COMPARATIVE ANATOMICAl RESEARCH WITHIN
THE GENUS RIBES

by

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Approved by:

[Signature]
professor in charge

[Signature]
Chairman of Dept.
ACKNOWLEDGMENT

The writer desires to make his appreciative acknowledgment to Professor W. C. Stevens for his direction and encouragement during the preparation of the work here presented.
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GEOGRAPHIC DISTRIBUTION AND INTRODUCTION INTO CULTIVATION

The species of Ribes which are discussed in this thesis have the following geographical distribution and introduction into cultivation, according to Rehder ('27).

R. alpinum.

This species is found from Europe to North Asia, and was introduced in 1588.

R. americanum.

This species is found from Nova Scotia to Virginia and west to Manitoba and Colorado. It was introduced about 1739.

R. aureum.

R. aureum is found from Minnesota to Missouri and Arkansas, Washington, Montana and California. It was introduced in 1806.

R. cynobasti.

R. cynobasti is found in East North America and westward to Manitoba and Missouri. It was brought under cultivation in 1759.

R. diacantha.

This species is found in North Asia, from Tianshan to Manchuria, and was introduced in 1781.

R. fasciculatum.

This is a Chinese species found in North-east Asia and Japan, and was introduced into cultivation in 1867.

R. hirtellum.

R. hirtellum is found in North-east North America and
westward to South Dakota. It was introduced in 1812.

R. holosericeum.

This species is a hybrid.

R. *luridum*.

This species is found in West China, and was introduced in 1918.

R. missouriense.

R. *missouriense* is found from Minnesota to Arkansas, and has been cultivated since 1907.

R. *nigrum*.

This species is found from Europe to North China, and has been cultivated since 1588.

R. *sativum*.

R. *sativum* is found in West Europe, and has been cultivated since 1600.

R. *stenocarum*.

This species, originating before 1909, is found in North-West China.

R. *tenue*.

R. *tenue* is found in West China. It was introduced about 1900.

R. *vilmorinii*.

This species is found in West China.
SUMMARY OF PUBLISHED ANATOMICAL RESEARCH

A comparatively small amount of anatomical work on Ribes has been published by Petit, Reinke, and Holle, and summarized by Solereder (1908) in his Systematic Anatomy of the Dicotyledons. Vol. I.

According to Holle (1893) the cuticle is thin in all species of Ribes examined. The hairs are long, simple, and conically pointed.

Solereder (1908) claims the unicellular trichomes are not calcified and that external glands have been observed only on the leaves of the genus Ribes. The glands on the leaf and stipules of Ribes, according to Solereder, exhibit a structure similar to the following: glandular shaggy hairs with a multiseriate stalk of variable length and a spherical or peltate head, the center of which is occupied by isodiametric cells, while the epidermal cells are elongated like a palisade.

According to Holle (1893) the glandular hairs differ in various species and are divided by him into two classes: (a) Wedge-formed glandular hairs with a rounded multicellular head and a rather long, several-celled stalk. In this group he includes R. alpinum, R. aureum, R. cynobastii, and R. fasciculatum; (b) Sessile glands with a relatively large multicellular head and a short multicellular stalk submerged in the epidermis. In this group he includes R. americanum and R. nigrum.
The spines of the species of Ribes are, according to Delbrouck (1875), essentially peribлем structures.

Occasionally the leaf-teeth in species of Ribes have a glandular function according to Reinke (1876).

Holle (1893) attributes the following features to Ribes: epidermal cells with mostly straight side walls as seen in surface view; the possession of fairly small pairs of guard cells of nearly circular outline and always surrounded by many associated cells; from one to three layers of palisade cells; the larger vascular bundles in the leaf with mostly thin-walled strengthening tissue extending to the epidermis of both surfaces; and isolated sclerenchyma fibers entirely lacking in both leaf and stem.

According to Petit (1887), all investigated species of Ribes have three vascular bundles pass into the petiole.

The following account of conditions found in the cortex, phloem, and xylem are given by Holle (1893).

Cortex

The two to three outer layers of the primary cortex are thickened collenchymatously, the outer layer becoming thickened all around. Aside from collenchyma this genus is lacking in all sclerotic elements in both primary and secondary cortex, unless some walls of the cork cells become sclerotic. Very characteristic also are the tangential rings and bands of cells, radially one celled broad, bearing small rosette crystals. Also in the primary cortex and pith of this genus are rosette crystals of considerably larger size. The con-
tents of the cortical parenchyma cells are often brown in color and possessed of tannin, especially in the outer cortex layers of Ribes. Cork originates in the innermost part of the cortex and the cork cells are somewhat radially elongated.

**Phloem**

In the phloem are 1 to 4 regular transverse rows of contiguous, small cluster crystals, the number of rows being characteristic of the species.

**Xylem**

The medullary rays reach as high as 7 cells in breadth. The elements of the tracheal tubes have scalariform perforations with few thick strips. The wall of a vessel where it is in contact with the parenchyma of the medullary rays bears bordered pits only. The wood prosenchyma, which mostly has thick walls, bears bordered and simple pits. The lumen of the simple-pitted wood fibers in Ribes is septate.

Holle (1893) divides the species into two classes and gives some of their distinguishing characteristics as follows: (a) With stalked glandular hairs.


outside this are sometimes groups of a second row.

R. cynobasti L. Ohio. Dr. Frank. Epidermal cell with undulating side walls. Palisade tissue 1-rowed. Only one, often interrupted, regular transverse row of cluster crystals in the phloem.

R. fasciculatum S. et Z. Leg. Burger, Japan. 4 to 5 almost continuous rows of cluster crystals in the phloem.

(b) With sessile glandular hairs.


R. nigrum L. In silva Caspat. Comm., Kitaibel. This is distinguished from R. multiflorum in that only isolated groups make up the 2 rows of cluster crystals in the phloem.
INTRODUCTION TO THE ANATOMICAL
STUDY OF STEMS AND LEAVES

The classification of plants is mostly based on external morphological characters which can be noted in a superficial observation, such as the number, arrangement, size, shape and color of floral parts; shape, size arrangement, and venation of leaves; color and furrowing of bark etc. Not only may a detailed anatomical study be useful in making a more exact classification of plants, but may also be helpful to the physiologist, ecologist etc., in understanding the machinery of the plant and its adaptation to the various functions under their investigation. A detailed anatomical study thus is not only useful in defining the specific differences occurring within a genus of plants, but also in bringing out those anatomical features which remain constant.

The fifteen species of Ribes used in making this comparative study were as follows: R. holosericeum, R. tenue, R. aureum, R. diacantha (female), R. americanum, R. nigrum, R. fasciculatum (Chinese), R. alpinum, R. sativum, R. luridum, R. stenocarpum (N.W. China), R. vilmorinii (W. China), R. missourinense, R. cynobasti, and R. hirtellum.

The material was obtained from the Arnold Aboretum, in August, 1928 and sent to Lawrence, Kansas preserved in a solution of formalin. Each plant was grown in the same type of soil, under the same environmental conditions, and had the same amount of cultivation and care. This eliminates
as far as possible any differences in size etc. being due to environmental conditions. After arriving at Lawrence, part of the material was changed to a 70% sol. of alcohol and the stems were cut up into small pieces for sectioning. From this material all of my sections for drawings and photographs were made. The material used in making microchemical tests for cell contents was taken directly from the formalin solution.

To keep my work as uniform as possible I have taken the material for sectioning, as near as possible, from corresponding parts of the plant in each species. The tips of the leaves were used for the study of venation. Margins and midribs were sectioned from portions of the leaf about midway in the extent of the leaf blade. Petioles were sectioned about midway between the base and point of attachment to the blade. Stem sections were taken at about the middle of the current and two year's growth.

The material sectioned and mounted for making drawings and photographs was taken from the 70% alcoholic solution and placed in a solution consisting of 30 parts water, 50 parts ethyl alcohol, and 20 parts butyl alcohol, until sectioned. The material was mounted on a soft pine block and inclosed in paraffin for sectioning. The sections were cut at 10 microns with a Jung sliding microtome. A valet razor blade was attached to the underside of the microtome knife with hard paraffin and used in preference to the microtome knife itself. The razor blades could be quickly changed.
and resharpened. A strong solution of bleaching powder was used to bleach the sections. The bleaching powder was removed with hydrochloric acid. The sections were then rinsed in water and dehydrated in 95\% ethyl alcohol. After thorough dehydration the sections were placed in toluol containing a small amount of n-butyl alcohol and mounted in hyrax, with the exception of the margins which were mounted in sandarac directly from the 95\% alcohol. Toluol is a solvent for hyrax and a small amount of n-butyl alcohol is added to prevent the sections from curling. Too much butyl alcohol will cloud the hyrax, and only as large an amount as 5\% is necessary to prevent curling, although, as high as 20\% may be used. The slides were then either left in the paraffin oven from 12 to 24 hours or left in a locker for a few days to harden. Sections mounted in this manner will keep indefinitely.

Hyrax is very similar to canada balsam, but is different from the latter in that it has a refractive index of 1.8 and makes the cell walls standing vertically appear dark as if drawn in india ink, without affecting or darkening the cross walls. It may also be used as a mounting medium for stained sections but these are not so good because the cross walls of the cells are likewise stained.

Radial and tangential sections of the stems were mounted in sandarac. Maserations were made from longitudinal stem sections by heating them in concentrated nitric acid containing a small amount of potassium chlorate until the sections turned white, then quickly plunging them into a dish of water.
These sections were mounted in sandarac.

The tip of the leaf was used in the study of venation. The leaves were bleached by placing them into a saturated solution of chloral hydrate for several months, then in bleaching powder, hydrogen peroxide, and back into chloral hydrate again. This method proved ineffective on leaves containing large quantities of tannin. These leaves were placed in test tubes and covered with a saturated solution of chloral hydrate for 48 hours or longer. The chloral hydrate was then poured from the material and enough potassium chlorate added to fill the bottom of the test tube to a depth of about $\frac{1}{2}$ inch. The material was then covered with concentrated nitric acid and let stand until the leaves had begun to change color. From 10 to 30 minutes was usually sufficient. The nitric acid was then poured out, leaving the potassium chlorate and leaves in the test tube, and the material again covered with a saturated solution of chloral hydrate. In this solution there was a continuous liberation of chlorine gas and within less than a week the leaves were quite transparent. The nitric acid treatment was repeated when necessary. This method proved very effective not only in bleaching the leaves, but also in obtaining large pieces of leaf epidermis for the study of epidermal cells, stomata, and trichomes.

Photomicrographs were made by using a carbon arc light to illuminate the object, and projecting the image by means of a microscope upon Cramer's contrast plates. The time of exposure was six seconds. Positive prints were made from these negatives.
on print paper (Rito Hard No. 31). The time of exposure varied from 4 to 10 seconds. The ink drawings combined in the large plates were drawn by using a projection microscope. Plates were then arranged on thick sheets of large white cardboard, measuring 22" x 28". A time exposure of 9 seconds was made, using a large dry plate camera. The negatives were made on Cramer's photo dry plates, size 8 x 10. Positive prints were made on sheets of No. 33 Rito hard paper. A 75 watt lamp held approximately 18" from the plates was used in making the exposures. The large cardboard plates were reduced 32% in making the positive prints.

Various microchemical tests were made to determine the character of the cell walls and the kinds of cell contents. To show lignified areas the sections were mounted in a drop of phloroglucin which was filtered off and followed by a drop of dilute HCL. This stained any lignified walls red. Sudan III was used in testing for cutin, cutinized walls, suberized walls, fats, and oils. The iodine test was used for starch. Nitric acid followed by ammonia was used to detect the presence of protein. HCL was used to determine the presence of CaCO₃ and CaCO₂. The presence of mucilage was indicated by treating with methylene blue. Fehling's solution was used to detect the presence of sugar and glucosides. Anhydrous iron chloride dissolved in anhydrous ether was used in testing for tannin.
SUMMARIZED DISCUSSION OF MICROCHEMICAL TESTS IN STEMS.

PETOILES AND MIDRIBS

The distribution of starch, tannin and cluster crystals of calcium oxalate in the tissues of the stem, petiole, midrib and blade are given in tables I, II, and III. These substances are represented by the symbols s, t, and * respectively and their relative abundance is shown by the number of symbols occurring together. Thus: s represents a small amount of starch, ss a moderate amount, and sss an abundance of starch. The figures in the third column of table I indicate the number of transverse rows of cluster crystals of calcium oxalate in the phloem.

When tannin and starch are present, they are always found in the phelloderm and pith and nearly always in the inner cortex, phloem, and phloem and xylem rays. These two substances are quite uniformly distributed throughout the pith cylinder with the exception of R. missouriense which has a larger amount of starch in the peripheral pith cells. These two substances, when both present, are usually found occurring together within the cell. A small amount of starch is found in the xylem parenchyma cells of R. aureum, R. alpinum, R. missouriense, and a relatively large amount in R. fasciculatum. Cluster crystals of calcium oxalate were found scattered throughout the cortex and pith, and in regular transverse rows in the phloem of the majority of species studied. Tannin is always present and starch is found in all species except R. stenocarpum and R. hirtellum, but varies in amount in the different species.
Table III shows that both tannin and starch may be present in abundance; either may be in excess of the other, or tannin may be present in small or moderate amounts with starch absent. Thus the different species may be grouped according to their tannin and starch content as follows: (1) abundance of both tannin and starch: R. aureum, R. discantha, R. americanum, R. nigrum, R. alpinum, and R. sativum; (2) abundance of tannin and a moderate amount of starch: R. tenue; (3) abundance of tannin and a small amount of starch: R. luridum, R. vilmorinii, and R. cynobasti; (4) moderate amount of tannin and abundance of starch: R. holosericeum and R. missouriense; (5) small amount of tannin and abundance of starch: R. fasciculatum; (6) a small to moderate amount of tannin with starch absent: R. stenocaroum and R. hirtellum. The distribution of starch and tannin in the petiole and midrib is given in tables II and III, only two classes of frequency being indicated. Table II shows for the petiole that starch was found only in the cortex, phloem, and xylem of four species; R. aureum, R. americanum, R. nigrum, and R. fasciculatum. Tannin is always present in the epidermis, cortex, phloem, and xylem rays and usually in the bast fibers, the amount varying somewhat in the different species. Relatively small amounts of tannin were found in R. fasciculatum, R. sativum, R. stenocaroum, and R. vilmorinii. The remaining species contained relatively large amounts of tannin in the phloem and xylem; however, the amount was small in the epidermis, cortex, and bast fibers of some species. Cluster crystals of calcium
oxalate were found in the cortex of R. tenue and R. alpinum. Starch was found in the midrib and mesophyll of R. aureum and R. fasciculatum. All of the tissues of the leaf contained relatively large quantities of tannin. Cluster crystals of calcium oxalate were found in the palisade tissue of R. holosericeum and R. hirtellum.

Tests were made also for sugar, glucosides, protein, volatile oils, resins, calcium carbonate, and mucilage, but only negative results were obtained.
TABLE I

TABLE SHOWING THE DISTRIBUTION OF STARCH, TANNIN, AND CLUSTER CRYSTALS OF CALCIUM OXALATE IN THE TISSUES OF THE STEM

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## TABLE II
**TABLE SHOWING THE DISTRIBUTION OF STARCH, TANNIN, AND CLUSTER CRYSTALS OF CALCIUM OXALATE IN THE TISSUES OF THE PETIOLE**

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* Indicates presence of crystals.
** Indicates very rare occurrence.
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Primary tissues

Epidermis

The epidermis is sparsely beset with short, coarse trichomes (Fig. 2) averaging about .07 mm. in length. The walls of the trichomes and the outer and radial walls of the epidermis are cutinised, and the epidermis is overlaid by a cuticle about .007 mm. thick. The epidermal cells as seen in surface view (Fig. 23) are irregular in outline and elongated vertically, measuring about .05 mm. in length, .015 mm. width, and .015 mm. in radial diameter. The outer walls of the epidermal cells are projecting and the radial walls are pitted.

Primary cortex

The epidermis and primary cortex slough off due to the formation of cork soon after their differentiation from the protoderm and ground meristem (Fig. 134). No collenchyma, starch sheath or bast fibers are present in this species. The parenchyma of the cortex is very early divided into two zones by a ring of peridermal tissue, the outer zone consisting of from three to four layers of cells and the inner from four to six. The cells of the outer zone are considerably larger than those of the inner zone and the latter are somewhat elongated tangentially. The outer
cortical parenchyma cells measure on an average about .035 mm. radially and those of the inner zone about .02 mm. The cells of the outer zone are flattened and broken down very early by the production of cork beneath them. The approximate breadth of the primary cortex is .12 mm. where the diameter of the stem section is 2.56 mm.

