell walls are cutinized. The entire upper surface is covered with a whitish bloom. No trichomes are found on the upper epidermis.

The cells of the lower epidermis are small, and vary much in size and shape, as seen in surface view (Fig. 61). The lateral walls are more or less
straight. These cells average .024 mm. longitudinally, as seen in surface view; .023 mm. tangentially and .014 mm. radially, as seen in cross section. The outer cell walls are approximately .0021 mm. in thickness, while the inner cell walls are .0017 mm. in thickness. The outer cell walls are cutinized. Simple, single-celled, twisted, clothing-hairs are found thickly scattered over the lower epidermis (Fig. 60). They are more numerous along the margin and at the base of the leaf blade. These trichomes average .47 mm. in length. An average of seventy-eight, large, rounded, stomata is found per sq. mm. for the lower epidermis.

Mesophyll.

There is a compact upper palisade layer, and a second layer of irregularly arranged palisade cells (Fig. 94). Those cells composing the upper layer average .039 mm. in length and .0032 mm. in breadth. There are approximately 8,835 of these upper palisade cells per sq. mm. of leaf surface. The second palisade layer is composed of cells averaging .023 mm. in length and .01 mm. in breadth.
The cells composing the spongy mesophyll are relatively small, more or less rounded and loosely arranged and with relatively thin cell walls. These cells vary in cross diameters from .013 to .02 mm. Many small veins, surrounded with a parenchyma sheath are found embedded in the spongy mesophyll.

Venation.

There are few veins at the very tip of the leaf, but less than one mm. from the tip there appears a fine network of veins. There are approximately forty-three meshes and fifteen free vein endings per sq. mm. of leaf surface (Fig. 115).

Midrib.

As seen in cross section, the midrib is elliptical in outline (Fig. 150). The upper side slightly projects above the surface of the leaf, while the lower side projects considerably below the surface. The upper epidermal cells over the midrib differ in size and shape from those over the rest of the leaf. These epidermal cells average .02 mm. radially and .016 mm. tangentially.
The outer cell walls are cutinized. There are two cell layers of tannin-bearing collenchyma cells lying next to both epidermises. A small group of parenchyma cells lie below the collenchyma on the top sides and the palisade cells indent the midrib at both sides. A region of 6 cells layers of thick-walled parenchyma cells lies next to the collenchyma on the lower side. A single vascular bundle, elliptical in shape, lies embedded within the fundamental tissue. A bast fiber zone, varying from one to three cell rows broad lies above the xylem region and subtends the phloem region. The fibers are relatively thin-walled, large cavitated and uniformly lignified. Large, tannin-bearing phloem ray cells appear prominent in the section studied. Tannin is scattered throughout the fundamental tissue.

Margin.

The margin of the leaves of this species is entire. The leaf tapers slightly toward the margin, then rounds off (Fig. 91). The epidermal cells surrounding the margin are somewhat smaller in radial diameter than those of other portions of the leaf blade. The outer walls of the epidermal
cells are more heavily cutinized than those of the upper surface of the leaf. Two cell-rows of thin-walled cells lie inside the epidermis. A small vein occurs .075 mm. from the outer limit of the margin.

Petiole.

The petiole in cross section is slightly more than semi-circular in outline (Fig. 163). The cross section is approximately .948 mm. broad and .69 mm. deep. A few trichomes are found scattered along the petiole. These are simple, thin-walled and twisted with cavities open the entire length (Fig. 59). They average .4 mm. in length. The epidermal cells are small, slightly pointed toward the outer surface. The outer surface is heavily cutinized. A collenchymatous hypoderm, two to three cell layers, in breadth is found next the upper side. A collenchymatous hypoderm one to five cell-rows broad lies below the epidermis at the sides and lower surface. Thin-walled, isodiametric, parenchyma cells, occasionally containing tannin or simple crystals occur in the collenchyma. A large, crescent-
shaped vascular bundle and two very small bundles are embedded within the fundamental tissue. A bast fiber zone quite uniform in breadth lies above the xylem region. These fibers are thick-walled and lignified. Irregular compact groups of thick-walled fibers subtend the phloem region. These fibers are heavily lignified.
PYRUS MICHAUXII

General features.

The leaves are ovate to elliptic-oblong, obtuse or abruptly pointed, with entire margins. An average leaf measures 3.5 cm. in length, 2 cm. in breadth and .173 mm. in thickness. The petioles average 1.5 cm. in length.

Epidermis.

The cells of the upper epidermis appear in surface view irregular in size, more or less rectangular in shape, with relatively thin cell walls (Fig. 66). No trichomes are present on the upper epidermis. The outer cell wall is heavily cutinized. The cells average .04 mm. longitudinally, .032 mm. tangentially and .021 mm. radially. The inner cell walls are approximately .0017 mm. thick.

The lower epidermis, as seen in surface view, is composed of cells more or less irregular in shape, elongated longitudinally, with undulating thin radial walls. (Fig. 62). Slender simple trichomes are densely scattered over the lower
surface. These trichomes, averaging .57 mm. in length, are usually twisted near the base, and tapering to a point (Fig. 57). The cell walls are thin and the cavities open the entire length. The lower epidermal cells average .036 mm. longitudinally, .02 mm. tangentially, and .016 mm. radially. The entire outer cell wall is cutinized. There are approximately eighty-five stomata per sq. mm. of the lower leaf surface.

Mesophyll.

There are two cell layers of palisade cells (Fig. 95). The cells composing the upper layer, average .039 mm. in length and .01 mm. in breadth. These cells taper somewhat downward. There are approximately 10,875 upper palisade cells per sq. mm. of leaf surface. The cells of the second layer are irregularly arranged. They average .024 mm. in length and .013 mm. in breadth.

The spongy mesophyll is composed of loosely arranged cells, very irregular in size and shape.

Venation.

The midrib is very prominent, with few fine lateral veins forming a fine network of small
veins. The network of veinlets consists of approximately twenty meshes and nine vein endings, per sq. mm. of leaf surface (Fig. 113).

Midrib.