Primary phloem

The primary phloem measures about .03 mm. in radial breadth where the diameter of the stem section is 2.56 mm. The phloem elements consist of sieve tubes, companion cells, and phloem parenchyma cells irregularly arranged. The elements of the sieve tubes measure approximately .02 mm. in radial diameter and .08 mm. in length. The companion cells measure from .06 to .08 mm. in length and approximately .01 mm. in radial diameter. The phloem parenchyma cells average about .015 mm. in radial diameter and from .02 to .04 mm. vertically. There is a small amount of starch present in the phloem parenchyma.

Primary xylem

The pith is only slightly indented by the protoxylem points (Fig. 134) which are composed of tracheal tubes measuring approximately .01 mm. in cross diameter. The metaxylem consists of tracheal tubes with bordered pits and scalariform perforations in the end walls of their elements (Fig. 89). The tracheal tubes measure about .015 mm. in cross diameter and their elements average about .44 mm. in length. Wood fibers and tracheids are absent.
and xylem parenchyma is very sparse in the metaxylem.

Pith

The pith cylinder is relatively large in this species, measuring 1.36 mm. in diameter where the diameter of the stem section is 2.56 mm. The pith cells are homogeneous and measure approximately .03 mm. vertically, tangentially, and radially.

Secondary tissues

Periderm

The formation of periderm is well advanced by August in the current year's growth (Fig. 134). There are five cell layers of cork and about four of phelloderm with cells measuring about .015 mm. in radial and .03 mm. in tangential diameter; these contain storage starch.

Phloem

The secondary phloem differs from the primary phloem in that the elements are laid down in definite radial rows. The radial breadth of the secondary phloem area is approximately .12 mm. where the diameter of the stem section is 3 mm. The elements of the sieve tubes measure approximately .02 mm. in radial diameter and .08 mm. in length. The companion cells measure from .06 to .08 mm. in length and approximately .01 mm. in radial diameter. The phloem parenchyma cells average about .015 mm. in radial diameter and from .02 to .04 mm. vertically.

Xylem

The secondary xylem differs from the metaxylem in
that the elements are laid down in definite radial rows. Radial groups of xylem elements from one to five rows wide alternate tangentially with the xylem rays (Fig. 134). The xylem rays as seen in tangential section are from one to two cells wide and up to fifteen cells high, with strongly pitted radial walls. The vertically longest cells occur at the upper and lower extremities of the ray. The tracheal vessels are, on the whole, uniformly disposed throughout the xylem, but are slightly more enlarged and numerous at the beginning of each season's growth. The vessels average about .015 mm. in cross diameter and the elements measure about .44 mm. in length (Fig. 89). The walls of the tracheal elements have reticulate pitting and scalariform perforations in the end walls. There are about 1035 tracheal vessels per square mm. as seen in a stem cross section. The wood fibers measure .007 mm. in cross diameter and .44 mm. in length. They are slightly more numerous toward the latter part of the season's growth. Fiber-tracheids are much more frequent than wood fibers and more than twice as numerous at the end of the season's growth than at the beginning. They measure, on an average, .01 mm. in cross diameter and .40 mm. in length (Fig. 89).
RIBES TENUE

Stems

Primary tissues

Epidermis

The epidermis has a moderate amount of slender trichomes (Figs. 1-6) averaging approximately .2 mm. in length. The walls of the trichomes and the outer wall of the epidermal cells are cutinized, and the cuticle is not distinct from the cutinized wall in this species. The epidermal cells as seen in surface view (Fig. 14) are quadrilateral, regular in outline, and elongated vertically, and measure .015 mm. tangentially, .05 mm. vertically and .015 mm. in radial diameter.

Primary cortex

The epidermis and primary cortex slough off due to the formation of cork soon after their differentiation from the protoderm and ground meristem. There are no collen-chyma cells, starch sheath or bast fibers present in the stem of this species (Fig. 136). The parenchyma of the cortex is very early divided into two zones by a ring of peridermal tissue, the outer zone consisting of from two to four layers of cells and the inner from four to six. The cells of the outer zone are considerably larger than those of the inner zone, measuring about .03 mm. in cross diameter, while the cells of the latter average approximately .015 mm. The cells of the outer zone are flattened and broken down very
early by the production of cork beneath them and those of the inner zone are somewhat tangentially stretched. The approximate breadth of the primary cortex is .11 mm. where the diameter of the stem section is 1.84 mm.

Primary phloem

The breadth of the primary phloem is approximately .03 mm. where the diameter of the stem section is 1.84 mm. The phloem elements consist of phloem parenchyma, sieve tubes, and companion cells irregularly arranged. The elements of the sieve tubes measure approximately .017 mm. in radial diameter and .06 mm. in length. The companion cells average about .01 mm. in cross diameter and .06 mm. vertically. The phloem parenchyma cells measure approximately .015 mm. in radial diameter and .03 mm. vertically.

Primary xylem

The pith is only slightly indented by the eleven protoxylem points (Fig. 136) which are composed of tracheal tubes measuring approximately .01 mm. in cross diameter. The metaxylem consists of tracheal tubes with bordered pits, and scalariform perforations in the end walls of their elements. The tracheal elements measure approximately .01 mm. in cross diameter and .30 mm. in length (Fig. 90). Wood fibers and tracheids are absent and xylem parenchyma is very scarce in the metaxylem.

Pith

The pith cylinder (Fig. 136) measures .15 mm. in diameter where the diameter of the stem section is 1.76 mm. The pith cells are homogeneous, and measure .02 mm.
radially and .04 mm. vertically next the xylem, and .03 mm. radially and vertically at the center of the cylinder.

Secondary tissues

Periderm

The formation of periderm (Fig. 136) is well advanced by August in the current year's growth. Then there are six layers of cork cells averaging approximately .03 mm. in tangential diameter and .017 mm. in radial diameter, and two to three cell layers of phelloderm, measuring approximately .01 mm. in radial and .03 mm. in tangential diameter.

Phloem

The secondary phloem differs from the primary phloem in that the elements are laid down in radial rows. The zone is approximately .05 mm. in radial breadth where the diameter of the stem section is 1.84 mm. The phloem consists of sieve tubes, companion cells and phloem parenchyma. The elements of the sieve tubes measure approximately .017 mm. in radial diameter and .06 mm. in length. The companion cells average about .01 mm. in cross diameter and .06 mm. vertically. The phloem parenchyma cells measure approximately .015 mm. in radial diameter and .03 mm. vertically.

Xylem

The secondary xylem differs from the metaxylem in that the elements are laid down in definite radial rows, and fibers and tracheids have been formed (Fig. 89) in addition to the elements of the metaxylem. Xylem elements from one to five rows wide alternate tangentially with the
xylem rays. The xylem rays as seen in tangential section are from one to two cells wide and up to eleven cells high with strongly pitted walls. The tracheal tubes are, on the whole, uniformly disposed throughout the xylem, but are slightly larger and more numerous at the beginning of each season's growth. There are approximately 1380 tracheal tubes per square mm. as seen in a stem cross section. The vessels average about .016 mm in cross diameter and their elements measure about .32 mm. in length (Fig. 89). The elements of the vessels have reticulate pitting, and scalariform perforations in their end walls. The wood fibers average approximately .007 mm. in cross diameter and .50 mm. in length. The fiber tracheids measure about .01 mm. in cross diameter and .32 mm. in length. Fiber tracheids are considerably more abundant than wood fibers and much more numerous toward the end than at the beginning of the season's growth.
Primary tissues

Epidermis

There are no trichomes with the epidermis of this species. The outer epidermal wall is not cutinised, but is overlaid by a cuticle about .008 mm. thick. The epidermal cells as seen in surface view (Fig. 16) are regular in outline and elongated vertically, measuring from .008 to .02 mm. tangentially, .012 mm. radially and from .02 to .12 mm. vertically. The outer walls of the epidermal cells are projecting and the radial walls are pitted.

Primary cortex

The epidermis and primary cortex slough off very early due to the formation of cork beneath them (Fig. 138). No collenchyma, starch sheath or bast fibers are present. The parenchyma of the cortex is very early divided into two zones by a ring of peridermal tissue, the outer zone consisting of from five to six layers of cells and the inner from six to eight. The cells of the outer zone are considerably larger than those of the inner zone, and the latter are very heterogeneous in size, ranging from .006 mm. to .25 mm. in cross diameter. The cells of the outer zone are flattened and broken down very early by the production of cork beneath them and those of the inner zone are somewhat tangentially stretched. The approximate breadth of
the primary cortex is .10 mm. where the diameter of the stem section is 1.44 mm.

Primary phloem

The primary phloem region measures from .02 to .03 mm. in radial breadth where the diameter of the stem section is 1.44 mm. The phloem elements consist of sieve tubes, companion cells, and phloem parenchyma irregularly arranged. The sieve-tube elements and companion cells measure approximately .08 mm. vertically, the former measuring .015 mm. in cross diameter and the latter .007 mm. The phloem parenchyma cells average approximately .01 mm. in cross diameter and from .02 to .04 mm. vertically.

Primary xylem

The pith (Fig. 138) is rather deeply indented by the twelve protoxylem points which consist of tracheal tubes that measure approximately .015 mm. in cross diameter. The elements of both the protoxylem and metaxylem are irregularly arranged. The metaxylem consists of tracheal tubes with bordered pits and scalariform perforations in the end walls of the elements. The tracheal tubes average about .018 mm. in cross diameter and their elements about .24 mm. in length. Wood fibers and tracheids are absent in the primary xylem, and xylem parenchyma is very sparse.

Pith

The pith cylinder (Fig. 138) measures .56 mm. in diameter where the diameter of the stem section is 1.6 mm. The pith cells are homogeneous, measuring from .015 to
.04 mm. in cross diameter and from .02 to .05 mm. vertically. The ninth cells bordering the xylem are slightly smaller than those in the center of the cylinder.

Secondary tissues

Periderm

The formation of periderm is well advanced by August in the current year's growth. Then there are five layers of cork cells and two of phelloderm, measuring approximately .02 mm. in cross diameter and .035 mm. vertically.

Phloem

The secondary phloem differs from the primary phloem only in that the elements are laid down in radial rows. The secondary phloem region measures from .06 to .08 mm. in radial breadth where the diameter of the stem section is 1.44 mm.

Xylem

The secondary xylem consists of wood fibers and fiber-tracheids (Fig. 91) in addition to the elements found in the metaxylem, and are laid down in definite radial rows. Xylem elements from one to seven rows wide alternate tangentially with the xylem rays. The xylem rays as seen in tangential section are one cell wide and from two to nine cells high with densely pitted radial walls. The tracheal vessels are on the whole uniformly disposed throughout the xylem, but considerably larger and more numerous at the beginning of the season's growth. There are approximately 1104 tracheal vessels per square mm. as seen in a
stem cross section. The vessels average about .02 mm. in cross diameter and their elements about .27 mm. in length, (Fig. 91). The walls of the tracheal elements have reticulate pitting and scalariform perforations in their end walls. Tracheids are more numerous than wood fibers and both are more abundant toward the close of the season's growth. The tracheids average about .01 mm. in cross diameter and .20 mm. in length, and the wood fibers measure approximately .007 mm. in cross diameter and .28 mm. in length. All of the xylem elements are lignified.
Primary tissues

Epidermis

There are no trichomes with the epidermis of this species. The outer and radial walls of the epidermal cells are cutinized, but the cuticle is not distinct from the cutinized wall; the outer walls are projecting and the radial walls are pitted. The epidermal cells as seen in surface view (Fig. 27) are regular in outline and elongated vertically, measuring approximately .01 mm. tangentially, .01 mm. radially, and .03 mm. vertically.

Primary cortex

The epidermis and primary cortex slough off very early due to the formation of cork beneath them (Fig. 140). No collenchyma, starch sheath or bast fibers are present. The parenchyma of the cortex is very early divided into two zones by a ring of peridermal tissue, the outer zone consisting of from four to five layers of cells and the inner from three to four. The cells of the outer zone are considerably larger than those of the inner zone and flattened due to the production of cork beneath them, while the cells of the inner zone are elongated tangentially. The approximate breadth of the primary cortex is .14 mm. where the diameter of the stem section is 2.24 mm.
Primary phloem

The primary phloem consists of sieve tubes, companion cells, and phloem parenchyma irregularly arranged. The sieve tube elements average about .05 mm. in length and .018 mm. in cross diameter. The companion cells average approximately .01 mm. in cross diameter and .05 mm. in length. The phloem parenchyma cells average about .015 mm. in cross diameter and .03 mm. in length. The radial breadth of the primary phloem area is approximately .03 mm. where the diameter of the stem section is 2.24 mm.

Primary xylem

The pith is only slightly indented by the eight protoxylem points (Fig. 140) which consist of tracheal tubes measuring approximately .01 mm. in cross diameter. The elements of the protoxylem and metaxylem are irregularly arranged. The metaxylem consists of tracheal tubes with bordered pits, and scalariform perforations in the end walls of the elements. The tracheal tubes average approximately .015 mm. in cross diameter and the elements measure about .36 mm. in length. Fiber-tracheids and wood fibers are absent and xylem parenchyma is very scarce in the metaxylem. The breadth of the primary xylem from the tips of the protoxylem points to the secondary xylem is approximately .10 mm. where the diameter of the stem section is 2.24 mm.

Pith

The pith cylinder (Fig. 140) is relatively large
in this species, measuring approximately .90 mm. where the diameter of the stem section is 2.34 mm. The pith cells are homogeneous and average approximately .025 mm. in cross diameter and .03 mm. vertically.

Secondary tissues

Periderm

The formation of periderm is well advanced by August in the current year's growth. The zone is approximately .14 mm. broad where the diameter of the stem section is 2.24 mm. There are seven cell layers of cork and from one to two of phelloderm with cells measuring approximately .01 mm. in radial and .025 mm. in tangential diameter.

Phloem

The secondary phloem consists of sieve tubes, companion cells, and phloem parenchyma such as were found in the primary phloem, but differs from the latter in that the elements are laid down in radial rows. The breadth of the secondary phloem is approximately .08 mm. where the diameter of the stem section is 2.24 mm.

Xylem

The secondary xylem has wood fibers and fiber-tracheids (Fig. 92), in addition to the other elements composing the metaxylem, laid down in definite radial rows. Radial groups of xylem elements from one to ten rows wide alternate tangentially with the xylem rays. The xylem rays as seen in tangential section are from one to three cells wide and
up to thirty cells high, with the vertically longer cells at the upper and lower extremity of the ray. The vessels are on the whole uniformly disposed throughout the xylem, but are slightly more numerous at the beginning of each season's growth. There are approximately 1025 tracheal tubes per square mm. as seen in a stem cross section. The vessels average about .018 mm. in cross diameter and the elements average approximately .36 mm. in length (Fig. 92). The walls of the tracheal elements have reticulate pitting and scalariform perforations in the end walls. Fiber-tracheids are more than twice as numerous as wood fibers and both are more abundant toward the close of the season's growth. The wood fibers average about .007 mm. in cross diameter and .44 mm. in length. The tracheids average approximately .01 mm. in cross diameter and .22 mm. in length. The breadth of the secondary xylem is .24 mm. where the diameter of the stem section is 2.24 mm.
RIBES AMERICANUM

Stems

Primary tissues

Epidermis

The epidermis is moderately beset with trichomes (Fig. 1) averaging approximately .12 mm. in length, and a moderate amount of multicellular, sessile glands measuring approximately .20 mm. in diameter. The outer and radial walls of the epidermis are cutinized, but the cuticle is not distinct from the cutinized wall. The outer walls of the epidermal cells are projecting and the radial walls are pitted. The epidermal cells as seen in surface view (Fig. 28) are rather irregular in outline and only slightly elongated vertically, measuring .01 mm. radially, .013 mm. tangentially, and .025 mm. vertically.