The midrib, as seen in cross section, is elliptical in outline, slightly projecting considerably below the lower surface. (Fig. 151). The epidermal cells of the midrib, are smaller in all dimensions than those elsewhere over the leaf. No collenchyma tissue is found below the upper surface, but there is an irregular tannin-bearing collenchymatous hypoderm of from one to two cell layers inside the lower epidermis. The remaining fundamental tissue consists of thickened-walled, isodiametric, parenchyma cells, containing tannin or rosette crystals. A single vascular bundle, elliptical in cross section lies embedded in in the fundamental tissue. A layer of thick-walled, lignified bast fibers lies above the xylem region and subtends the phloem area. An abundance of tannin is stored within the phloem region, especially in the phloem rays, thus making the photomicrograph of this midrib appear very dark.
Margin.

The margin is entire. The leaf tapers very slightly at the margin (Fig. 92). The epidermal cells surrounding the margin are slightly smaller in tangential diameter than those of the upper epidermis and the entire outer cell walls, and a portion of the radial walls are heavily cutinized. A group of collenchyma cells lies next to the epidermis and a vein and palisade cells appear .06 mm. from the outer limit of the margin.

Petiole.

The petiole in cross section is nearly circular in outline with the upper surface slightly concave (Fig. 164). The cross section is approximately .958 mm. broad and .82 mm. in depth. No trichomes are present on the petiole. The epidermis is composed of small, practically isodiametric cells, pointed toward the outer surface. The outer cell wall and approximately one-half the radial walls are heavily cutinized. The collenchyma, encircling the petiole, varies from one to three irregular cell layers. Within this the parenchyma tissue consists of thin-walled
isodiametric cells very irregular in size. The vascular tissues form a single large, bean-shaped vascular bundle, and one small bundle at one end of the large bundle. A large bundle and two small bundles enter the petiole. A zone of thin-walled bast fibers lies above the xylem region of the large bundle. These fibers are slightly lignified. A compact region of heavy-walled bast fibers subtends the phloem region. These fibers are heavily lignified. Tannin is found scattered throughout the fundamental tissue, phloem region and in all phloem rays. Occasional crystals occur in the parenchyma cells and fibers. Starch is stored in the xylem rays.
PYRUS AMYGDALIFORMIS

General Features.

Leaves of this species vary considerably in length. An average leaf measures 5 cm. in length, 2 cm. in breadth and .163 mm. in thickness. The leaves are oval to obovate, or oblong, cuneate, or sometimes rounded at the base, slightly crenate or entire. The petiole averages 2 cm. in length.

Epidermis.

According to Rehder the leaves of this species are slightly tomentose when young. I found no trichomes on either surface of the leaves I studied.

The upper epidermis, as seen in surface view, is composed of large, thin-walled cells, more or less uniform in size and rectangular in shape, and with occasionally slightly, undulating radial cell walls. (Fig. 67). The outer cell wall is cutinized. The upper epidermal cells are approximately .04 mm. longitudinally, .036 mm. tangentially and .023 mm. radially. The cell wall is approximately .00082 mm. thick.
The cells of the lower epidermis vary in size and shape as seen in surface view (Fig. 63). Some of the cells are unusually small, averaging .023 mm. longitudinally, while others are large-cavitied and elongated, averaging .04 mm. longitudinally. The radial walls are slightly undulating. In cross section the lower epidermal cells are approximately .023 mm. in tangential diameter and .015 mm. in radial diameter. The outer wall is cutinized. There are on an average, 125 stomata per sq. mm. of lower leaf surface.

Mesophyll

As is characteristic of all the species studied, there are two cell layers of palisade cells (Fig. 100). The cells composing the upper layer average .041 mm. in length and .012 mm. in breadth. There are approximately 15,235 upper palisade cells per sq. mm. of leaf surface. The cells of the second layer are relatively shorter, being .034 mm. in length, but of the same average breadth as the upper cells.

The cells, composing the spongy mesophyll, vary greatly in size and shape, and in arrangement. In some portions of the cross section of the leaf
studied, this tissue appeared compactly formed, while in other portions, it was very loosely arranged.

Venation.

The midrib tapers slightly as it nears the tip of the leaf (Fig. 112). Numerous lateral veins are formed terminating in numerous small veinlets. There are approximately thirty-four meshes and sixteen free vein endings per sq. mm. of leaf surface.

Midrib.

As seen in cross section, the midrib is circular in outline, slightly projecting above the upper surface, but projecting considerably below the lower surface (Fig. 152).

A single, oval vascular bundle lies embedded in the center of the midrib. A zone of bast-fibers, one to four cell-layers in breadth lies above the xylem region. These fibers have relatively thick-walls and are heavily lignified. Approximately six cell layers of small, isodiametric thick-walled parenchyma cells lie next to the bast region toward the upper surface; followed by a collenchymatous hypoderm, of two irregular cell layers. The upper epidermal cells,
over the midrib are smaller in all diameters from those of other portion of the blade.

A bast-fiber region, one to six cell layers, in breadth subtends the phloem region. The fibers composing this region are small, thick-walled and heavily lignified. There are five cell layers of isodiametric, parenchyma cells lying below this bast region, and next to the parenchyma is a collenchymatous hypoderm of from two to three cell layers in breadth. The lower epidermal cells surrounding the midrib on the lower surface are very small in all diameters with the entire outer wall, and a portion of the radial walls heavily cutinized.

Starch is stored in the xylem rays. Tannin is found in abundance in the collenchyma cells, and phloem ray cells, and scattered throughout the parenchyma tissue.

Margin.

The margin of the leaf of this species is very similar to the margin of P. Michauxii. The leaf tapers very little toward the margin (Fig. 96). The epidermal cells surrounding the margin are slightly shorter tangentially than the other epidermal cells and the outer cell walls
and 1/3 the radial walls are cutinized. A group of collenchyma cells borders the epidermis. A vein occurs .05 mm. from the marginal limit.

Petiole.

The petiole appears circular in outline with the upper surface somewhat straight across, as seen in cross section (Fig. 165). The petiole is approximately .31 mm. broad and .79 mm. deep. As is characteristic of the petioles studied, the epidermal cells are relatively small in all dimensions with the outer walls and part of the radial walls heavily cutinized. A collenchymatous hypoderm of from two to four irregular cell layers, encircles the petiole. Next follows a region of relatively thin-walled, isodiametric, parenchyma cells. Embedded within this tissue is a single, crescent-shaped vascular bundle with a zone, of from one to three cell layers of thin-walled, lignified bast fibers, lying above the xylem region and a relatively wider zone of compactly-grouped, thick-walled, heavily lignified, bast fibers, subtending the phloem region.
Tannin is stored within the collenchyma cells, phloem rays, and occasional parenchyma cells. Occasional simple crystals are found in some of the parenchyma cells bordering the bast-fiber zones.
PYRUS PERSICA.

General Features.

The leaves of this species are oblong, slightly crenulate and broadened at the tip. An average leaf blade measures approximately 5 cm. in length, 2.5 cm. in breadth and .175 mm. in thickness. The petioles average 1.5 cm. in length.

Epidermis.

As seen in surface view the upper epidermis is composed of cells more or less rectangular in shape and uniform in size (Fig. 65). The upper epidermal cells average .035 mm. longitudinally, .023 mm. tangentially and .02 mm. radially. The outer cell wall is cutinized. The inner cell walls are relatively thin, being approximately .00094 mm. in thickness. Simple one-celled, slender, slightly twisted trichomes are present on the upper surface, and are sparsely scattered over the blade, especially along the midrib (Fig. 72). These trichomes average .58 mm. in length and have thin cell walls with the cavities open the full length.
The cells composing the lower epidermis are irregular in size and shape. The radial walls are not at all undulating (Fig. 64). These lower epidermal cells average .032 mm. longitudinally, .021 mm. tangentially, and .015 mm. radially. The outer cell wall is cutinized, the inner cell wall is approximately .001 mm. in thickness. A dense mat of trichomes is present towards the base of the lower surface of the leaf. A few are scattered along the midrib and veins towards the tip (Fig. 75). These trichomes are simple, elongated, slender, clothing hairs, slightly curving toward the tip. The cell walls of these hairs are relatively thin, with cavities open the full length. These hairs vary in length from .32 mm. to 1.3 mm.

Mesophyll.

There are two layers of palisade cells (Fig. 101). The cells of the upper layer average .036 mm. in length and .034 mm. in breadth, while those cells of the lower layer are .027 mm. in length and .0092 mm. in breadth. There are approximately 11,785 upper palisade cells per sq. mm. of leaf surface.
The spongy tissue is composed of loosely arranged cells of varying size and shape.

Venation.

There is a fine meshwork of veins near the tip of the leaf of this species with approximately twenty-eight meshes and seven free vein endings per sq. mm. of leaf surface (Fig. 114).

Midrib.

As seen in cross section the midrib is circular in outline, convexly projecting above the upper surface and considerably projecting below the lower surface (Fig. 153).

A single, more or less rounded, vascular bundle, lies embedded within the fundamental tissue. A bast-fiber zone of one to five cell layers are above the xylem region. These fibers are relatively thick-walled, lignified and with large cavities. Several cell layers of isodiametric, comparatively thick-walled parenchyma cells lie next to the bast region, followed by a single cell layer of large-cavitied collenchyma cells. The upper epidermal cells are somewhat smaller in all diameters than those over the rest of the leaf.
A bast-fiber region of quite uniform width subtends the phloem region. These fibers are very similar in wall thickness and lignification to those lying above the xylem. Approximately seven cell layers of isodiametric parenchyma cells lie next in order and then follows a collenchymatous hypoderm of from one to two irregular cell layers. The epidermal cells covering the lower surface are very small, in all diameters.

Tannin is stored within the collenchyma cells, occasional parenchyma cells and phloem-raycells. Occasional clustered or single crystals occur in some of the parenchyma cells bordering the bast-fiber regions.

Margin.

The margin of the leaf blade is bluntly rounded, (Fig. 97). The epidermal cells surrounding the margin are elongated radially with the entire outer cell walls, and a portion of the radial walls heavily cutinized. A group of collenchyma cells lies next to the epidermis and palisade tissue is present 06 mm. back from the marginal limit.

Petiole.

The petiole cross section is circular in
outline with the upper surface flattened (Fig. 166).
The petiole averages 1.03 mm. in breadth and 0.98 mm. in depth. Long, slender, simple clothing-hairs, tapering toward the tip, are scattered along the petiole (Fig. 73). These trichomes average 0.87 mm. in length.

A single large slightly crescent-shaped vascular bundle lies embedded in the fundamental tissue bordered on both xylem and phloem sides with a zone of bast fibers. These fibers are thick walled and heavily lignified. Several cell layers of large isodiametric, thin-walled parenchyma cells compose the bulk of the fundamental tissue and inside this a collenchymatous hypoderm, of from three to four irregular cell layers encircles the petiole. The epidermal cells are small in cross section, with the entire outer wall and a portion of the radial walls heavily cutinized.

Clustered and single crystals are scattered throughout the parenchyma cells. Tannin occurs in the collenchyma, phloem rays and occasional parenchyma cells. Starch is stored in the xylem rays.
PYRUS USSURIENSIS-OVOIDEA

General Features.

The leaves of this species are orbicular-ovate to ovate, acuminate, rounded or subcordate at the base, setosely serrate, glabrous or nearly so. An average leaf measures approximately 4.8 cm. in length, 3 cm. in breadth and .132 mm. in thickness. The petiole averages 1.5 cm. in length.

Epidermis.

No trichomes are present on either of the leaf surfaces.

The upper epidermis is composed of cells varying in size and shape as seen in surface view (Fig. 68). These cells average .039 mm. longitudinally, .035 mm. tangentially, and .032 mm. radially. The outer cell wall is cutinized.

The cells of the lower epidermis in surface view present cells with thin, undulating radial walls (Fig. 69). These cells are approximately .037 mm. in longitudinal diameter, .002 mm. in tangential diameter and .017 mm. in radial diameter.
The entire outer wall is cutinized. There are approximately 93 stomata per sq. mm. occurring only in the lower epidermis.

**Mesophyll.**

There are two cell layers of palisade cells (Fig. 102). The upper layer is composed of cells averaging 0.037 mm. in length and 0.0093 mm. in breadth. The lower layer is composed of cells averaging 0.032 mm. in length and 0.0087 mm. in breadth. The upper palisade cells average 12,325 per sq. mm. of leaf surface.

The cells of the spongy mesophyll are loosely arranged and are relatively large and thin-walled.