Primary cortex

The epidermis and primary cortex are sloughed off very early, due to the formation of cork beneath them (Fig. 142). No collenchyma, starch sheath, or bast-fibers are present. The parenchyma of the cortex is very early divided into two zones by a ring of peridermal tissue, the outer zone consisting of from 4 to 5 layers of cells and the inner from 3 to 4. The cells of the outer zone measure approximately .035 mm. in cross diameter and those of the inner zone .015 mm. The cells of the outer zone are flattened and broken down by pressure from within and the cells of the inner zone are somewhat elongated tangentially. The approximate breadth of the primary cortex is .013 mm. where
the diameter of the stem section is 1.76 mm.

Primary phloem

The primary phloem consists of sieve tubes, companion cells, and phloem parenchyma cells irregularly arranged. The sieve tube elements measure approximately .018 mm. in cross diameter and .06 mm. in length. The companion cells average about .008 mm. in cross diameter and .06 mm. in length. The phloem parenchyma cells measure approximately .015 mm. in cross diameter and .035 mm. in length. The approximate breadth of the primary phloem is .03 mm. where the diameter of the stem section is 1.76 mm.

Primary xylem

The pith cylinder is slightly indented by twelve protoxylem points (Fig. 142) which consist of tracheal vessels with a cross diameter of .02 mm. The elements of the protoxylem and metaxylem are irregularly arranged. The metaxylem consists chiefly of tracheal vessels with bordered pits, and scalariform perforations in the end walls of the elements. The elements of the tracheal vessels measure approximately .018 mm. in cross diameter and .36 mm. in length. Wood-fibers and fiber-tracheids are absent and xylem parenchyma is very sparse in the metaxylem. The breadth of the primary xylem from the tips of the protoxylem points to the secondary xylem is approximately .06 mm. where the diameter of the stem section is 1.76 mm.

Pith

The pith cylinder is relatively small in this species,
measuring .50 mm. in diameter—where the diameter of the stem section is 1.76 mm. The pith cells are homogenous and measure approximately .022 mm. in cross diameter and .035 mm. vertically.

Secondary tissues

Periderm

The formation of periderm is well advanced by August in the current year's growth. Then there are 7 cell layers of cork and 2 of phelloderm, measuring approximately .025 mm. in cross and vertical diameters. The zone of periderm measures approximately .12 mm. in radial breadth where the diameter of the stem section is 1.50 mm.

Phloem

The elements of the secondary phloem consist of sieve tubes, companion cells, and phloem parenchyma cells similar to those of the primary phloem, but differing from the latter in that the elements are in radial rows. The breadth of the secondary phloem is approximately .05 mm. where the diameter of the stem section is 1.50 mm.

Xylem

The secondary xylem has wood-fibers and fiber-trach-eids (Fig. 93) in addition to the elements found in the metaxylem and the elements are laid down in definite radial rows. Radial groups of xylem elements from 1 to 6 rows wide alternate tangentially with the xylem rays. The xylem rays as seen in tangential section are from 1 to 3 cells
wide and up to 10 cells high, with the vertically longer cells at the upper and lower extremity of the ray. The tracheal vessels are on the whole uniformly disposed throughout the xylem, and are relatively more numerous in this species, with a corresponding decrease in the number of wood-fibers and fiber-tracheids. There are approximately 1725 vessels per square mm. as seen in a stem cross section. The vessels are slightly larger and more numerous at the beginning of the season's growth. The tracheal elements measure approximately .02 mm. in cross diameter and .34 mm. in length (Fig. 93). The walls of the tracheal elements have reticulate pitting and scalariform perforations in the end walls. Fiber-tracheids are relatively more numerous than wood-fibers and each is more abundant toward the close of the season's growth. The wood-fibers measure approximately .008 mm. in cross diameter and .30 mm. in length. The fiber-tracheids measure about .016 mm. in cross diameter and .29 mm. in length. The breadth of the secondary xylem is approximately .20 mm. where the diameter of the stem section is 1.50 mm.
RIBES NIGRUM

Stems

Primary tissues

Epidermis

The epidermis is densely beset with short, slender trichomes (Figs. 1-6) averaging about .04 mm. in length, and a moderate amount of multicellular, sessile glands measuring approximately .20 mm. in diameter (Fig. 144). The walls of the trichomes and the outer and radial walls of the epidermis are cutinized, and the epidermis is overlaid by a cuticle about .002 mm. thick. The outer walls of the epidermal cells are projecting and the radial walls are pitted. The epidermal cells as seen in surface view (Fig. 24) are irregular in outline and elongated vertically, measuring approximately .015 mm. tangentially, .06 mm. vertically, and .012 mm. radially.

Primary cortex

The parenchyma of the cortex is very early divided into two zones by a ring of peridermal tissue, each zone consisting of from four to six layers of cells. The cells of the outer zone are considerably larger than those of the inner zone and are flattened, broken down, and very early sloughed off with the epidermis due to the production of cork beneath them. No starch sheath, collenchyma, or bast fibers are present. The approximate breadth of the primary cortex is .12 mm. where the diameter of the stem
Primary phloem

The primary phloem consists of sieve tubes, companion cells and phloem parenchyma irregularly arranged. The sieve tube elements average approximately .015 mm. in cross diameter and .05 mm. in length. The companion cells measure about .008 mm. in cross diameter and .04 mm. in length. The phloem parenchyma cells average .01 mm. in cross diameter and .035 mm. in length. The approximate breadth of the primary phloem is .03 mm where the diameter of the stem section is 2.88 mm.

Primary xylem

The pith cylinder (Fig. 144) is only slightly indented by the twelve protoxylem points which consist of tracheal tubes measuring approximately .018 mm. in cross diameter and irregularly arranged. The metaxylem consists of tracheal tubes with reticulate pitting and scalariform perforations in the end walls of the elements. The tracheal elements average approximately .028 mm. in cross diameter and .36 mm. in length. Fiber-tracheids and wood fibers are absent and xylem parenchyma is very sparse in the primary xylem. The breadth of the primary xylem from the tips of the protoxylem points to the secondary xylem is approximately .035 mm. where the diameter of the stem section is 2.06 mm.

Pith

The pith cylinder is relatively large in this species,
measuring approximately 1.44 mm. in diameter in a stem section 2.88 mm. in diameter. The pith cells are homogeneous and measure approximately .038 mm. in cross diameter and .04 mm. vertically.

Secondary tissues

Periderm

The formation of periderm is well advanced by August in the current year's growth (Fig 144). Then there are ten cell layers of cork and four of phelloderm measuring approximately .038 mm. tangentially, .01 mm. radially, and .025 mm. vertically. The zone of periderm measures approximately .015 mm. in radial breadth where the diameter of the stem section is 2.88 mm.

Phloem

The secondary phloem consists of sieve tubes, companion cells, and phloem parenchyma, such as were found in the primary phloem, but differs from the latter in that the elements are laid down in radial rows. The breadth of the secondary phloem is approximately .08 mm. where the diameter of the stem section is 2.88 mm.

Xylem

The secondary xylem consists of fiber-tracheids and wood fibers, in addition to the kinds of elements found in the metaxylem, and differs from the latter in that the elements are laid down in definite radial rows. Radial groups of xylem elements from one to seven rows wide alter-
nate tangentially with the xylem rays. The xylem rays as seen in tangential section are from one to five cells wide and up to sixteen cells high, with the vertically longer cells at the upper and lower extremity of the ray. The vessels are on the whole uniformly disposed throughout the xylem, but are slightly more numerous at the beginning of each season's growth (Fig. 144). There are approximately 759 tracheal tubes per square mm. as seen in a stem cross section. Relatively more space is given over to conduction vessels, with a corresponding decrease in the number of wood fibers and fiber tracheids in the xylem of this species. Fiber-tracheids are more numerous than wood fibers and both are more abundant toward the close of the season's growth. The tracheids average approximately .015 mm. in cross diameter and .24 mm. in length (Fig. 94). The wood fibers average .01 mm. in cross diameter and .34 mm. in length.
RIBES FASCICULATUM (chinese)

Stems

Primary tissues

Epidermis

The epidermis is rather thickly bestrewn with slender, curved trichomes averaging about .16 mm. in length (Figs. 1-6). The walls of the trichomes and the outer and radial walls of the epidermis are cutinized, and the epidermis is overlaid by a cuticle about .004 mm. thick. The outer walls of the epidermal cells are decidedly projecting and the radial walls are pitted. The epidermal cells as seen in surface view (Fig. 15) are regular in outline and elongated vertically, measuring about .015 mm. tangentially, .06 mm. vertically and .015 mm. radially.

Primary cortex

The primary cortex is very early divided into two zones by a ring of peridermal tissue (Fig. 146), the outer zone consisting of from 6 to 7 cell layers and the inner zone from 3 to 4. The cells of the inner zone are smaller than those of the outer zone, the former measuring .018 mm. in cross diameter while those of the latter average approximately .025 mm. The outer zone of the cortex is soon sloughed off with the epidermis due to the formation of cork beneath them, and the cells of the inner zone are somewhat tangentially stretched. No collenchyma, endodermis, or bast fibers are present. The approximate breadth of the primary cortex is .01 mm. where the diameter of the stem section is 1.76 mm.
Primary phloem

The primary phloem consists of sieve tubes, companion cells and phloem parenchyma cells irregularly arranged. The sieve tube elements measure approximately .015 mm. in cross diameter and .06 mm. in length. The phloem parenchyma cells measure approximately .01 mm, in cross diameter and .03 mm. in length. The companion cells average about .008 mm. in cross diameter and .04 mm. in length. The radial breadth of the primary phloem is approximately .02 mm. where the diameter of the stem section is 1.68 mm.

Primary xylem

The pith is only very slightly indented by the six protoxylem points (Fig. 146) which consist of tracheal tubes measuring approximately .02 mm. in cross diameter. The elements of the primary xylem are irregularly arranged. The metaxylem consists of tracheal tubes with reticulate pitting and scalariform perforations in the end walls of the elements. The tracheal tubes average approximately .02 mm. in cross diameter and the elements about .32 mm. in length. Tracheids and wood fibers are absent and xylem parenchyma is very scarce in the metaxylem. The breadth of the primary xylem from the tips of the protoxylem points to the secondary xylem is approximately .08 mm. where the diameter of the stem section is 1.76 mm.

Pith

The diameter of the pith cylinder is approximately .72 mm. where the diameter of the stem section is 1.76 mm.
The pith is homogeneous and its cells measure approximately .035 mm. in cross diameter and .04 mm. vertically.

Secondary tissues

Periderm

The formation of periderm is well advanced by August in the current year's growth. The zone is approximately .14 mm. broad where the diameter of the stem section is 1.76 mm. There are 11 cell layers of cork and 4 of phelloderm with cells measuring .03 mm. tangentially, .01 mm. radially, and .04 mm. vertically.

Phloem

The elements of the secondary phloem consist of sieve tubes, companion cells, and phloem parenchyma cells the same as found in the primary phloem, save that the elements are laid down in radial rows. The breadth of the secondary phloem is approximately .06 mm. where the diameter of the stem section is 1.76 mm.

Xylem

The secondary xylem has wood-fibers and fiber-tracheids (Fig. 95), in addition to the elements composing the metaxylem, laid down in radial rows. Radial groups of xylem elements from 1 to 10 rows wide alternate tangentially with the xylem rays. The xylem rays as seen in tangential section are from 1 to 3 cells wide and up to 25 cells high. The vessels are on the whole uniformly disposed throughout the xylem, but are slightly larger and more numerous at the
The beginning of each season's growth. There are approximately 690 vessels per square mm. as seen in a stem cross section. The vessels average approximately .02 mm. in cross section and the elements .30 mm. in length (Fig. 95). The tracheal elements have reticulate pitting and scalariform perforations in the end walls. Fiber-tracheids are more abundant than wood-fibers and these structures more numerous toward the end of the season's growth. The fiber-tracheids average approximately .015 mm. in cross diameter and .36 mm. in length. The wood-fibers measure approximately .01 mm. in cross diameter and .38 mm. in length. The breadth of the secondary xylem is approximately .24 mm. where the diameter of the stem section is 1.76 mm.
Primary tissues

Epidermis

There are no trichomes with the epidermis of this species. The outer and radial walls of the epidermis are cutinized, and the epidermis is overlaid by a cuticle about .004 mm. thick. The outer walls of the epidermal cells are slightly projecting and the radial walls are pitted. The epidermal cells as seen in surface view (Fig. 21) are irregular in outline and elongated vertically, measuring .013 mm. tangentially, .04 mm. vertically, and .02 mm. radially.

Primary cortex

The parenchyma of the cortex (Fig. 148) is very early divided into two zones by a ring of peridermal tissue, the outer zone consisting of from four to five layers of cells and the inner from four to six. The cells of the outer zone measure approximately .035 mm. in cross diameter while those of the inner zone average about .02 mm. The cells of the outer zone are very early flattened, broken down, and sloughed off with the epidermis due to the production of cork beneath them. No collenchyma, bast fibers or endodermis are present. The breadth of the primary cortex is approximately .012 mm. where the diameter of the stem section is 3.08 mm.
Primary phloem

The primary phloem consists of sieve tubes, companion cells and phloem parenchyma cells irregularly arranged. The sieve tube elements average approximately .015 mm. in cross diameter and .05 mm. in length. The companion cells average approximately .008 mm. in cross diameter and .05 mm. in length. The phloem parenchyma cells measure about .01 mm. in cross diameter and .03 mm. in length. The breadth of the primary phloem is approximately .03 mm. where the diameter of the stem section is 3.08 mm.

Primary xylem

The sixteen protoxylem points (Fig. 148) project into the pith cylinder about .12 mm. and consist of irregularly arranged tracheal tubes measuring approximately .01 mm. in cross diameter. The tracheal tubes of the metaxylem have reticulate pitting and scalariform perforations in the end walls of the elements. The tracheal tubes average approximately .015 mm. in cross diameter and the elements measure .30 mm. in length. Tracheids and wood fibers are absent and xylem parenchyma is very scarce in the metaxylem. The breadth of the primary xylem from the tips of the protoxylem points to the secondary xylem is approximately .14 mm. where the diameter of the stem section is 3.08 mm.

Pith

The diameter of the pith cylinder (Fig. 148) is approximately 1.44 mm. where the diameter of the stem section is 3.08 mm. The pith cells are homogeneous and measure approx-
Secondary tissues

Periderm

The formation of periderm is well advanced by August in the current year's growth (Fig. 148). Then there are seven cell layers of cork and three of phelloderm with cells measuring approximately .03 mm. tangentially, .02 mm. radially, and .04 mm vertically. The zone of periderm measures approximately .36 mm. in radial breadth where the diameter of the stem section is 3.08 mm.

Phloem

The elements of the secondary phloem are the same as those of the primary phloem but are formed in radial rows. The radial breadth of the secondary phloem is approximately .04 mm. where the diameter of the stem section is 3.08 mm.

Xylem

The secondary xylem has wood fibers and fiber tracheids (Fig. 96), in addition to the elements composing the metaxylem, laid down in definite radial rows (Fig. 148). Radial groups of xylem elements from 1 to 8 rows wide alternate tangentially with the xylem rays. The xylem rays as seen in tangential section are from 1 to 15 cells wide and up to 60 cells high with the vertically longer cells at the upper and lower extremity of the ray. The vessels are on the whole uniformly disposed throughout the xylem, but are slightly larger and more numerous at the
beginning of each season's growth. There are approximately 828 vessels per square mm. as seen in a stem cross section. The tracheal elements average approximately .015 mm. in cross diameter and .25 mm. in length (Fig. 96). The tracheal elements have reticulate pitting and scalariform perforations in their end walls (Fig. 96). Fiber tracheids are more numerous than wood fibers and both are more numerous toward the close of the season's growth. The fiber tracheids average approximately .01 mm. in cross diameter and .22 mm. in length. The wood fibers measure approximately .008 mm. in cross diameter and 32 mm. in length. The breadth of the secondary xylem area is approximately .48 mm. where the diameter of the stem section is 3.08 mm.
RIBES SATIVUM (W. Europe)

Stems

Primary tissues

Epidermis

The epidermis is sparsely beset with short, coarse trichomes (Fig. 5) averaging approximately 0.07 mm. in length. The epidermis is overlaid with a cuticle about 0.004 mm. thick and the outer wall of the epidermal cells are cutinized and projecting, while their radial walls are pitted. The epidermal cells as seen in surface view (Fig. 18) are regular in outline and elongated vertically, measuring approximately 0.015 mm. tangentially, 0.06 mm. vertically, and 0.015 mm. radially.

Primary cortex

The epidermis and primary cortex slough off very early due to the formation of cork beneath them, (Fig. 150). No collenchyma, starch sheath or bast fibers are present. The parenchyma of the cortex is very early divided into two zones by a ring of peridermal tissue, the outer zone consisting of from 3 to 4 layers of cells and the inner from 6 to 7. The cells of the outer zone are slightly larger than those of the inner zone, measuring approximately 0.03 mm. in cross diameter while the cells of the latter average about 0.02 mm. The cells of the outer zone are flattened and broken apart in places, and those of the inner zone are somewhat elongated tangentially due to the formation
of cork. The approximate breadth of the primary cortex is .12 mm. where the diameter of the stem section is 4.06 mm.

Primary phloem

The phloem elements consist of phloem parenchyma cells, sieve tubes, and companion cells irregularly arranged. The elements of the sieve tubes measure approximately .02 mm. in cross diameter and .04 mm. in length. The companion cells measure about .008 mm. in cross diameter and .04 mm. in length. The phloem parenchyma cells average approximately .01 mm. in cross diameter and .05 mm. in length. The radial breadth of the primary phloem is approximately .05 mm. where the diameter of the stem section is 4.06 mm.

Primary xylem

The pith cylinder is only slightly indented by the thirteen protoxylem points which are composed of tracheal tubes measuring approximately .02 mm. in cross diameter. The elements of the primary xylem are irregularly arranged. The metaxylem consists of a sparse amount of xylem parenchyma, and tracheal tubes with bordered pits, and scalariform perforations in the end walls of their elements. The tracheal elements measure approximately .02 mm. in cross diameter and .24 mm. in length. Wood fibers and fiber tracheids are absent and xylem parenchyma is sparse in the metaxylem.

Pith

The pith cylinder ( Fig. 150 ) measures approximately 1.92 mm. in diameter where the diameter of the stem section
is 4.06 mm. The bith cells are homogeneous and measure on an average about .04 mm. in cross diameter and .04 mm. vertically.

Secondary tissues

Periderm

The formation of periderm is well advanced by August in the current year's growth (Fig. 150). Then there are 15 layers of cork cells and from 3 to 4 of phelloderm. The cork cells measure .03 mm. radially, .04 mm. tangentially, and .02 mm. vertically. The phellodermal cells average .012 mm. radially, .04 mm. tangentially, and .02 mm. vertically.

Phloem

The secondary phloem consists of sieve tubes, companion cells and phloem parenchyma cells radially arranged. The elements of the sieve tubes measure approximately .02 mm. in cross diameter and .04 mm. in length. The companion cells measure about .008 mm. in cross diameter and .04 mm. vertically. The phloem parenchyma cells average approximately .01 mm. in cross diameter and .05 mm. in length. The radial breadth of the secondary phloem in a stem 4.06 mm. in diameter is approximately .09 mm.

Secondary xylem

The secondary xylem consists of wood fibers and fiber tracheids in addition to the elements found in the metaxylem and are arranged in definite radial rows. Xylem elements from 1 to 9 rows wide alternate tangentially with the xylem rays. The xylem rays as seen in tangential section are from 1 to
3 cells wide and up to 27 cells high. The tracheal tubes are on the whole uniformly disposed throughout the xylem, but are slightly larger and more numerous toward the beginning of each season's growth (Fig. 151). There are approximately 800 tracheal tubes per square mm. as seen in a stem cross section. The tracheal elements measure approximately .027 mm. in cross diameter and .30 mm. in length (Fig. 97). The wood fibers average about .01 mm. in cross diameter and .26 mm. in length. The fiber tracheids measure approximately .014 mm. in cross diameter and .25 mm. in length. Fiber tracheids are more numerous than wood fibers and both are more abundant toward the close of the season's growth. The radial breadth of the secondary xylem is approximately .44 mm. where the diameter of the stem section is 4.06 mm.
Primary tissues

Epidermis

There are no trichomes with the epidermis of this species. The outer and radial walls of the epidermal cells are cutinized, but the cuticle is not distinct from the cutinized wall. The outer wall of the epidermal cells are decidedly projecting, the radial walls are pitted and relatively thick compared with the other species. The epidermal cells as seen in surface view (Fig. 25) are regular in outline and elongated vertically, measuring .013 mm. tangentially, .015 mm. radially, and .05 mm. vertically.

Primary cortex

The epidermis and primary cortex are sloughed off very early due to the production of cork beneath them (Fig. 152). No endodermis, collenchyma, or bast fibers are present. The primary cortex consists of from 6 to 8 layers of parenchyma cells which are flattened and broken down by the production of cork beneath them. The approximate breadth of the primary cortex is .08 mm. where the diameter of the stem section is 2.40 mm.

Primary phloem

The primary phloem consists of sieve tubes, companion cells, and phloem parenchyma cells irregularly arranged. The sieve tube elements average .015 mm. in cross diameter and .05 mm. in length. The companion cells average approx-
imately .008 mm. in cross diameter and .05 mm. in length. The phloem parenchyma cells measure about .01 mm. in cross diameter and .03 mm. in length. The breadth of the primary phloem is approximately .02 mm. where the diameter of the stem section is 2.40 mm.

Primary xylem

The thirteen protoxylem points (Fig. 152) project about .09 mm. into the pith cylinder, and are composed of tracheal tubes measuring approximately .02 mm. in cross diameter. The elements of the primary xylem are irregularly arranged. The metaxylem consists of scant xylem parenchyma and tracheal vessels with bordered pits and scalariform perforations in the end walls of the elements. The tracheal elements average approximately .02 mm. in cross diameter and .34 mm. in length. Fiber tracheids and wood fibers are absent. The breadth of the primary xylem from the tips of the protoxylem points to the secondary xylem is approximately .12 mm. where the diameter of the stem section is 2.24 mm.

Pith

The diameter of the pith cylinder is approximately .96 mm. where the diameter of the stem section is 2.24 mm. (Fig. 152). The pith is homogeneous and its cells measure approximately .035 mm. in cross diameter and .04 mm. vertically.

Secondary tissues

Periderm

The formation of periderm is well advanced by August
in the current year's growth (Fig. 152). Then there are 9 cell layers of cork, and from 2 to 3 of phelloderm measuring approximately .024 mm. tangentially and .03 mm. vertically. The cork cells measure .03 mm. and the phellodermal cells .01 mm. in radial diameter. The zone of periderm measures approximately .18 mm. in radial breadth where the diameter of the stem section is 2.24 mm.

**Phloem**

The secondary phloem consists of sieve tubes, companion cells, and phloem parenchyma cells, and differs chiefly from the primary phloem in that the elements are laid down in radial rows. The radial breadth of the secondary phloem area is approximately .06 mm. where the diameter of the stem section is 2.24 mm.

**Xylem**

The secondary xylem has wood fibers and fiber tracheids (Fig. 98), in addition to the elements found in the metaxylem, laid down in definite radial rows. Radial groups of xylem elements from 1 to 8 rows wide alternate tangentially with the xylem rays. The xylem rays as seen in tangential section are from 1 to 4 cells wide and up to 47 cells high with the vertically longer cells at the upper and lower extremity of the ray. The vessels are on the whole uniformly disposed throughout the xylem, but are slightly larger and more numerous at the beginning of each season's growth (Fig. 153). There are approximately 690 tracheal vessels per square mm. as seen in a stem cross section. The tracheal
elements average approximately .02 mm. in cross diameter and .40 mm. in length (Fig. 98). The vessels have reticulate pitting and scalariform perforations in the end walls of the elements. Fiber tracheids are more numerous than wood fibers and both are more abundant toward the close of the season's growth. The fiber tracheids average approximately .015 mm. in cross diameter and .24 mm. in length. The wood fibers measure approximately .01 mm. in cross diameter and .30 mm. in length. The approximate breadth of the secondary xylem is .30 mm. where the diameter of the stem section is 2.24 mm.
RIBES STENOCARPUM (N. W. China)

Stems

Primary tissues

Epidermis

The epidermis is rather thickly beset with slender trichomes (Figs. 1-6) averaging about .16 mm. in length. The walls of the trichomes and the outer and radial walls of the epidermal cells are cutinized. The epidermal cells as seen in surface view (Fig. 22) are irregular in outline and elongated vertically, measuring .015 mm. tangentially, .018 mm. radially and .04 mm. vertically. The outer walls of the epidermal cells are slightly projecting and the radial walls are pitted.

Primary cortex

There are from 4 to 5 layers of collenchymatous hypodermal cells in this species (Fig. 154). The parenchyma of the cortex is very early divided into two zones by a ring of peridermal tissue, the outer zone consisting of from 1 to 2 layers of cells and the inner from 3 to 4. The cells of the outer zone are considerably larger than those of the inner zone and the latter are somewhat tangentially stretched. The cells of the outer zone average about .025 mm. in cross diameter while those of the inner zone average approximately .015 mm. No endodermis or bast fibers are present. The approximate breadth of the primary cortex is .15 mm. where the diameter of the stem section is 1.84 mm.
Primary phloem

The primary phloem consists of sieve tubes, companion cells, and phloem parenchyma cells irregularly arranged. The sieve tube elements measure approximately .015 mm. in cross diameter and .04 mm. in length. The companion cells average about .008 mm. in cross diameter and .03 mm. in length. The phloem parenchyma cells measure about .01 mm. in cross diameter and .03 mm. in length. The radial breadth of the primary phloem is approximately .02 mm. where the diameter of the stem section is 1.80 mm.

Primary xylem

The twelve protoxylem points (Fig. 154) project into the pith cylinder about .02 mm and consist of tracheal tubes measuring approximately .01 mm. in cross diameter. The elements of the primary xylem are irregularly arranged. The metaxylem consists of scant xylem parenchyma and tracheal tubes with bordered pits and scalariform perforations in the end walls of their elements. The tracheal vessels average approximately .015 mm. in cross diameter and the elements measure about .28 mm. in length. Fiber tracheids and wood fibers are absent. The breadth of the primary xylem from the tips of the protoxylem points to the secondary xylem is approximately .09 mm. where the diameter of the stem section is 1.80 mm.

Pith

The diameter of the pith cylinder is approximately
.50 mm. where the diameter of the stem section is 1.80 mm. (Fig. 154). The pith is homogeneous and its cells measure approximately .03 mm. in cross diameter and .35 mm. vertically.

Secondary tissues

Periderm

The formation of periderm is well advanced by August in the current year's growth (Fig. 154). Then there are 8 cell layers of cork and from 1 to 2 of phelloderm measuring approximately .01 mm. radially, .03 mm. tangentially, and .015 mm. vertically. The zone of periderm measures approximately .12 mm. in radial breadth where the diameter of the stem section is 1.80 mm.

Phloem

The elements of the secondary phloem consist of sieve tubes, companion cells and phloem parenchyma cells such as were found in the primary phloem, excepting that the elements are laid down in radial rows. The radial breadth of the secondary phloem is approximately .06 mm. where the diameter of the stem section is 1.80 mm.

Xylem

In addition to the elements found in the metaxylem, the secondary xylem has wood fibers and fiber tracheids (Fig. 99) laid down in definite radial rows (Fig. 154). Radial groups of xylem elements from 1 to 5 rows wide alternate tangentially with the xylem rays. The xylem rays as seen in tangential section are from 1 to 4 cells wide and up to 35 cells high with the vertically longer cells at the upper
and lower extremities of the ray. The vessels are on the whole uniformly disposed throughout the xylem, but are slightly larger and more numerous at the beginning of each season's growth. There are approximately 1173 tracheal vessels per square mm. as seen in a stem cross section. The vessels average approximately .015 mm. in cross diameter and the elements measure about .30 mm. in length ( Fig. 99 ). The walls of the tracheal elements have reticulate pitting and scalariform perforations in the end walls. Fiber tracheids are more than twice as numerous as wood fibers and both are more abundant toward the close of the season's growth. The wood fibers average approximately .008 mm. in cross diameter and .36 mm. in length. The fiber tracheids measure approximately .01 mm. in cross diameter and .38 mm. in length. The radial breadth of the secondary xylem is approximately .24 mm. where the diameter of the stem section is 1.68 mm.
RIBES VILMORINII (W. China)

Stems

Primary tissues

Epidermis

The epidermis is moderately beset with short trichomes (Fig. 2) averaging about .06 mm. in length. The walls of the trichomes and the outer walls of the epidermal cells are cutinized, but the cuticle is not distinct from the cutinized wall. The outer walls of the epidermal cells are decidedly projecting and the radial walls are pitted. The epidermal cells as seen in surface view are slightly irregular in outline and elongated vertically, measuring .014 mm tangentially, .02 mm. radially, and .08 mm. vertically.

Primary cortex

The peridermal tissue is formed at the outer edge of the phloem in this species. No collenchyma, endodermis, or bast fibers are present. The approximate breadth of the primary cortex is .09 mm. where the stem section is 1.76 mm. in diameter.

Primary phloem

The radial breadth of the primary phloem in a stem of the above diameter is approximately .03 mm. The phloem elements consist of phloem parenchyma cells, companion cells, and sieve tubes irregularly arranged. The elements of the sieve tubes measure approximately .017 mm. in cross diameter.
and .06 mm. in length. The companion cells average about .01 mm. in cross diameter and .06 mm. in length. The phloem parenchyma cells average approximately .01 mm. in cross diameter and .03 mm. vertically.

Primary xylem

The pith cylinder is only slightly indented by the 13 protoxylem points which consist of tracheal tubes measuring approximately .015 mm. in cross diameter. The elements of the primary xylem are irregular in arrangement. The metaxylem consists of tracheal tubes with bordered pits, and scalariform perforations in the end walls of their elements. The tracheal elements average approximately .015 mm. in cross diameter and .28 mm. in length. The xylem parenchyma cells measure approximately .015 mm. in cross diameter and .08 mm. in length. Wood fibers and fiber tracheids are absent and xylem parenchyma are very sparse in the metaxylem. The breadth of the primary xylem from the tips of protoxylem points to the secondary xylem is approximately .08 mm. where the diameter of the stem section is 1.76 mm.

Pith

The pith cells are homogeneous and measure approximately .035 mm. in cross diameter and .04 mm. vertically. The approximate diameter of the pith cylinder is .56 mm. where the diameter of the stem section is 1.68 mm.

Secondary tissues

Periderm

The formation of periderm is well advanced by August
in the current year's growth. Then there are from 4 to 5 cell layers of cork and from 2 to 3 of phelloderm. The cork cells measure .02 mm. radially, .04 mm. tangentially, and .035 mm. vertically. The phellodermal cells average about .01 mm. radially, .04 mm. tangentially, and .035 mm. vertically. The radial breadth of the zone of periderm is .12 mm. in a stem 1.68 mm. in diameter.

Phloem

The secondary phloem consists of sieve tubes, companion cells, and phloem parenchyma cells similar to those found in the primary phloem, but differing from the latter in that the elements are in radial rows. The approximate breadth of the secondary phloem is .04 mm. where the diameter of the stem section is 1.68 mm.

Xylem

The secondary xylem consists of wood fibers and fiber tracheids (Fig. 100), in addition to the elements found in the primary xylem, laid down in definite radial rows. Radial groups of xylem elements from 1 to 11 rows wide alternate tangentially with the xylem rays. The xylem rays as seen in tangential section are from 1 to 3 cells wide and up to 25 cells high with the vertically longer cells at the upper and lower extremity of the ray. The tracheal vessels are on the whole uniformly disposed throughout the xylem, but are slightly more numerous toward the beginning of the season's growth. There are approximately 828 tracheal vessels per
square mm. as seen in a stem cross section. The tracheal elements measure approximately .02 mm. in cross diameter and .28 mm. in length (Fig. 100). Fiber tracheids are slightly more numerous than wood fibers and each is more abundant toward the close of the season's growth. The fiber tracheids measure approximately .013 mm. in cross diameter and .32 mm. in length. The wood fibers average about .01 mm. in cross diameter and .42 mm. in length. The approximate breadth of the secondary xylem is .24 mm. in a stem 1.76 mm. in diameter.
RIBES MISSOURIENSE

Stems

Primary tissues

Epidermis

There are no trichomes with the epidermis of this species. The outer walls of the epidermal cells are cutinized, but the cuticle is not distinct from the cutinized wall. The outer walls of the epidermal cells are projecting and the radial walls are pitted. The epidermal cells as seen in surface view (Fig. 19) are regular in outline and elongated vertically, measuring on the average 0.015 mm. tangentially, 0.02 mm. radially, and 0.06 mm. vertically.