**Venation.**

When viewed from the lower surface the leaf is seen to have numerous prominent veins and a network of smaller veins. There are approximately eight meshes and 14 vein endings per sq. mm. (Fig. 111).

**Midrib.**

The midrib, as seen in cross section, is elliptical in outline, slightly extending above the upper surface, but roundly convex below the
lower surface (Fig. 154). A single, more or less rounded, vascular bundle, bordered dorsally and ventrally by a single layer of bast fibers lies embedded in the fundamental tissue. The ground parenchyma cells are small-cavitied, isodiametric, with slightly thickened cell walls. A collenchymatous hypoderm, one to two irregular cell layers lies inside both epidermises. Simple, octahedral crystals are present within some of the parenchyma cells bordering the bast fibers. Tannin is stored in abundance in the phloem rays, and occurs scattered throughout the fundamental tissue.

Margin.

The structure of the leaf margin is very little different from that of other portions of the blade (Fig. 98). The margin tapers slightly. The epidermal cells are as elsewhere but the outer walls and a portion of the radial walls are more heavily cutinized. No collenchyma tissue is present in this margin. A group of parenchyma cells, irregular in size and shape compose the marginal mesophyll.

Petiole.

The petiole averages 1.14 mm. broad and 1.03 mm. deep and in general outline it is circular with
upper surface depressed and with wings projecting equally on both sides (Fig. 167). The epidermal cells are more or less isodiametric and uniform in size and shape. The outer cell walls and a very small portion of the radial walls are heavily cutinized. A collenchymatous hypoderm of from two to five irregular cell layers encircles the petiole.

A large, bean-shaped, vascular arc and two small bundles lie embedded within the fundamental tissue. A few small, thin-walled bast fibers lie above the xylem area and the phloem is subtended by an irregular band of bast fibers which have relatively thick and lignified cell walls. Large simple crystals and a few rosette crystals are scattered throughout the parenchyma region. Tannin is present in the collenchyma cells and phloem rays.
General Features.

The leaves of this species average 4.5 cm. in length, 3 cm. in breadth and .17 mm. in thickness. They are elliptic to obovate, acute, entire and white tomentose. The petioles average 2 cm. in length.

Epidermises.

A few, slender, twisted, simple trichomes about .67 mm. in length are sparsely scattered along the midrib and main veins of the upper surface of the leaves (Fig. 74). The upper epidermis is composed of cells quite large and uniform in size and shape and the complete outer cell wall is cutinized (Fig. 70). The cells are approximately .042 mm. in longitudinal diameter, .031 mm. in tangential diameter and .021 mm. in radial diameter.

As seen in surface view, the lower epidermal cells vary much in size and shape, with undulating radial walls (Fig. 71). These cells average .04 mm. longitudinally, .018 mm. tangentially and .012 mm. radially. The outer walls are cutinized and long slender, trichomes, looped over several times, and tapering toward the tip are densely
scattered over the lower surface and around the margin (Fig. 76). These trichomes have thin walls; with cavities open the entire length, and average .78 mm. in length. Large rounded stomata occur in the lower epidermis only. There are approximately 64 per sq. mm. of leaf surface.

Mesophyll.

There is one compact cell layer of palisade cells and a second layer of slightly shorter, irregularly arranged palisade cells (Fig. 103). The cells composing the upper cell layer are approximately .032 mm. in length and .01 mm. in breadth, and the second layer is composed of cells averaging .029 mm. in length and approximately the same in breadth as the upper cells. There are approximately 10,575 upper palisade cells per sq. mm. of leaf surface.

The spongy tissue is composed of relatively thin-walled, isodiametric cells more or less compactly grouped together.

Venation.

The midrib of the leaf is somewhat prominent with numerous lateral veins, as seen in surface view (Fig. 116). Approximately eleven meshes and
eight vein endings are found within a sq. mm. of leaf surface.

Midrib.

As seen in cross section the midrib is elliptical in general outline, projecting slightly on both surfaces (Fig. 155). A single, round vascular bundle lies embedded within the fundamental tissue. It is bordered dorsally and ventrally with an irregular zone of bast fibers outside of which lie large isodiametric, thin-walled parenchyma cells. A collenchymatous hypoderm of from one to two irregular cell layers lies next to the lower epidermis, but no collenchyma occurs below the upper epidermis. Occasional crystals occur throughout the parenchyma region. Tannin is not so abundantly stored as usual within the cells of the midrib of the species.

Margin.

The leaf tapers toward the margin which is incurved on the lower surface (Fig. 99). The epidermal cells are elongated radially and the entire outer wall and a slight portion of the radial walls are cutinized. A group of thick-walled
cells lie within the epidermis. The remaining marginal tissue is composed of thin-walled parenchyma cell. The palisade cells extend within .047 mm. of the edge.

Petiole.

The petiole of this species appears in cross section nearly semi-circular in outline, with the upper surface flattened (Fig. 168). It is approximately 1.74 mm. broad and 1.32 mm. in depth. Slender curved simple clothing-hairs are densely scattered along the petiole and these average .52 mm. in length (Fig. 77). The epidermal cells are very small in all dimensions with the outer and a portion of the radial walls cutinized. A collenchymatous hypoderm of three irregular cell layers encircles the petiole. The vascular system consists of a relatively large, elongated, bean-shaped central bundle, and two very small rounded, bundles. An irregular narrow band of relatively thin-walled, large-cavitied, lignified bast fibers lies above the xylem region of the large bundle and a zone, of irregular groups of thick-walled, heavily-lignified, bast fibers subtends the phloem region. Rosette crystals of calcium oxalate are scattered among the parenchyma cells. Tannin is stored in the collenchyma and phloem rays.
ANATOMICAL KEY TO THE LEAVES.

Based upon external features and thickness of the leaf blade.

A. Leaves ovate or oblong ovate to elliptic.
   B. Margin sharply serrate.
      C. Trichomes present on both surfaces of the leaf. _______ congosta.
      CC. No trichomes present on either of the leaf's surface. ______ betulaefolia.

BB. Margin dentate.
   C. Trichomes sparsely scattered over both surfaces of the leaf. ______
      communis cotinifolia.
   CC. Trichomes present only on the lower surface of the leaf.
   D. Tip of blade acuminate. ______ pashia.
   DD. Tip of blade acute or short acuminate. ______ communis.

CC. No trichomes present on either surface of the leaf.
   D. Thickness of leaf approximately .152 mm. ______ phaeocarpa globosa.
DD. Thickness of leaf approximately .188 mm. *Bretschneideri.*

BBB. Margin slightly serrate.

C. No trichomes present on either surface. *...amygdaliformis.*

CC. A few trichomes present on upper surface, densely scattered on lower surface. *...persica.*

CCC. No trichomes present on either surface of the leaf. *...ussuriensis ovoides.*

BBBB. Margin entire.

C. A few trichomes present on the lower surface of leaf. *...Michauxii.*

CC. Trichomes present on both surfaces of the leaf. *...nivalis.*

AA. Leaves lanceolate.

B. Margin entire; trichomes present on lower surface only. *...elaeagnifolia.*
ANATOMICAL KEY TO THE MIDRIBS.

Based on general shape and trichomes.

A. Midrib elliptical in general outline.

B. No trichomes present on either surface of the leaf.

C. Midrib projecting slightly more above the upper surface than below the lower surface.

D. Vascular bundle more or less round in outline...ussuriensis ovoidea

(Fig. 154)

DD. Vascular bundle elongated, oblong in outline...Bretschneideri

(Fig. 145)

CC. The upper surface of the midrib projecting to a peak.

D. Vascular bundle round in outline...phaeocarpa globosa

(Fig. 146)

DD. Vascular bundle is elongated, elliptical in outline...betulasefolia

BB. Trichomes present on the lower surface of the leaf... (Fig. 147)

C. Upper surface of the midrib slightly projecting.

D. A bloom covers the upper surface of the leaf... elaeagnifolia (Fig. 150).
DD. No bloom on upper surface of the leaf. *Michauxii* (Fig. 151).

CC. Midrib projecting convexly to a peak above upper surface...

*communis* (Fig. 144).

BBB. Trichomes present on both surfaces of the leaf.

C. The upper surface of the midrib projecting to a short peak; vascular bundle elliptical in outline...

*congesta* (Fig. 143).

CC. The upper surface of the midrib roundly convex; vascular bundle more or less round in outline. *nivalis* (Fig. 155).

CCC. Midrib projecting very slightly above the upper surface; vascular bundle is an elongated ellipse.

*communis cotinifolia* (Fig. 148).

AA. Midrib circular in general outline.

B. No trichomes present on either surface of the leaf.... *amygdaliformis* (Fig. 152).

BB. A few trichomes present on the lower surface of the leaf... *pashia* (Fig. 149).

BBB. Trichomes present on both surfaces of the leaf............ *persica* (Fig. 153).
ANATOMICAL KEY TO THE PETIOLES

Based upon the general outline; presence or absence of trichomes; and average dimensions of the petiole in cross section.

A. Petiole more or less circular in outline.
   B. Upper surface more or less concave.
      1. No wings projecting.
         C. Trichomes present at the base...
            betulaefolia (Fig. 160).
      CC. No trichomes present.
         D. Average dimensions, 1.3 mm.
            broad and .9 mm. deep....
            communis (Fig. 157).
      DD. Average dimensions, 1.22 mm.
            broad and 1.22 mm. deep...
            pashia (Fig. 162).

2. Wings projecting.
   C. Wings very slightly projecting at each side.
      D. Trichomes present along the petiole.............. congesta (Fig. 156).
DD. No trichomes present.

Bretschneideri (Fig. 158).

CC. Wings projecting more on each side.

D. Trichomes present. Communis-cotinifolia (Fig. 161).

DD. No trichomes present.

Ussuriensis ovoidea (Fig. 167).

CCC. Depression deeply furrowed in the center, with wings projecting considerably on each side.

Phaeocarpa globosa (Fig. 159).

AA. Petiole semi-circular in general outline.

B. The upper surface straight; trichomes present on both surfaces.

C. Petiole averages .943 mm. in breadth and .69 mm. in depth. Elaeagnifolia (Fig. 163).

CC. Petiole averages 1.74 mm. in breadth and 1.32 mm. in depth. Nivalis (Fig. 168).
A SUMMARIZED DISCUSSION OF THE ANATOMICAL FEATURES OF THE LEAVES.

The leaves of the thirteen species studied, vary little in general features. The majority of the leaves are ovate or oblong-ovate to elliptical. Pyrus elaeagnifolia is the only species with a distinct lanceolate leaf. The margins of most of the leaves were serrate or dentate. The margins of elaeagnifolia, Michauxii and nivalis were entire, while those of amygdaliformis and persica are only slightly serrate.

Trichomes are found on the lower surface only of the leaves of communis, pashia, elaeagnifolia, and Michauxii. Trichomes are present on both surfaces of the leaves of congesta, communis-cotinifolia, persica and nivalis. These trichomes were of the simple, clothing-hair type, being slender, elongated and more or less wavy or twisted. No glandular hairs were found.

No trichomes were found on either epidermises of the following species: Bretschneideri,
phaeocarpa-globosa, betulaefolia, amygdaliformis and ussuriensis-ovoidea.

The epidermal cells have a varying outline in surface view. The cells of the lower and upper epidermises seldom have the same longitudinal diameter. The upper epidermal cells average slightly more in longitudinal diameter with the lateral walls more or less straight. There is more or less undulation of the lateral walls of the lower epidermal cells. The outer cells walls of both epidermises were cutinized and in some cases a distinct cuticle was distinguishable.

Stomata occur only on the lower side of the leaves. The stomata are provided with subsidiary cells occasionally. The guard cells were very slightly depressed below the level of the leaf surface, and more often surrounded by a variable number of ordinary epidermal cells. Solereder ('03) quotes Gérard as finding elevations of the cuticle present around the stomata in Pyrus communis. However, I found very little elevation of the cuticle around the stomata in this species.
The approximate number of stomata present in the lower epidermis, per sq. mm, varied among the species. The range was from 64 stomata per sq. mm. in nivalis to 167 per sq. mm. in betulaefolia.

The structure of the mesophyll was very uniform throughout the thirteen species, it being composed of two cell layers of palisade cells and a region of more or less loosely arranged spongy tissue, and a parenchyma sheath surrounding the veins.

There is very little variation in size and shape of the midribs of the various species. Because the midribs were so similar in all characteristics, it was very difficult to construct a key by their anatomical features.