Primary cortex

There are about 6 cell layers of collenchymatous hypodermal cells measuring approximately 0.015 mm. in cross diameters. The parenchyma of the cortex is divided into two zones by a ring of peridermal tissue, the outer zone consisting of from 1 to 2 layers of cells and the inner from 2 to 3. The cells of the outer zone average about 0.03 mm. in cross diameters and those of the inner zone about 0.015 mm. The cells of the inner zone are somewhat tangentially stretched. The approximate breadth of the primary cortex is 0.21 mm. where the diameter of the stem section is 2.24 mm.

Primary phloem

The radial breadth of the primary phloem in a stem
2.24 mm. in diameter is approximately .02 mm. The phloem elements consist of phloem parenchyma, sieve tubes, and companion cells irregularly arranged. The elements of the sieve tubes measure approximately .017 mm. in radial diameter and .06 mm. in length. The companion cells average about .01 mm. in cross diameter and .06 mm. in length. The phloem parenchyma cells measure approximately .015 mm. in radial diameter and .03 mm. vertically.

Primary xylem

The pith is only slightly indented by the 13 protoxylem points (Fig. 158) which consist of tracheal tubes measuring approximately .01 mm. in cross diameter. The metaxylem consists of tracheal tubes with bordered pits and scalariform perforations in the end walls of the elements. The tracheal elements measure approximately .018 mm. in cross diameter and .36 mm. in length. Fiber tracheids and wood fibers are absent and xylem parenchyma is sparse in the metaxylem.

Pith

The pith cylinder measures .72 mm. in diameter where the diameter of the stem section is 2.24 mm. The pith cells are homogeneous and measure .03 mm. radially and .035 mm. vertically.

Periderm

The formation of periderm is well advanced by August in the current year's growth. Then there are 7 cell layers of cork and 3 of phelloderm, with cork cells measuring .024 mm. in radial and .035 mm. in tangential diameter, and phello-
dermal cells measuring .024 mm. in tangential and .013 mm. in radial diameter, (Fig. 158). There are three rings of peridermal tissue in the two year's growth (Fig. 159).

**Phloem**

The elements of the secondary phloem consist of sieve tubes, companion cells, and phloem parenchyma cells such as were found in the primary phloem, but differ from the latter in that the elements are laid down in radial rows. The radial breadth of the secondary phloem is approximately .05 mm. where the diameter of the stem section is 1.12 mm.

**Xylem**

The secondary xylem has wood fibers and fiber tracheids (Fig. 101) in addition to the elements found in the meta-xylem, but differs from the latter in that the elements are laid down in definite radial rows. Radial groups of xylem elements from 1 to 7 rows wide alternate tangentially with the xylem rays. The xylem rays as seen in tangential section are from 1 to 3 cells wide and up to 13 cells high with the vertically longer cells at the upper and lower extremity of the ray. The vessels are on the whole uniformly disposed throughout the xylem. The vessels measure approximately .018 mm. in cross diameter and their elements average about .30 mm. in length. The walls of the tracheal elements have reticulate pitting and scalariform perforations in the end walls (Fig. 101). Fiber tracheids are more numerous than wood fibers and both are more abundant toward the close of the season's growth. The fiber tracheids measure approxi-
imately .01 mm. in cross diameter and .30 mm. in length. The wood fibers average about .007 mm. in cross diameter and .39 mm. in length. The approximate breadth of the secondary xylem is .20 mm. where the diameter of the stem section is 2.14 mm.
RIBES CYNOBASTI

Stems

Primary tissues

Epidermis

The epidermis is thickly beset with slender trichomes averaging about .16 mm. in length. The walls of the trichomes and the outer walls of the epidermal cells are cutinized, but the cuticle is not distinct from the cutinized wall. The outer walls of the epidermal cells are projecting and the radial walls are pitted. The epidermal cells as seen in surface view (Fig. 26) are irregular in outline and elongated vertically, measuring .015 mm. tangentially, .015 mm. radially, and .035 mm. vertically.

Primary cortex

There are from 3 to 4 layers of collenchymatous hypodermal cells (Fig. 160). The parenchyma of the cortex is divided into two zones by a ring of peridermal tissue, the outer zone consisting of from 2 to 3 cell layers and the inner from 4 to 5. The cells of the outer zone average about .016 mm. in cross diameter and those of the inner zone about .015 mm. The cells of the outer zone are very early flattened and broken down due to the formation of cork beneath them and the cells of the inner zone are elongated tangentially. The approximate breadth of the primary cortex is .12 mm. where the diameter of the stem section is 1.76 mm.
Primary phloem

The phloem elements consist of sieve tubes, companion cells and phloem parenchyma cells irregularly arranged. The sieve tube elements measure approximately .015 mm. in cross diameter and .04 mm. in length. The companion cells average about .008 mm. in cross diameter and .035 mm. in length. The phloem parenchyma cells measure approximately .01 mm. in cross diameter and .035 mm. in length. The radial breadth of the primary phloem in a stem 1.60 mm. in diameter is .04 mm.

Primary xylem

The fourteen protoxylem points (Fig. 160) project into the pith cylinder about .08 mm. and are composed of tracheal tubes measuring approximately .01 mm. in cross diameter. The elements of the primary xylem are irregular in arrangement. The metaxylem consists of tracheal tubes with bordered pits and scalariform perforations in the end walls of their elements. The tracheal elements measure approximately .015 mm. in cross diameter and .34 mm. in length. Wood fibers and fiber tracheids are absent and xylem parenchyma is very sparse in the metaxylem. The approximate breadth of the primary xylem from the tips of the protoxylem points to the secondary xylem is .08 mm. where the diameter of the stem section is 1.60 mm.

Pith

The pith cells are homogeneous and measure approximately .035 mm. in cross diameter and .04 mm. vertically. The diameter of the pith cylinder is about .64 mm. in a
stem 1.76 mm in diameter.

Secondary tissues

Periderm

The formation of periderm is well advanced by August in the current year's growth (Fig. 160). Then there are from 6 to 7 cell layers of cork and from 1 to 2 of phelloderm. The cork cells measure approximately .013 mm. radially, .03 mm. tangentially, and .02 mm. vertically. The phellodermal cells measure on an average .01 mm. radially, .03 mm. tangentially, and .02 mm. vertically. The zone of peridermal tissue measures approximately .08 mm. in radial breadth where the diameter of the stem section is 1.60 mm.

Phloem

The secondary phloem consists of sieve tubes, companion cells, and phloem parenchyma cells such as were found in the primary phloem, but differs from the latter in that the elements are radially arranged. The radial breadth of the secondary phloem in a stem 1.60 mm. in diameter is approximately .04 mm.

Xylem

The secondary xylem consists of wood fibers and fiber tracheids in addition to the elements found in the metaxylem and are arranged in definite radial rows. Xylem elements from 1 to 9 rows wide alternate tangentially with the xylem rays. The xylem rays as seen in tangential section are from 1 to 3 rows wide and up to 27 cells high with the vertically longer cells at the upper and lower extremity of the ray. The tracheal vessels are on the whole uniformly disposed throughout the xylem, but are slightly larger and more
numerous at the beginning of each season's growth (Fig. 161). There are approximately 1035 tracheal vessels per square mm. as seen in a stem cross section. The tracheal elements (Fig. 102) measure approximately .02 mm. in cross diameter and .32 mm. in length. Fiber tracheids are relatively more numerous than wood fibers and each is more abundant toward the close of the season's growth. The fiber tracheids measure approximately .012 mm. in cross diameter and .22 mm. in length. The wood fibers average about .008 mm. in cross diameter and .46 mm. in length. The radial breadth of the secondary xylem in a stem 1.60 mm. in diameter is approximately .28 mm.
RIBES HIRTELLUM

Stems

Primary tissues

Epidermis

There are no trichomes with the stem epidermis of this species. The radial walls of the epidermal cells are pitted and the outer walls are projecting and cutinized, but the cuticle is not distinct from the cutinized wall. The epidermal cells as seen in surface view (Fig. 17) are regular in outline and elongated vertically, measuring approximately .015 mm. tangentially, .018 mm. radially, and .04 mm. vertically.

Primary cortex

The parenchyma of the cortex is very early divided into two zones by a ring of peridermal tissue, the outer zone consisting of from 2 to 3 layers of cells and the inner from 4 to 5. The cells of the outer zone average approximately .035 mm. in cross diameter and those of the inner zone about .02 mm. The cells of the inner zone are elongated tangentially and those of the outer zone are very early flattened and broken down due to the formation of cork beneath them. No collenchyma, endodermis or bast fibers are present. The approximate breadth of the primary cortex is .013 mm. where the diameter of the stem section is 1.84 mm.

Primary phloem

The primary phloem consists of sieve tubes, companion
cells, and phloem parenchyma cells irregularly arranged. The sieve tube elements measure approximately 0.013 mm. in cross diameter and 0.05 mm. in length. The companion cells average 0.008 mm. in cross diameter and 0.05 mm. in length. The phloem parenchyma cells measure 0.015 mm. in cross diameter and 0.035 mm. in length. The radial breadth of the primary phloem in a stem 3 mm. in diameter is 0.02 mm.

Primary xylem

The sixteen protoxylem points (Fig. 163) project into the pith cylinder approximately 0.16 mm. and consist of tracheal tubes measuring 0.015 mm. in cross diameter. The elements of the primary xylem are irregularly arranged. The metaxylem consists of tracheal tubes with bordered pits and scalariform perforations in the end walls of their elements. Fiber tracheids and wood fibers are absent and xylem parenchyma is very sparse in the metaxylem. The approximate breadth of the primary xylem from the tips of the protoxylem points to the secondary xylem is 0.16 mm. where the diameter of the stem section is 3 mm.

Pith

The pith cells are homogeneous and measure approximately 0.038 mm. in cross diameter and 0.03 mm. vertically. The diameter of the pith cylinder in a stem 3 mm. in diameter is approximately 1.44 mm.

Secondary tissues

Periderm

The formation of periderm is well advanced by August
in the current year's growth (Fig. 162). Then there are 8 cell layers of cork and 2 to 3 of phelloderm. The cork cells measure approximately .035 mm. tangentially, .02 mm. radially, and .02 mm. vertically. The phellodermal cells average .01 mm. radially, .035 mm. tangentially, and .02 mm. vertically. The radial breadth of the zone of periderm is .12 mm. where the diameter of the stem section is 3 mm.

Phloem

The secondary phloem consists of sieve tubes, companion cells and phloem parenchyma cells as were found in the primary phloem, but differs from the latter in that the elements are radially arranged. The radial breadth of the secondary phloem is approximately .04 mm. where the diameter of the stem section is 3 mm.

Xylem

The secondary xylem consists of wood fibers and fiber tracheids, in addition to the elements found in the metaxylem, occurring in definite radial rows. Xylem elements from 1 to 8 rows wide alternate radially with the xylem rays. The xylem rays as seen in tangential section are from 1 to 4 cells wide and up to 18 cells high with the vertically longer cells at the upper and lower extremity of the ray. The teacheal tubes are on the whole uniformly disposed throughout the xylem, but are slightly larger and more numerous at the beginning of each season's growth. There are approximately 866 tracheal vessels per square mm. as
seen in a stem cross section. The tracheal elements measure approximately .02 mm. in cross diameter and .20 mm. in length. The vessels have bordered pits and scalariform perforations in the end walls of their elements. Fiber tracheids are relatively more numerous than wood fibers and both are more abundant toward the close of the season's growth. The fiber tracheids measure approximately .012 mm. in cross diameter and .44 mm. in length. The wood fibers average about .008 mm. in cross diameter and .30 mm. in length. The radial breadth of the secondary xylem is approximately .33 mm. where the diameter of the stem section is 3 mm.
SUMMARY OF STEMS

The following features are common to the stems of all of the fifteen species studied: the outer wall of the epidermal cells is cutinized and projecting. The epidermal cells are elongated vertically, but vary considerably in the amount of elongation in the different species; radial walls are straight and pitted. The absence of both endodermis and bast fibers. The formation of cork within the innermost part of the cortex, and the sloughing off of the epidermis and outer part of the cortex soon after their formation. A relatively small amount of phloem consisting of phloem parenchyma, sieve tubes, and companion cells. Protoxylem points project into the pith cylinder giving it a stellate appearance as seen in cross section. The protoxylem consists of tracheal tubes with spirally thickened walls. The metaxylem is composed of tracheal vessels with bordered pits and a sparse amount of xylem parenchyma. The secondary xylem has fiber tracheids and wood fibers in addition to the elements found in the metaxylem, and its elements are radially arranged. Xylem elements from 1 to 10 rows wide alternate tangentially with xylem rays from 1 to 7 cells wide. The tracheal vessels have oblique cross walls with few thick strips, reticulate pitting, and scalariform perforations in the end walls of their elements. The xylem rays consist of vertically elongated cells with the vertically longest cells occurring at the upper and lower extrem-
ities of the ray. A relatively large cylinder of homogeneous pith. The cells at the center of the cylinder have larger cross diameters and relatively thinner walls than those bordering the xylem. The presence of tannin in the phelloderm, cortex, phloem, xylem rays and pith.

Trichomes are present in 9 of the 15 species studied. Those without trichomes are R. aureum, R. diacantha, R. alpinum, R. luridum, R. missouriense, and R. hirtellum. There is considerable variation in amount and length of trichomes in the various species. R. holosericeum and R. sativum have a sparse amount of short trichomes with an average length of .07 mm. R. vilmorinii, R. americanum, and R. tenue have a moderate amount with an average length of .06, .12, and .20 mm. respectively. The remaining four species have a dense amount with an average length of .04 mm. in R. nigrum, and .16 mm. in R. fasciculatum, R. luridum, and R. cynobasti. The radial walls of the epidermal cells are cutinized in all except the following six species: R. tenue, R. sativum, R. vilmorinii, R. missouriense, R. cynobasti, and R. hirtellum. Multicellular sessile glands were found with the epidermis of R. americanum and R. nigrum, and multicellular stalked glands with the epidermis of R. alpinum and R. cynobasti. According to Holle ('93) external glands have only been observed only on the leaves of the genus Ribes. There is also considerable variation in the vertical elongation of the epidermal cells, which ranges from very slight in R. americanum, R. nigrum,
R. cynobasti, and R. hirtellum to considerable elongation in R. fasciculatum, R. sativum, and R. missouriense. Typical collenchyma was found lignified in R. stenocaroum, R. missouriense, and R. cynobasti. The cork cells are tangentially elongated in all of the fifteen species except R. aureum, R. americana, and R. luridum. According to Solereder ('08) the cork cells are somewhat radially elongated. R. missouriense differs from all other species in having three rings of peridermal tissue in the two years growth. Table IV shows the number of protoxylem points, diameter of pith cylinder, and number of tracheal tubes per square mm. of xylem area in each of the fifteen species studied. The number of protoxylem points varies from 6 to 16 in the different species. There is also considerable variation in diameter of pith cylinders, which ranges from .43 mm. to 1.92 mm. There is little or no correlation between diameter of pith cylinder and number of protoxylem points. The number of tracheal tubes per square mm. varies from 690 in R. fasciculatum and R. horridum to 1725 in R. americana. Table V shows the average length of tracheal elements, tracheids, and wood fibers in the different species. The average length of tracheal elements varies from .22 mm. in R. sativum and R. hirtellum to .36 mm. in R. holosericea. The average length of tracheids shows a similar variation, ranging from .21 mm. in R. diacantha, R. alpinum, and R. cynobasti to .46 mm. in R. hirtellum. The greatest variation occurs in the length of wood fibers which ranges from .22 mm. in R. sativum to .55 mm. in R. tenue.
There is little or no correlation in length of any two of these elements in all of the different species. There is little or no variation in size or shape of the xylem parenchyma cells in the different species. These cells measure approximately .025 mm. in cross diameter and .062 mm. in vertical length. There is considerable variation in the amount and distribution of starch, tannin and cluster crystals of calcium oxalate in the tissues of the stem as shown in table I.
TABLE IV.