A single, rounded or elliptical vascular bundle, lies embedded within the fundamental tissue. A bast fiber zone lies above the xylem region, and a similar zone of more heavily-lignified and thicker walled bast fibers subtends the phloem region. The remainder of fundamental tissue consists of several cell layers of
parenchyma cells, and a collenchymatous hypoderm of several irregular cell layers in breadth.

The petioles also vary little within the genus. The structure of the petiole has been studied by Gerard ('84), who states that the number of vascular bundles which enter the petiole, is in most cases three. I found this to be true of all the species I studied. In sections taken midway between the base of the petiole and its attachment, I found, in most species, a single, large vascular bundle, and one or two very small bundles at each end of the large bundle.

The vascular bundles are embedded within the fundamental tissue. A very narrow region of thin-walled, faintly lignified bast fibers, lies above the xylem region. A wider region of compactly grouped, thick-walled, heavily-lignified fibers subtends the phloem region. The remaining fundamental tissue consists of several cell layers of isodiametric, parenchyma cells and an irregular collenchymatous hypoderm.
PLATE I

STEM EPIDERMIS AND TRICHOMES.
(x 166)

Fig. 1 Stem epidermis of P. congesta.
Fig. 2 Stem epidermis of P. communis.
Fig. 3 Stem epidermis of P. Bretschneideri.
Fig. 4 Stem trichome of P. congesta.
Fig. 5 Stem epidermis of P. betulaefolia.
Fig. 6 Stem epidermis of P. phaeocarpa globosa.
Fig. 7 Stem trichome of P. phaeocarpa globosa.
Fig. 8 Stem epidermis of P. communis cotinifolia.
Fig. 9 Stem trichome of P. betulaefolia.
Fig. 10 Stem epidermis of P. pashia.
Fig. 11 Stem trichome of P. elaeagnifolia.
Fig. 12 Stem epidermis of P. Michauxii.
Fig. 13 Stem trichome of P. Michauxii.
Fig. 14 Stem epidermis of P. amygdaliformis.
Fig. 15 Stem epidermis of P. persica.
Fig. 16 Stem trichome of P. persica.
Fig. 17 Stem epidermis of P. ussuriensis ovoidea.
Fig. 18 Stem epidermis of P. elaeagnifolia.
Fig. 19 Stem epidermis of P. nivalis.
Fig. 20 Stem trichome of P. nivalis.
PLATE II

ELEMENTS OF THE XYLEM, PRIMARY SCLERENCHYMA AND PITH.

( x 166)

a bast fiber
b tracheal tube
c fiber tracheids
d xylem parenchyma
e stone cell
f outer pith cells
g inner pith cells

Fig. 21 P. congesta.
Fig. 22 P. communis
Fig. 23 P. Bretschneideri
Fig. 24 P. phaeocarpa globosa
Fig. 25 P. betulaefolia
Fig. 26 P. communis cotinifolia
PLATE III

ELEMENTS OF THE XYLEM, PRIMARY SCLERECHYMA AND PITH.

( x166 )

<table>
<thead>
<tr>
<th>Fig.</th>
<th>Description</th>
<th>Species</th>
</tr>
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<tbody>
<tr>
<td>27</td>
<td>P. pashia</td>
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</tr>
<tr>
<td>28</td>
<td>P. elaeagnifolia</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>P. Michauxii</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>P. amygdaliformis</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>P. persica</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>P. ussuriensis ovoidea</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>P. nivalis</td>
<td></td>
</tr>
</tbody>
</table>
PLATE IV

LEAF EPIDERMISES AND TRICHOMES ( x 166)

Fig. 34 Upper leaf epidermis of P. congesta.
Fig. 35 Upper leaf epidermis of P. communis.
Fig. 36 Lower leaf epidermis of P. communis.
Fig. 37 Lower leaf epidermis of P. congesta.
Fig. 38 Lower leaf epidermis of P. Bretschneideri.
Fig. 39 Upper leaf epidermis of P. Bretschneideri.
Fig. 40 Trichome from the lower surface of the leaf of P. congesta.
Fig. 41 Trichome from the upper surface of the leaf of P. congesta.
Fig. 42 Upper leaf epidermis of P. communis cotinifolia.
Fig. 43 Trichome from the lower surface of P. communis.
Fig. 44 Upper leaf epidermis of P. phaeocarpa globosa.
Fig. 45 Upper leaf epidermis of P. betulaefolia.
Fig. 46 Trichome from the lower epidermis of P. betulaefolia.
Fig. 47 Lower leaf epidermis of P. communis cotinifolia.
Fig. 48 Trichome from the petiole of P. phaeocarpa globosa.
Fig. 49 Lower leaf epidermis of P. phaeocarpa globosa.
Fig. 50 Lower leaf epidermis of P. betulaefolia.
Fig. 51 Trichome from the petiole of P. communis cotinifolia.
Fig. 52 Trichome from the upper surface of the leaf of P. communis cotinifolia.
Fig. 53 Lower leaf epidermis of P. phasdia.
Fig. 54 Trichome from the lower surface of P. communis cotinifolia.
Fig. 55 Upper leaf epidermis of P. betulaefolia.
Fig. 56 Lower leaf epidermis of P. phasia.
Fig. 57 Trichome from the lower surface of P. Midhauxii.
Fig. 58 Trichome from the lower surface of the leaf of P. phasia.
Fig. 59 Trichome from the petiole of P. elaeagnifolia.
Fig. 60 Trichome from the lower surface of the leaf of P. elaeagnifolia.
Fig. 61 Lower leaf epidermis of P. elaeagnifolia.
PLATE V

LEAF EPIDERMISES AND TRICHOMES

(x 166)

Fig. 62 Lower leaf epidermis of P. Michauxii.
Fig. 63 Lower leaf epidermis of P. amygdaleformis.
Fig. 64 Lower leaf epidermis of P. persica.
Fig. 65 Upper leaf epidermis of P. persica.
Fig. 66 Upper leaf epidermis of P. Michauxii.
Fig. 67 Upper leaf epidermis of P. amygdaliformis.
Fig. 68 Upper leaf epidermis of P. ussuriensis ovoidea.
Fig. 69 Lower leaf epidermis of P. ussuriensis ovoidea.
Fig. 70 Upper leaf epidermis of P. nivalis.
Fig. 71 Lower leaf epidermis of P. nivalis.
Fig. 72 Trichome from the upper surface of the leaf of P. persica.
Fig. 73 Trichome from the petiole of P. persica.
Fig. 74 Trichome from the upper surface of the leaf of P. nivalis.
Fig. 75 Trichome from the lower surface of the leaf of P. persica.
Fig. 76 Trichome from the lower surface of the leaf of P. nivalis.
Fig. 77 Trichome from the petiole of P. nivalis.

LEAF MARGINS AND CROSS SECTIONS

(x 166)

Fig. 78 Margin of the leaf of P. congesta.
Fig. 79 Cross section of the leaf of P. congesta.
Fig. 80 Margin of the leaf of P. communis.
Fig. 81 Cross section of the leaf of P. communis.
PLATE VI

LEAF MARGINS AND CROSS SECTIONS

(x 166)

Fig. 82 Margin of the leaf of P. Bretschneideri.
Fig. 83 Margin of the leaf of P. phaeocarpa globosa.
Fig. 84 Margin of the leaf of P. betulaefolia.
Fig. 85 Margin of the leaf of P. communis cotinifolia.
Fig. 86 Cross section of the leaf of P. Bretschneideri.
Fig. 87 Cross section of the leaf of P. phaeocarpa globosa.
Fig. 88 Cross section of the leaf of P. betulaefolia.
Fig. 89 Cross section of the leaf of P. communis cotinifolia.
Fig. 90 Margin of the leaf of P. pashia.
Fig. 91 Margin of the leaf of P. elaeagnifolia.
Fig. 92 Margin of the leaf of P. Michauxii.
Fig. 93 Cross section of the leaf of P. pashia.
Fig. 94 Cross section of the leaf of P. elaeagnifolia.
Fig. 95 Cross section of the leaf of P. Michauxii.
Fig. 96 Margin of the leaf of P. amygdaliformis.
Fig. 97 Margin of the leaf of P. persica.
Fig. 98 Margin of the leaf of P. ussuriensis woodea.
Fig. 99 Margin of the leaf of P. nivalis.
Fig. 100 Cross section of the leaf of P. amygdaliformis.
Fig. 101 Cross section of the leaf of P. persica.
Fig. 102 Cross section of the leaf of P. ussuriensis woodea.
Fig. 103 Cross section of the leaf of P. nivalis.
PLATE VII

LEAF VENATION

(x 28)

Fig. 104  P. congesta.
Fig. 105  P. communis.
Fig. 106  P. betulaefolia.
Fig. 107  P. phaeocarpa globosa.
Fig. 108  P. Bretschneideri.
PLATE VIII

LEAF VENATION
( x 28)

Fig. 109       P. communis cotinifolia.
Fig. 110       P. pashia.
Fig. 111       P. ussuriensis ovoidea.
Fig. 112       P. amygdaliformis.
PLATE IX

LEAF VENATION
( x 28)

Fig. 113  P. Michauxii.
Fig. 114  P. persica.
Fig. 115  P. elaeognifolia.
Fig. 116  P. nivalis.
STEM CROSS SECTIONS
( x 35)

Fig. 117  One year stem of P. congesta.
Fig. 118  Two year stem of P. congesta.
Fig. 119  One year stem of P. communis.
Fig. 120  Two year stem of P. communis.
STEM CROSS SECTIONS
( x 35)

Fig. 121  One year stem of *P. Bretschneideri*.
Fig. 122  Two year stem of *P. Bretschneideri*.
Fig. 123  One year stem of *P. phaeocarpa globosa*.
Fig. 124  Two year stem of *P. phaeocarpa globosa*. 
STEM CROSS SECTIONS
(x 35)

Fig. 125  One year stem of *P. betulaefolia*.
Fig. 126  Two year stem of *P. betulaefolia*.
Fig. 127  One year stem of *P. communis cotinifolia*
Fig. 128  Two year stem of *P. communis cotinifolia*. 
Fig. 129 One year stem of P. pashia.
Fig. 130 Two year stem of P. pashia.
Fig. 131 One year stem of P. elaeagnifolia.
Fig. 132 Two year stem of P. elaeagnifolia.
STEM CROSS SECTIONS
( x 35)

Fig. 133 One year stem of P. Michauxii.
Fig. 134 Two year stem of P. Michauxii.
STEM CROSS SECTIONS

( x 35 )

Fig. 135  One year stem of *P. amygdaliformis*.
Fig. 136  Two year stem of *P. amygdaliformis*.
Fig. 137  One year stem of *P. persica*.
Fig. 138  Two year stem of *P. persica*. 
Fig. 139 One year stem of P. ussuriensis ovoida.
Fig. 140 Two year stem of P. ussuriensis ovoida.
Fig. 141 One year stem of P. nivalis.
Fig. 142 Two year stem of P. nivalis.
MIDRIB CROSS SECTIONS
( x 65)

Fig. 143  P. congesta.
Fig. 144  P. communis.
Fig. 145  P. Bretschneideri.
Fig. 146  P. phaeocarpa globosa.
Fig. 147  P. betulaefolia.
MIDRIB CROSS SECTIONS
(x 65)

Fig. 148  P. communis cotinifolia.
Fig. 149  P. pashia.
Fig. 150  P. elaeagnifolia.
Fig. 151  P. Michauxii.
MIDRIB CROSS SECTIONS
(x 65)

Fig. 152  P. amygdaliformis.
Fig. 153  P. persica.
Fig. 154  P. ussuriensis ovoidea.
Fig. 155  P. nivalis.
PETIOLE CROSS SECTIONS
(x 37)

Fig. 156  P. congesta.
Fig. 157  P. communis.
Fig. 158  P. Bretschneideri.
Fig. 159  P. phaeocarpa globosa.
Fig. 160  P. betulaefolia.
PETIOLE CROSS SECTIONS
( x 37)

Fig. 161  P. communis cotinifolia.
Fig. 162  P. pashia.
Fig. 163  P. elaegnifolia.
Fig. 164  P. Michauxii.
Fig. 165  P. mygdaliformis.
PETIOLE CROSS SECTIONS
( x 37)

Fig. 166  P. persica.
Fig. 167  P. ussuriensis ovoidea.
Fig. 168  P. nivalis.
CONCLUSION

In the summarized discussions of the stems and leaves, I have compared the various anatomical features of the different species.