TABLE SHOWING THE NUMBER OF PROTOXYLEM POINTS, DIAMETER OF PITH CYLINDER, AND NUMBER OF TRACHEAL TUBES PER SQUARE MM. OF XYLEM AREA

<table>
<thead>
<tr>
<th>Species</th>
<th>No. Protoxylem Points</th>
<th>Diam. Pith Cylinder</th>
<th>No. Tracheal Tubes</th>
</tr>
</thead>
<tbody>
<tr>
<td>R. holosericeum</td>
<td>15</td>
<td>1.20</td>
<td>1480</td>
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<tr>
<td>R. tenue</td>
<td>11</td>
<td>0.52</td>
<td>1380</td>
</tr>
<tr>
<td>R. aureum</td>
<td>12</td>
<td>0.43</td>
<td>1104</td>
</tr>
<tr>
<td>R. diacantha</td>
<td>8</td>
<td>0.90</td>
<td>1025</td>
</tr>
<tr>
<td>R. americanum</td>
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<td>0.50</td>
<td>1725</td>
</tr>
<tr>
<td>R. nigrum</td>
<td>12</td>
<td>1.44</td>
<td>725</td>
</tr>
<tr>
<td>R. fasciculatum</td>
<td>6</td>
<td>0.72</td>
<td>690</td>
</tr>
<tr>
<td>R. alpinum</td>
<td>16</td>
<td>1.20</td>
<td>828</td>
</tr>
<tr>
<td>R. sativum</td>
<td>13</td>
<td>1.92</td>
<td>800</td>
</tr>
<tr>
<td>R. luridum</td>
<td>13</td>
<td>0.96</td>
<td>690</td>
</tr>
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</tr>
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<td>828</td>
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<tr>
<td>R. missouriense</td>
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<td>800</td>
</tr>
<tr>
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<td>0.98</td>
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</tr>
<tr>
<td>R. hirtellum</td>
<td>14</td>
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</table>
TABLE V

TABLE SHOWING THE AVERAGE LENGTH OF TRACHEAL ELEMENTS, TRACHEIDS, AND WOOD FIBERS IN THE DIFFERENT SPECIES

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<thead>
<tr>
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<td>.43</td>
<td>.41</td>
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<td>.32</td>
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<td><strong>R. holosericeum</strong></td>
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<td><strong>R. nigrum</strong></td>
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<td></td>
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<tr>
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<td><strong>R. alpinum</strong></td>
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<tr>
<td><strong>R. stenocarpum</strong></td>
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<td></td>
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<tr>
<td><strong>R. missouriense</strong></td>
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<td></td>
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<tr>
<td><strong>R. cynobasti</strong></td>
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<tr>
<td><strong>R. hirtellum</strong></td>
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<tr>
<td><strong>Summary of leaves</strong></td>
<td>133</td>
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</tbody>
</table>
RIBES HOLOSERICEUM

Leaf

General features

This species has a 3-lobed, palmately-veined leaf with a dentate margin. The leaf is broadly cordate in shape, measuring from 30 to 50 mm. in width, from 40 to 70 mm. in length and .24 mm. in thickness. The midrib and main branches from the midrib are very prominent on the lower surface. The petiole measures from 10 to 24 mm. in length and .92 mm. in thickness. The lower side of the petiole is circular and the upper surface is nearly flat.

Epidermis

The upper epidermis of the blade is sparsely beset with trichomes while the lower epidermis of the blade and the epidermis of the petiole are densely pubescent. The trichomes of the petiole (Fig. 3) measure from .08 to .16 mm. in length and those of the blade from .20 to .50 mm. (Fig. 6). The radial walls of both the upper and lower epidermal cells are straight and their outer walls are projecting (Figs. 35 and 43). The upper epidermal cells measure approximately .023 mm. in width, .042 mm. in length, and .02 mm. in thickness. The lower epidermal cells measure .015 mm. in width, .035 mm. in length, and .018 mm. in thickness. The stomata occur only in the lower epidermis where their frequency is approximately 342 per square mm.

Mesophyll

There are from 1 to 2 layers of palisade cells composing
approximately 1/3 of the mesophyll volume (Fig. 64). These cells measure approximately .05 mm. in length and .015 mm. in cross diameter. There are approximately 5,639 palisade cells per square mm. of leaf area in the upper palisade layer. The cells of the spongy mesophyll are irregular in arrangement.

Midrib

The midrib measures .32 mm. in thickness and .40 mm. in width; its upper surface is V-shaped and its lower surface is circular (Fig. 118). The upper epidermal cells measure .026 mm. in width and .02 mm. in thickness; their outer walls are slightly projecting and overlaid by a thin cuticle. The lower epidermal cells measure approximately .01 mm. in width and .018 mm. in thickness; their outer walls are decidedly projecting and overlaid by a thin cuticle. No collenchyma or bast fibers are present. The single vascular bundle is nearly circular in outline with irregularly arranged xylem and phloem elements. The parenchyma cells of the midrib measure approximately .025 mm. in cross diameter.

Venation

The three main veins extending through the blade gradually diminish in size as they approach the tips of the lobes, giving off numerous side branches. There are approximately 22 meshes per square mm. of leaf area and 9 veinlet ends terminating within the mesophyll per square mm.

Margin

The leaf blade as seen in cross section gradually tapers to a rounded point at the margin (Fig. 66). Cells the size
and shape of the upper epidermal cells extend around to the lower surface where there is a gradual transition in size and shape to that of the typical lower epidermal cells. The palisade cells do not extend to the margin.

Petiole

The petiole cross section of this species measures approximately .72 mm. in width, and .88 mm. in thickness, being in the shape of an inverted bell jar with the upper surface flat (Fig. 128). The cells of both the upper and lower epidermis are projecting and overlaid by a thin cuticle. These cells measure approximately .016 mm. in width and .02 mm. in thickness. There are from 1 to 3 layers of bast fibers bordering the outer edge of the phloem. The three separate, equal sized vascular bundles are arranged in a triangle at the base of the petiole and fuse on passing to the blade into a single distinctly 3-lobed bundle. The radial breadths of the radially arranged xylem and phloem elements are .12 and .05 mm. respectively. The parenchyma cells measure approximately .04 mm. in cross diameter.
RIBES TENUE

Leaf

General features

This species has a 3-5 lobed, palmately-veined leaf with a dentate margin. The leaf is ovate in shape, measuring from 10 to 25 mm. in width, from 15 to 36 mm. in length, and approximately .26 mm. in thickness. The midrib and main branches from the midrib are relatively less prominent on the lower surface of the blade. The petiole measures from 4 to 8 mm. in length and is approximately .64 mm. in thickness. The lower side of the petiole is circular and the upper surface is concave.

Epidermis

The epidermis of this species is glabrous except for a very few multicellular trichomes and slightly curved unicellular hairs on the upper epidermis of the blade, and a few multicellular trichomes on the edges of the petiole. The multicellular trichomes measure approximately .50 mm. in length and the unicellular hairs (Figs. 7-13) from .08 to .40 mm. in length. The radial walls of both the upper and lower epidermal cells are undulated (Figs. 57& 58) and their outer walls are projecting. The upper epidermal cells measure approximately .025 mm. in width, .05 mm. in length, and .025 mm. in thickness. The lower epidermal cells measure .02 mm. in width, .045 mm. in length, and .02 mm. in thickness. The stomata occur only in the lower epidermis where their frequency is approximately
207 per square mm.

Mesophyll

There are two layers of palisade cells composing approximately 1/3 of the mesophyll volume, (Fig. 70). The palisade cells measure approximately .03 mm. in length and .015 mm. in cross diameter. There are approximately 6,210 palisade cells per square mm. of leaf area in the upper palisade layer. The cells of the spongy mesophyll are irregular in arrangement.

Midrib

The V-shaped upper surface of the leaf blade curves slightly downward at the midrib which is not much thicker than the portion on either side, and measures approximately .40 mm. in thickness (Fig. 111). The outer walls of both the upper and lower epidermal cells are decidedly projecting and overlaid by a thin cuticle which is roughened on the lower epidermis. The upper epidermal cells measure approximately .04 mm. in width and .022 mm. in thickness while those of the lower epidermis measure .013 mm. in width and .018 mm. in thickness. No collenchyma or bast fibers are present. The single vascular bundle as seen in cross section is oval in shape, measuring .21 mm. in width and .16 mm. in thickness. The palisade layer is almost continuous across the upper side of the midrib.

Venation

The three main veins extending through the blade are relatively less prominent on the lower surface and gradually diminish in size as they approach the tips of the lobes,
giving off numerous side branches. There are 12 meshes per square mm. of leaf area and 5 veinlet ends terminating within the mesophyll per square mm.

Margin

The margin as seen in cross section (Fig. 70) is blunt and rounded, with the palisade cells extending to the margin. Cells the size and shape of the upper epidermal cells extend around to the lower surface where there is an abrupt transition in size and shape to those of the typical lower epidermal cells.

Petiole

The petiole as seen in cross section (Fig. 124) is decidedly concave on the upper surface and rounded on the lower surface; it measures approximately .84 mm. in width and .80 mm. in thickness. The petiole has a multiple epidermis with the outer walls of the epidermis on both the upper and lower side projecting and overlaid by a thin cuticle. The epidermal cells on the upper side measure .01 mm. in width, and .02 mm. in thickness while those on the lower surface measure .015 mm. in width, and .02 mm. in thickness. The three separate vascular bundles are arranged in an arc at the base of the petiole, and fuse on passing to the blade into a single bundle bent in the shape of a semicircle. There are from one to three cell layers of bast fibers bordering nearly the entire outer edge of the phloem. The radial breadth of the xylem area is approximately .15 mm. and that of the phloem .04 mm. Their ele-
ments are radially arranged. The parenchyma cells measure .03 mm. in cross diameter.
RIBES AUREUM

Leaf

General features

This species has a 3-lobed, palmately veined leaf with a dentate margin. The leaf is orbicular-reniform to obovate in shape, measuring from 14 to 35 mm. in width, from 20 to 60 mm. in length, and approximately .17 mm. in thickness. The midrib and main branches from the midrib are not prominent on the lower surface (Fig. 112). The petiole measures from 11 to 25 mm. in length and approximately .56 mm. in thickness. The upper surface of the petiole is slightly convex and the lower surface is rounded (Fig. 131).

Epidermis

There are no trichomes with the epidermis of the blade or petiole of this species. The radial walls of both the upper and lower epidermal cells are regular in outline (Figs. 55 and 56). The upper epidermal cells measure approximately .022 mm. in width, .04 mm. in length, and .02 mm. in thickness. The lower epidermal cells measure .021 mm. in width, .04 mm. in length, and .015 mm. in thickness. The frequency of the stomata in the upper epidermis is approximately 26 per square mm. and in the lower epidermis 185 per square mm.

Mesophyll

There are two layers of palisade cells, composing approximately 1/3 of the mesophyll volume (Fig. 68). These cells measure .03 mm. in length and .012 mm. in cross diameter. There are approximately 6,831 cells per square mm. of leaf.
area in the upper palisade layer. The cells of the spongy mesophyll are relatively compact and irregular in arrangement.

Midrib

The midrib measures approximately .24 mm. in both tangential width and radial thickness; its upper surface is slightly concave and its lower surface is slightly convex (Fig. 112). The outer walls of the epidermal cells are decidedly projecting and overlaid by a thin cuticle. No typical collenchyma cells or bast fibers are present. The single vascular bundle as seen in cross section is circular in outline with somewhat irregularly arranged xylem and phloem elements. The parenchyma cells of the midrib measure approximately .015 mm. in cross diameter.

Venation

The three main veins extending through the blade gradually diminish in size as they approach the tips of the lobes, giving numerous side branches (Fig. 76). There are approximately 34 meshes per square mm. of leaf area and 16 veinlet ends terminating within the mesophyll per square mm.

Margin

The leaf blade as seen in cross section is blunt and rounded at the margin (Fig. 68). Epidermal cells the size and shape of the upper epidermal cells extend around to the lower surface where there is an abrupt transition in size and shape to typical lower epidermal cells. The palisade cells extend to the margin.

Petiole
The petiole cross section of this species measures approximately .50 mm. in tangential width and radial thickness, being almost circular in outline (Fig. 131). The outer walls of the epidermal cells are decidedly projecting and overlaid by a thin cuticle. These cells measure approximately .01 mm. in tangential width and .018 mm. in radial thickness. There are from 4 to 6 cell layers of bast fibers bordering the outer edge of the phloem. The single vascular bundle is almost circular in outline with radially arranged xylem and phloem elements. The radial breadth of the xylem area is approximately .14 mm. and that of the phloem .04 mm. The parenchyma cells of the petiole measure approximately .02 mm. in cross diameter.
RIBES DIACANTHA (female)

Leaf

General features

This species has a simple leaf, ovate in shape, with a dentate margin. The leaves measure from 23 to 38 mm. in length, from 10 to 18 mm. in width, and .26 mm. in thickness. The midrib and main branches from the midrib are not prominent on the lower surface (Fig. 115). The petiole measures from 6 to 10 mm. in length and approximately .74 mm. in thickness. The under surface of the petiole is rounded and the upper surface is nearly flat (Fig. 125).

Epidermis

There are no trichomes with the epidermis of this species. The radial walls of both the upper and lower epidermal cells are regular in outline (Figs. 50 and 54). The upper epidermal cells measure .025 mm. in width, .042 mm. in length, and .035 mm. in thickness. The lower epidermal cells measure approximately .022 mm. in width, .04 mm. in length, and .02 mm. in thickness. The stomata occur only in the lower epidermis where their frequency is approximately 201 per square mm.

Mesophyll

There are from 1 to 2 layers of palisade cells composing from 1/3 to 1/2 of the mesophyll volume (Fig. 67). The palisade cells measure approximately .05 mm. in length and .02 mm. in cross diameter. There are approximately 3,726 palisade cells per square mm. of leaf area in the upper
palisade layer. The cells of the spongy mesophyll are irregular in arrangement with relatively more intercellular space.

Midrib

The midrib is relatively less prominent on the lower surface than in most of the species studied; its upper surface is flat and its under surface is slightly convex (Fig. 115). The midrib measures .14 mm. in width and .24 mm. in thickness. No collenchyma or bast fibers are present. The single vascular bundle as seen in cross section is relatively small, being in the shape of a circle with more or less irregularly arranged xylem and phloem elements.

Venation

Three main veins extending through the blade are relatively less prominent on the lower surface and gradually diminish in size as they approach the tips of the lobes, giving off numerous side branches. There are approximately 17 meshes per square mm. of leaf area and 9 veinlet ends terminating within the mesophyll per square mm. (Fig. 75).

Margin

The leaf blade as seen in cross section is very abruptly rounded at the margin (Fig. 67). Cells the size and shape of the upper epidermal cells extend around to the lower surface where there is an abrupt transition in size and shape to the typical lower epidermal cells. The palisade cells extend to the margin.

Petiole

The petiole cross section of this species measures 1.44
mm. in width and .72 mm. in thickness, being almost in the shape of a circle (Fig. 125). The cuticle of the upper epidermis is roughened, and the outer walls of both the upper and lower epidermal cells are projecting. The epidermal cells measure approximately .02 mm. in width, .045 mm. in length, and .022 mm. in thickness. The outer edge of the phloem is bordered by from 2 to 4 cell layers of bast fibers. There are three separate, equal sized vascular bundles arranged in a widespread arc at the base of the petiole which fuse on passing to the blade into a single fan-shaped bundle. The vascular bundles as seen in cross section are round in outline with radially arranged xylem and phloem elements. The radial breadth of the xylem area is approximately .16 mm. and that of the phloem .08 mm.
RIBES AMERICANUM

Leaf

General features

This species has a 3 to 5 lobed, palmately veined leaf with a serrate margin. The leaf is broadly cordate in shape, measuring from 40 to 60 mm. in length, from 30 to 45 mm. in width, and .12 mm. in thickness. The midrib and main branches from the midrib are very prominent on the lower surface. The petiole measured from 15 to 21 mm. in length and approximately .64 mm. thick. The under surface of the petiole is rounded and the upper surface nearly flat.

Epidermis

The epidermis of the petiole is densely beset with short appressed hairs, measuring from .02 to .08 mm. in length, giving it a fuzzy appearance. The margin of the petiole in addition has a few large branched trichomes measuring from .50 to 1.5 mm. in length. The lower epidermis of the blade is moderately beset with slender trichomes somewhat longer than those of the upper epidermis, measuring from .10 to .64 mm. in length, and are much thicker on the veins and at the margin (Figs. 7 and 13). The radial walls of both the upper and lower epidermal cells are undulated (Figs. 33 and 34). The upper epidermal cells of the blade measure approximately .03 mm. in length, .02 mm. in width, and .018 mm. in thickness. The lower epidermal cells average .025 mm. in length, .018 mm. in width, and .01 mm. in thickness. The stomata occur only in the lower epidermis where their frequency is approximately 432 per square mm. The under surface
of the leaf is rather thickly and uniformly covered with multicellular amber colored glands, measuring approximately .20 mm. in cross diameter (Fig. 114). The glands are spherical in shape and consist of from 3 to 4 layers of cells from center to periphery.