In the study of the anatomy of the stem sections of the several species, P. pashia stands apart from the others in the lignification of the pith and the amount of its phelloderm tissue. In all the species studied except P. pashia, the entire pith cylinder was heavily lignified. In P. pashia the outer pith cells were not lignified but the inner central cells were. A very distinct four cell layer region of phelloderm was present in the one and two year stem sections of P. pashia studied. In several of the other species a two cell layer region of phelloderm is present, while in the remainder no phelloderm exists.

The stems of all the species studied had essentially the same tissues present in relatively the same positions; but there was considerable variation in the number of cell layers composing
each tissue, and in the approximate diameters of the cells of the tissues.

The various species differ in the arrangement of the primary and secondary sclerenchyma, and in the length of the elements of these tissues.

In the study of the anatomy of the leaves, I find variation in the number of stomata, arrangement and length of palisade cells and in the type of venation at the tip of the leaves.

While the several species seem to differ more in their external features this in only because these features are more easily perceived.

P. elaegnifolia is the only species with a distinct lanceolate leaf. There has been some discussion as to the spelling of P. elaegnifolia. In Rehder's key it appears as P. elaegrifolia. In my writing of this specific name, I have spelled it elaegnifolia, as that is the way it is printed on the label at the Arnold Arboretum. In Bailey's Cyclopedia of Horticulture the statement occurs that the -agri spelling was first written by Pallas because he considered
elaeagnus to be the proper spelling of the name of the oleaster genus.

The other species have oblong-ovate to orbicular-ovate leaves but these vary in the type of margin.

P. amygdaliformis, persica and elaeagnifolia are shrubby or small trees. Pyrus nivalis and communis are large trees varying from 16-20 m. in height. Bretschneideri, phaeocarpa globosa, betulaefolia, pashia and ussuriensis ovoidea are smaller trees varying from 10 to 12 m. in height.

P. communis or the common pear, is probably the most well known pear tree. It lives to a great age and sometimes attains a height of 75 ft. This pear grows wild over the whole of temperate Europe and Western Asia, where it has been cultivated from the earliest times. Some authors hold that its area extends as far as China. In the Syrio-Persian region are several very distinct Pyruans of the pear group, a number of which may be outlying forms of P. communis.

P. nivalis, commonly known as the snow pear, is quite different from P. communis in type of leaf.
This tree is grown in the cooler temperate parts of Europe. It has been considered by some writers to be a form of P. communis. But I find the most striking differences between the leaves of these two species. The leaf of P. communis is relatively thin, and practically glabrous, having only a few, sparsely scattered trichomes on the lower surface of the leaves, while the leaves of P. nivalis are densely covered with trichomes on both surfaces giving the appearance of thick leaves.

Among the species studied I have two hybrids, and the parents of each; and one variety and the species of which it is a variety.

P. congesta is a hybrid between P. elaeagnifolia and P. betulaefolia. It has a leaf more the shape of P. betulaefolia, being more obovate than lanceolate like the leaf of P. elaeagnifolia. P. congesta has trichomes present on both surfaces of the leaf, thus differing from both of its parents, as P. elaeagnifolia has dense trichomes on the lower surface only and P. betulaefolia has only a few trichomes on the lower surface.
The midrib cross section of *P. congesta* is more similar in size to *P. elaeagnifolia*. The midrib of *betulaefolia* is smaller and more rounded in general outline. The petiole cross section of *P. congesta* appears similar in outline and approximate size to the petiole of *P. elaeagnifolia*. The petiole of *P. congesta* has wings projecting on both sides while the petioles of *betulaefolia* and *elaeagnifolia* are more or less straight across the upper surface.

*P. Michauxii* is a hybrid between *P. amygdaliformis* and *P. nivalis*. It resembles *P. nivalis* more in the shape of leaves and type of venation. However, *P. Michauxii* differs from *P. nivalis* in the presence of trichomes only on the lower surface, as *P. nivalis* has trichomes present on both surfaces of the leaf.

The midrib cross section of *P. Michauxii* is similar in general outline to the midrib of *P. nivalis*.

The petiole cross section of *P. Michauxii* differs from the petiole cross sections of *P. nivalis* and *P. amygdaliformis* in the general outline and size. The petiole of *P. amygdaliformis* is small with the upper surface straight, while the petiole of *P. Michauxii* has the upper surface
while the petiole of *P. michauxii* has the upper surface concave. The petiole of *P. nivalis* is larger in all diameters with a straight upper surface.

*P. communis* cotinifolia is a variety of *P. communis*. It differs from *P. communis* in the presence of trichomes, as its leaves have trichomes on both surfaces and *P. communis* has only a few trichomes on the lower surface of the leaves.

The midrib cross section of *P. communis* cotinifolia is quite different from the midrib cross section of *P. communis*. It is more or less elliptical in outline, with neither of its surfaces projecting while the petiole of *P. communis* is elliptical in outline and projects considerably above both surfaces. The petiole cross section of *P. communis* cotinifolia is more similar to the petiole cross section of *P. communis* than the midrib sections. The petioles have the same general shape; but the petiole of *P. communis* cotinifolia has wings projecting on either side, while that of *P. communis* is very slightly depressed at the upper surface.
BIBLIOGRAPHY

1. Solereeder ('08)
   Systematic Anatomy of the Dicotyledons.

2. Rehder ('27)
   Manual of Cultivated Trees and Shrubs.

3. Julius Von Wiesner ('23)
   Die Robstoffe des Pflanzenreiches,
   vierte auflage.

4. Burgerstein ('96)
   Weitere Untersuchungen über den
   Histologischen Bau des Holzes der
   Pomaceen, nebst Bemerkungen über das
   Holz der Amygdaleen.

5. Solereeder ( )
   Über den Systematischen Wert der Holzstructur.

6. Moller ('76)
   Beiträge zur vergleichenden Anatomie
   des Holzes.
7. P. Schulz ('83)
    "Jahrbücher des Königlichen Botanischen
    Gartens und Botanischen Museums zu
    Berlin.

8. Sanio ('63)
    "Botanische Zeitung. 1863, S. 116."