Mesophyll

There are from 1 to 2 layers of palisade cells composing approximately \( \frac{1}{3} \) of the mesophyll volume (Fig. 114). The palisade cells measure approximately .04 mm. in length and .013 mm. in cross diameter. There are approximately 6,240 palisade cells per square mm. of leaf area in the upper palisade layer. The cells of the spongy mesophyll are irregular in arrangement.

Midrib

The midrib measures .24 mm. in thickness and .28 mm. in width; in cross section it's upper surface is V-shaped and it's lower surface rounded (Fig. 114). The outer walls of the epidermal cells are projecting, and those on the lower surface are overlaid by a roughened cuticle. No collenchyma or bast fibers are present. The single vascular bundle measures .12 mm. in depth and .16 mm. in width with radially arranged xylem and phloem elements.

Venation

The three main veins extending through the blade gradually diminish in size as they approach the tips of the lobes, giving off numerous side branches. There are approximately 20 meshes per square mm. of leaf area and 12 veinlet ends
terminating within the mesophyll per square mm.

Margin

The margin of the leaf is rounded and the palisade cells extend to the margin. Epidermal cells the size and shape of the upper epidermal cells extend around to the lower surface where there is a more or less abrupt transition in size and shape to the typical lower epidermal cells.

Petiole

The petiole cross section of this species measures approximately .64 mm. thick and .72 mm. wide, being in the shape of an inverted dome with the lower surface rounded and the upper surface nearly flat (Fig. 119). The epidermis is densely beset with short, slender, appressed hairs measuring from .02 to .08 mm. in length, giving the petiole a fuzzy appearance. The outer walls of the epidermal cells are projecting and overlaid by a cuticle approximately .005 mm. thick. The epidermal cells measure .26 mm. tangentially, .04 mm. vertically, and .03 mm. radially. The single vascular bundle is decidedly three lobed at the base of the petiole and on passing to the blade the lobing dissapears leaving the bundle almost round as seen in cross section. The xylem and phloem elements are radially arranged. The radial breadth of the xylem area is approximately .16 mm. and that of the phloem .05 mm.
RIBES NIGRUM

Leaf

General features

This species has a 3-5-lobed, palmately veined leaf with a dentate margin. The leaf is broadly cordate in shape, measuring from 35 to 100 mm. in length, from 20 to 60 mm. in width, and approximately .16 mm. in thickness. The midrib and main branches from the midrib are very prominent on the lower surface (Fig. 106). The under surface of the blade is moderately and uniformly beset with sessile, multicellular glands, visible to the naked eye, and measuring approximately .20 mm. in diameter. The petiole measures from 12 to 35 mm. in length and .90 mm. in thickness. The petiole cross section is nearly circular in outline (Fig. 130).

Epidermis

The upper epidermis, lower epidermis directly beneath the veins, and the petiole have a sparse amount of short slender trichomes, measuring from .08 to .25 mm. in length (Figs. 7-13). There are in addition two rows of large multicellular trichomes, measuring approximately 1 mm. in length, on the winged edge of the petiole. The radial walls of both the upper and lower epidermal cells are undulated. The upper epidermal cells measure approximately .035 mm. in width, .05 mm. in length, and .02 mm. in thickness. The lower epidermal cells measure .025 mm. in width, .04 mm. in length, and .012 mm. in thickness. Stomata occur only in the lower epidermis, where their frequency is approximately 276 per square mm.
Mesophyll

There are mostly two layers of palisade cells composing approximately \( \frac{1}{3} \) of the mesophyll volume (Fig. 106). These cells measure approximately 0.04 mm. in length and 0.015 mm. in cross diameter. There are approximately 5,383 palisade cells per square mm. of leaf area in the upper palisade layer. The cells of the spongy mesophyll are relatively compact and irregular in arrangement.

Midrib

The midrib measures 0.80 mm. in tangential width and 0.54 mm. in radial thickness; it's upper surface is concave and it's lower surface is rounded (Fig. 130). The outer wall of the epidermal cells is decidedly projecting and overlaid by a thin cuticle. No collenchyma or bast fibers are present. The single vascular bundle is slightly 2-lobed, being formed by the fusion of two unequal sized, fan-shaped bundles. The xylem and phloem elements are radially arranged.

Venation

The main veins extending through the blade give off numerous side branches, and gradually diminish in size as they approach the tips of the lobes. There are approximately 26 meshes per square mm. of leaf area and 13 veinlet ends terminating within the mesophyll per square mm.

Margin

The leaf blade near the margin as seen in cross section gradually diminishes in thickness toward the periphery, forming a blunt rounded edge (Fig. 60). Cells the size and
shape of the upper epidermal cells extend around to the lower surface where there is a relatively abrupt transition in size and shape to the typical lower epidermal cells. The palisade cells extend to the margin.

Petiole

The petiole cross section of this species (Fig. 130) is roughly triangular in outline, with the upper surface nearly flat and the lower surface somewhat rounded; it measures approximately 1.13 mm. in tangential width and .96 mm. in radial thickness. The epidermis is sparsely beset with unicellular trichomes measuring from .08 to .25 mm. in length, and in addition there are two rows of multicellular trichomes on the winged edge of the petiole toward the base, measuring approximately 1 mm. in length. The outer wall of the epidermal cells is decidedly projecting and is overlaid by a thin cuticle. These cells measure approximately .012 mm. in tangential width and .02 mm. in radial thickness. There are from 1 to 5 cell layers of bast fibers bordering the phloem. The three separate, equal-sized vascular bundles are arranged in a broadly spread arc at the base of the petiole, while at the middle of the petiole they are fused into a triangular closed system, and at the attachment with the blade this system is a 3-lobed triangle. The radial breadth of the xylem area is approximately .16 mm. and that of the phloem .04 mm. The parenchyma cells of the petiole measure approximately .03 mm. in cross diameter.
RIBES FASCICULATUM (chinese)

Leaf

General features

This species has a 3-5-lobed, palmately-veined leaf with a dentate margin. The leaf is round ovate, rounded or subcordate at the base and measures from 25 to 60 mm. in length, from 18 to 48 mm. in width, and .15 mm. in thickness. The midrib and main branches from the midrib are very prominent on the lower surface (Fig. 117). The under surface of the petiole is rounded and the upper surface is concave, and measures from 8 to 16 mm. in length and approximately .68 mm. in thickness (Fig. 133).

Epidermis

Both the upper and lower epidermis of the blade and petiole are densely pubescent, with trichomes measuring from .16 mm. to .36 mm. in length (Figs. 7-13). The radial walls of both the upper and lower epidermal cells are undulated, (Figs. 42 and 49) and their outer walls are projecting. The upper epidermal cells measure approximately .05 mm. in length and .03 mm. in width. The lower epidermal cells measure .02 mm. in width and .04 mm. in length. Stomata occur only in the lower epidermis where their frequency is approximately 242 per square mm.

Mesophyll

There is mostly one layer of palisade cells composing approximately 1/3 of the mesophyll volume (Fig. 63). The palisade cells measure approximately .04 mm. in length and
.02 mm. in cross diameter. There are approximately 3,405 palisade cells per square mm. of leaf area in the upper palisade layer. The cells of the spongy mesophyll are irregular in arrangement.

Midrib

The midrib of this species measures approximately .48 mm. in width and .40 mm. in thickness; it's upper surface is V-shaped and it's lower surface is rounded (Fig. 117). The upper epidermal cells measure approximately .38 mm. in tangential width and .38 mm. in radial thickness, their outer walls are decidedly projecting and overlaid by a thin cuticle. The lower epidermal cells measure .014 mm. in width and .022 mm. in thickness, their outer walls are relatively less projecting than are those of the upper epidermis. No collenchyma or bast fibers are present. The parenchyma cells measure, on an average, approximately .022 mm. in cross diameter. The single vascular bundle is in the shape of a semi-circle with radially arranged xylem elements. The radial breadth of the xylem area is approximately .10 mm. and that of the phloem .04 mm.

Venation

The three main veins extending through the blade gradually diminish in size as they approach the tips of the lobes, giving off numerous side branches. There are approximately 22 meshes per square mm. of leaf area and 9 veinlet ends terminating within the mesophyll per square mm. (Fig. 77).

Margin
The leaf blade as seen in cross section is abruptly rounded at the margin (Fig. 60). Cells the size and shape of the upper epidermal cells extend around to the lower surface where there is an abrupt transition in size and shape to that of the typical lower epidermal cells. The palisade cells extend to the margin.

Petiole

The petiole cross section of this species is circular beneath with a concave upper surface, measuring approximately .92 mm. in width and .72 mm. in thickness, (Fig. 133). The epidermis of the petiole is densely beset with simple hairs measuring from .16 to .36 mm. in length. The epidermal cells measure approximately .015 mm. tangentially, .05 mm. vertically, and .02 mm. radially; their outer walls are projecting and overlaid by a thin cuticle. The three separate vascular bundle at the base of the petiole fuse on passing to the blade, forming a single oblong shaped bundle. The xylem and phloem elements are radially arranged. The radial breadth of the xylem area is approximately .16 mm. and that of the phloem .06 mm.
RIBES ALPINUM

Leaf

General features

This species has a three-lobed, palmately-veined leaf with a dentate margin. The leaf is ovate in shape, measuring from 12 to 25 mm. in length, from 8 to 16 mm. in width, and .24 mm. in thickness. The midrib and main branches from the midrib are prominent on the lower surface (Fig. 113). The petiole measures from 5 to 9 mm. in length and approximately .64 mm. in thickness. The under surface of the petiole is rounded and the upper surface is concave (Fig. 132).

Epidermis

There are only a few short, simple hairs mostly at the leaf margin, measuring from .08 to .12 mm. in length (Figs. 7-13). Both the upper and lower epidermises of the blade and petiole are moderately beset with multicellular glands having a rounded head and a considerably elongated, several-celled stalk. The head consists of isodiametric cells in the center surrounded by radially elongated cells; it measures approximately .06 mm. in vertical height and .08 mm. in radial diameter. The stalk is conical in shape, measuring from .10 to .40 mm. in length. The glands with the upper epidermis have, on an average, longer stalks than those with the lower epidermis. The radial walls of both the upper and lower epidermal cells are slightly undulated
The upper epidermal cells measure approximately .022 mm. in width, .045 mm. in length, and .02 mm. in thickness. The lower epidermal cells measure .02 mm. in width, .04 mm. in length, and .018 mm. in thickness. The stomata occur only in the lower epidermis where their frequency is approximately 207 per square mm.

**Mesophyll**

There is a single layer of palisade cells, composing approximately 1/3 of the mesophyll volume (Fig. 65). These cells measure approximately .06 mm. in length and .015 mm. in cross diameter. There are approximately 5,000 palisade cells per square mm. of leaf area. The cells of the spongy mesophyll are loosely arranged with relatively large intercellular spaces.

**Midrib**

The midrib measures approximately .36 mm. in tangential width, and .36 mm. in radial thickness; its upper surface is slightly concave and its lower surface is rounded (Fig. 113). The outer wall of the epidermal cells is projecting and overlaid by a thin cuticle. No collenchyma or bast fibers are present. The single vascular bundle as seen in cross section is circular in outline with irregularly arranged xylem and phloem elements.

**Venation**

The three main veins extending through the blade gradually diminish in size as they approach the tips of the
lobes, giving off numerous side branches. There are approximately fourteen meshes per square mm. of leaf area and five veinlet ends terminating within the mesophyll per square mm. (Fig. 84).

Margin

The leaf blade as seen in cross section is blunt and rounded at the margin (Fig. 65). Cells the size and shape of the upper epidermal cells extend around to the lower surface where there is a gradual transition in size and shape to typical lower epidermal cells. The palisade cells extend to the margin.

Petiole

The petiole cross section (Fig. 132) is in the shape of an inverted helmet with the upper surface slightly concave and the lower surface rounded; it measures 1.12 mm. in tangential width and .80 mm. in radial thickness. There are a few short trichomes on the upper surface of the petiole, measuring approximately .06 mm. in length. This species has a multiple epidermis consisting of two cell layers. The outer wall of the epidermal cells of the lower surface is slightly projecting while that of the upper epidermis is decidedly projecting. These cells measure approximately .017 mm. in width and .022 mm. in thickness. No collenchyma or bast fibers are present. The two separate vascular bundles at the base of the petiole fuse on passing towards the blade into a single fan-
shaped bundle. The radial breadths of the radially arranged xylem and phloem tissues are approximately .20 mm. and .05 mm. respectively. The parenchyma cells of the petiole measure approximately .04 mm. in cross diameter.
RIBES SATIVUM

Leaf

General features

This species has a 3-5 lobed, palmately veined leaf with a serrate margin. The leaf is broadly cordate, measuring from 26 to 83 mm. in length, from 21 to 68 mm. in width, and .14 mm. in thickness. The midrib and main branches from the midrib are very prominent on the lower surface (Fig. 105). The petiole measures from 9 to 24 mm. in length and 1.28 mm. in thickness. The under surface of the petiole is rounded and its upper surface is concave (Fig. 126).

Epidermis

The lower epidermis is densely beset with slender hairs, measuring from .24 to .48 mm. in length; while the upper epidermis, margin and petiole are sparcely pubescent (Figs. 7-13). There are a few large branched trichomes on the winged edge of the petiole, measuring approximately .50 mm. in length. The radial walls of both the upper and lower epidermal cells are undulated (Figs. 51 and 46). The upper epidermal cells measure approximately .025 mm. in width, .04 mm. in length, and .03 mm. in radial thickness. The lower epidermal cells measure about .03 mm. in width, .042 mm. in length, and .018 mm. in radial thickness. The stomata occur only in the lower epidermis where their frequency is approximately 208 per square mm.

Mesophyll

There is mostly a single layer of palisade cells, com-
posing approximately 1/3 of the mesophyll volume (Fig. 73). These cells measure .04 mm. in length and .02 mm. in cross diameter. There are approximately 3,933 palisade cells per square mm. of leaf area in the upper palisade layer. The cells of the spongy mesophyll are loosely arranged with relatively large intercellular spaces.

Midrib

The midrib measures .64 mm. in tangential width and .50 mm. in thickness; its upper surface is V-shaped and its under surface is circular (Fig. 105). The radial walls of the epidermal cells are undulated, their outer walls are projecting and overlaid by a thin cuticle. No collenchyma or bast fibers are present. The single vascular bundle as seen in cross section is fan-shaped with radially arranged xylem and phloem elements. The parenchyma cells of the midrib measure approximately .025 mm. in cross diameter.

Venation

The three main veins extending through the blade gradually diminish in size as they approach the tips of the lobes, giving off numerous side branches (Fig. 88). There are approximately 14 meshes per square mm. of leaf area and 8 veinlet ends terminating within the mesophyll per square mm.

Margin

The leaf blade as seen in cross section tapers to a blunt point at the margin, with the upper surface curving down and the lower surface curving up (Fig. 73). Cells the size and shape of the upper epidermal cells extend around to the lower surface where there is a gradual transition in size.
and shape to the typical lower epidermal cells. The palisade extend to the margin.

Petiole

The petiole cross section of this species (Fig. 126) measures approximately 1.54 mm. tangentially and 1.28 mm. radially, being in the shape of an inverted dome with the lower surface rounded and the upper surface nearly flat (Fig. 126). The epidermis is sparcely beset with slightly curved hairs measuring approximately .30 mm. in length, and a few large multicellular trichomes on the blade of the petiole measuring .50 mm. in length. The outer walls of the epidermal cells are decidedly projecting and overlaid by a thin cuticle. These cells measure .02 mm. tangentially, .05 mm. vertically, and .023 mm. radially. There are from 2 to 5 cell layers of bast fibers bordering the phloem, forming a continuous ring around the three equal sized vascular bundles. The three separate vascular bundles are arranged in a wide spread arc at the base of the petiole, but change their position to form an equilateral triangle inclosing pith at the point of attachment to the blade. The xylem and phloem elements are radially arranged. The radial breadth of the xylem area in each bundle is approximately .24 mm. and that of the phloem .08 mm.
RIBES LURIDUM

Leaf

General features

This species has a 3-lobed, palmately-veined leaf with a dentate margin. The leaf is ovate in shape, measuring from 40 to 70 mm. in length, from 24 to 34 mm. in width, and approximately .34 mm. in thickness. The midrib and main branches from the midrib are prominent on the lower surface (Fig. 109). The petiole measures from 12 to 30 mm. in length and approximately 1.12 in thickness. The upper surface of the petiole is decidedly V-shaped and the lower surface is rounded (Fig. 121).

Epidermis

The leaf is glabrous, except for a very few short stout trichomes on the upper surface of the blade near the margin, a few short slender hairs on the margin of the sinuses and upper surface of the base of the petiole (Figs. 7-13). The radial walls of both the upper and lower epidermal cells are slightly undulated (Figs. 29 & 36). The upper epidermal cells measure approximately .04 mm. in width, .06 mm. in length, and .02 mm. in radial thickness. The lower epidermal cells measure .03 mm. in width, .04 mm. in length, and .025 mm. in radial thickness. The stomata occur only in the lower epidermis where their frequency is approximately 276 per square mm.

Mesophyll

There are mostly 2 layers of palisade cells composing
approximately 2/5 of the mesophyll volume (Fig. 69). These cells measure approximately .055 mm. in length and .015 mm. in cross diameter. There are approximately 5,589 palisade cells per square mm. of leaf area in the upper palisade layer. The cells of the spongy mesophyll are relatively compact and irregular in arrangement.

Midrib

The midrib cross section (Fig. 109) is slightly concave on the upper side and convex on the lower side, and measures approximately .56 mm. in width and .36 mm. in thickness. The outer walls of the epidermal cells are decidedly projecting and overlaid by a thin cuticle. No collenchyma or bast fibers are present. The single vascular bundle as seen in cross section is elliptical in outline, measuring .40 mm. in tangential and .24 mm. in radial diameter. The radial breadth of the xylem area is approximately .18 mm. and that of the phloem .06 mm. The parenchyma cells of the midrib measure approximately .035 mm. in cross diameter.

Venation

The three main veins extending through the blade gradually diminish in size as they approach the tips of the lobes, giving off numerous side branches. There are approximately 22 meshes per square mm. of leaf area and 14 veinlet ends terminating within the mesophyll per square mm.

Margin

The leaf blade as seen in cross section is blunt and rounded at the margin (Fig. 69). Cells the size and shape of
the upper epidermal cells extend around to the lower surface
where there is an abrupt transition in size and shape to
typical lower epidermal cells. The double layer of palisade
cells extends to the margin.

Petiole

The petiole cross section of this species is broadly
cordate in outline, with the upper surface V-shaped and the
lower surface rounded; it measures 1.28 mm. in width and
1.12 mm. in thickness. There are a few slender hairs on the
upper surface and toward the base of the petiole. This
species has a multiple epidermis. The outer walls of the
epidermal cells are decidedly projecting and overlaid by a
thin cuticle. These cells measure approximately .02 mm.
in tangential and radial diameters. There are from 1 to
4 cell layers of bast fibers bordering the outer edge of
the phloem. There are 3 separate vascular bundles arranged
in a triangle at the base of the petiole, which fuse on
passing to the blade into a single slightly curved bundle.
The radial breadth of the xylem area is approximately .16 mm.
and that of the phloem .06 mm. The parenchyma cells of the
petiole measure approximately .04 mm. in cross diameter.
RIBES STENOCARPUM

Leaf

General features

This species has a 3-lobed, palmately-veined leaf with a dentate margin. The leaf is ovate in shape measuring from 15 to 40 mm. in length, from 6 to 15 mm. in width, and approximately .20 mm. in thickness. The midrib and main branches from the midrib are slightly prominent on the lower surface (Fig. 110). The petiole measures from 6 to 15 mm. in length and approximately .69 mm. in thickness. The under side of the petiole is rounded and the upper surface is nearly flat (Fig. 122).

Epidermis

Both the upper and lower epidermises of the blade and the upper epidermis of the petiole are densely beset with short slender trichomes measuring from .10 to .36 mm. in length, (Figs. 7-13). There are two rows of multicellular trichomes measuring approximately 1.5 mm. in length, on the winged edge of the petiole. The upper epidermal cells measure approximately .06 mm. in length, .04 mm. in width, and .021 mm. in radial thickness. The lower epidermal cells measure .03 mm. in width, .05 mm. in length, and approximately .023 mm. in radial thickness. The stomata occur only in the lower epidermis where their frequency is approximately 250 per square mm.

Mesophyll

There are mostly two layers of palisade cells composing approximately $\frac{3}{5}$ of the mesophyll volume (Fig. 62). The cells composing the upper palisade layer measure approxima-
tely .05 mm. in length and .015 in cross diameter, while those composing the lower layer measure approximately .035 mm. in length. There are approximately 4,968 palisade cells per square mm. of leaf area in the upper palisade layer. The cells of the spongy mesophyll are irregular in arrangement.

**Midrib**

The midrib measures .24 mm. tangentially and approximately .24 mm. radially; it's upper surface forms an obtuse angle and it's lower surface is rounded (Fig. 110). The epidermal cells on the upper side measure approximately .03 mm. in width and .02 mm. in radial thickness. No collenchyma or bast fibers are present. The single vascular bundle is fan-shaped as seen in cross section and relatively small, measuring approximately .12 mm. tangentially and .10 mm. in radial diameter. The radial breadth of the xylem area is approximately .06 mm. and that of the phloem .04 mm. The parenchyma cells of the midrib measure approximately .02 mm. in cross diameter.

**Venation**

The three main branches extending through the blade gradually diminish in size as they approach the tips of the lobes, giving off numerous side branches. There are approximately 22 meshes per square mm. of leaf area and 14 veinlet ends terminating within the mesophyll per square mm.

**Margin**

The leaf blade gradually diminishes in thickness toward the periphery, forming a slightly rounded edge (Fig. 62).
The upper layer of palisade cells extends to the margin. The transition in size and shape of the upper epidermal to typical lower epidermal cells occurs at the margin.

Petiole

The petiole cross section of this species (Fig. 122) is in the shape of an inverted bell, with the upper surface nearly flat and the lower surface rounded; it measures .84 mm. in width and .68 mm. in thickness. The upper epidermis of the petiole is densely beset with unicellular trichomes measuring from .10 to .36 mm. in length. The outer walls of the epidermal cells are decidedly projecting and overlaid by a thin cuticle. These cells measure .012 mm. in width and .02 mm. in radial thickness. No collenchyma or bast fibers are present. The single vascular bundle as seen in cross section is slightly three lobed at the base of the petiole, but on passing to the blade, the lobing disappears leaving the bundle in the shape of a circle with the phloem surrounding the xylem. The radial breadth of the xylem area is approximately .12 mm. and that of the phloem .06 mm.
RIBES VILMORINII

Leaf

General features

The leaf of this species is deeply 3 lobed, palmately-veined, and has a dentate margin. The leaf is broadly cordate in shape and measures from 15 to 40 mm. in length, from 8 to 30 mm. in width, and approximately .16 mm. in thickness. The midrib and main branches from the midrib are prominent on the lower surface (Fig. 116). The petiole measures from 8 to 15 mm. in length and .50 mm. in thickness. The under surface of the petiole is rounded and the upper surface is slightly concave.

Epidermis

Both the upper and lower epidermis of the blade and petiole are densely beset with short trichomes measuring from .04 to .16 mm. in length (Fig. 12) and scattering larger trichomes measuring from .54 to .72 mm. occur on the blade and upper surface of the petiole. The radial walls of both the upper and lower epidermal cells are undulated (Figs. 44 and 45) and their outer walls are projecting (Fig. 116). The upper epidermal cells measure approximately .06 mm. in length, .03 mm. in width, and .022 mm. in thickness. The lower epidermal cells average approximately .04 mm. in length, .022 mm. in width, and .018 mm. in thickness. The stomata occur only in the lower epidermis where their frequency is approximately 414 per square mm.

Mesophyll
There are from 1 to 2 layers of palisade cells composing approximately 1/2 of the mesophyll volume (Fig. 61). The palisade cells measure approximately .04 mm. in length and .015 mm. in cross diameter. There are approximately 8,240 palisade cells per square mm. of leaf area in the upper palisade layer. The cells of the spongy mesophyll are irregular in arrangement.

**Midrib**

The midrib measures .35 mm. in thickness and .36 mm. in width; its upper surface is V-shaped and its lower surface is rounded (Fig. 116). The radial walls of the epidermal cells are undulated and their outer walls are projecting. The lower epidermal cells are overlaid by a roughened cuticle. The single vascular bundle is circular in outline with radially arranged xylem elements. The parenchyma cells of the midrib measure approximately .02 mm. in cross diameter.

**Venation**

The three main veins extending through the blade gradually diminish in size as they approach the tips of the lobes, giving off numerous side branches (Fig. 82). There are approximately 31 meshes per square mm. of leaf area and 26 veinlet ends terminating within the mesophyll per square mm.

**Margin**

The margin of the leaf blade as seen in cross section is wedge shaped (Fig. 61). Epidermal cells the size and shape of those of the upper epidermis extend around to the lower surface where there is a gradual transition in size and shape to that of the typical lower epidermal cells. The
palisade cells extend nearly to the margin.

Petiole

The petiole cross section of this species measures approximately .88 mm. in width and .50 mm. in thickness, being in the shape of a three quarter moon with the under surface rounded and the upper surface concave (Fig. 127). Both the upper and lower epidermis have short trichomes measuring from .04 to .16 mm. in length and in addition a few larger trichomes on the upper surface measuring from .54 to .72 mm. in length. The outer walls of the epidermal cells are projecting and overlaid by a thin cuticle. These cells measure .06 mm. vertically, .015 mm. tangentially, and .02 mm. radially. There are from 1 to 4 layers of bast fibers bordering the phloem. The three vascular bundles are arranged in a widespread arc at the base of the petiole, and fuse on passing to the blade into a single, slightly bent bundle. The xylem elements are radially arranged. The radial breadth of the xylem area is approximately .14 mm. and that of the phloem .04 mm.
RIBES MISSOURIENSE

Leaf

General features

This species has a three to five lobed, palmately-veined leaf with a dentate margin. The leaf is broadly cordate in shape, measuring from 22 to 40 mm. in length, from 20 to 40 mm. wide, and approximately .18 mm. thick. The midrib and main branches from the midrib are very prominent on the lower surface (Fig. 104). The petiole measures from 8 to 12 mm. in length and .96 mm. thick. The lower side of the petiole is circular and the upper surface is nearly flat.

Epidermis

There are no trichomes with the upper epidermis of this species, excepting along the margin and at the base of the larger veins on the lower surface there are simple, slightly curved trichomes (Fig. 7), and the epidermis covering the upper surface of the petiole has a moderate amount of simple, slightly curved hairs. These trichomes measure from .08 to .48 mm. in length (Figs. 7-13). There are in addition a few large multicellular trichomes toward the base of the petiole, measuring approximately 1 mm. in length. The radial walls of both the upper and lower epidermal cells are undulated (Figs. 52 & 53) and their outer walls are projecting. The upper epidermal cells measure approximately .06 mm. in length, .035 mm. wide, and .025 mm. thick. The lower epidermal cells average approximately .05 mm. in length, .03 mm. wide, and .015 mm. thick. The stomata occur only in the lower epidermis where their frequency is approximately
Mesophyll

There is mostly one layer of palisade cells composing from 1/3 to 1/2 of the mesophyll volume (Fig. 64). The palisade cells measure approximately .04 mm. in length and .015 mm. in cross diameter. There are approximately 3,519 palisade cells per square mm. of leaf area in the upper palisade layer. The cells of the spongy mesophyll are irregular in arrangement.

Midrib

The midrib measures .39 mm. thick and .36 mm. in width; it's upper surface is V-shaped and it's under surface is circular (Fig. 104). The radial walls of the epidermal cells are undulated and the outer walls are projecting. The lower epidermal cells are overlaid by a roughened cuticle. No collenchyma or bast fibers are present. The single vascular bundle is in the shape of a circle with radially arranged xylem and phloem elements. The parenchyma cells of the midrib measure approximately .02 mm. in cross diameter.

Venation

The three main veins extending through the blade gradually diminish in size as they approach the tips of the lobes, giving off numerous side branches (Fig. 83). There are approximately 22 meshes per square mm. of leaf area and 14 veinlet ends terminating within the mesophyll per square mm.

Margin

The leaf blade as seen in cross section gradually diminishes in thickness toward the periphery with the upper sur-
face at the pointed margin (Fig. 64). Cells the size and shape of the upper epidermal cells extend around to the lower surface where there is a gradual transition in size and shape to that of the typical lower epidermal cells. The palisade cells extend to the margin.

Petiole

The petiole cross section of this species measures approximately 1.12 mm. in width and .96 mm. thick, being in the shape of an inverted dome with the lower surface rounded and the upper surface nearly flat (Fig. 129). The upper epidermis is beset with simple, slightly curved trichomes measuring from .08 to .48 mm. in length and a few large multicellular trichomes toward the base of the petiole measuring approximately 1 mm. in length. The outer walls of the epidermal cells are projecting and overlaid by a thin cuticle. These cells measure .06 mm. vertically, .02 mm. tangentially, and .02 mm. radially. There are from 2 to 4 cell layers of bast fibers bordering the phloem. The single vascular bundle is decidedly 3-lobed at the base of the petiole and bent in the shape of a semicircle, and on passing to the blade the lobing disappears and the bundle is further bent nearly into a complete circle. The xylem and phloem elements are radial breadth of the xylem area is approximately .16 mm. and that of the phloem .04 mm.
RIBES CYNOBASTI

Leaf

General features

This species has a three to five-lobed, palmately-veined leaf with a dentate margin. The leaf is round-ovate, rounded or subcordate at the base, and measures from 11 to 62 mm. in length, from 8 to 45 mm. in width, and approximately .17 mm. in thickness. The midrib and main branches from the midrib are prominent on the lower surface (Fig. 107). The petiole measures from 4 to 16 mm. in length and .80 mm. in thickness. The under side of the petiole is rounded and the upper side is slightly concave (Fig. 123).

Epidermis

Both the upper and lower epidermises of the blade and petiole are densely beset with trichomes, measuring from .08 to .50 mm. in length. There are two rows of multicellular trichomes, measuring approximately 1.5 mm. in length, on the winged edge of the petiole. The epidermis of the petiole and upper epidermis of the blade are moderately beset with multicellular glands having an inverted thimble-shaped head and a slightly cone-shaped stalk. The head measures approximately .08 mm. in both vertical height and radial diameter at the free end. The stalk measures approximately .18 mm. in length. The radial walls of both the upper and lower epidermal cells are regular in outline.
The upper epidermal cells of the blade measure approximately .03 mm. in width, .045 mm. in length, and .06 mm. in thickness. The lower epidermal cells measure approximately .025 mm. in width, .04 mm. in length, and .028 mm. in thickness. Stomata occur only in the lower epidermis where their frequency is approximately 208 per square mm.

Mesophyll

There is a single layer of palisade cells, composing approximately 1/3 of the mesophyll volume (Fig. 72). These cells measure approximately .04 mm. in length and .012 mm. in cross diameter. There are approximately 5,589 palisade cells per square mm. of leaf area. The cells of the spongy mesophyll are relatively compact and irregular in arrangement.

Midrib

The midrib measures .38 mm. in tangential width and .35 mm. in thickness; its upper surface is slightly concave and its lower surface is rounded (Fig. 107). The outer walls of the epidermal cells are decidedly projecting and overlaid by a thin cuticle. No collenchyma or bast fibers are present. The single vascular bundle is nearly a circle in outline as seen in cross section, measuring .20 mm. radially and .24 mm. tangentially. The parenchyma cells of the midrib measure approximately .03 mm. in cross diameter.

Venation

The three main veins extending through the blade grad-
ually diminish in size as they approach the tips of the lobes, giving off numerous side branches. There are approximately 22 meshes per square mm. of leaf area and ten veinlet ends terminating within the mesophyll per square mm. (Fig. 80).

Margin

The leaf blade has a rather sharp edge, due to a relatively rapid decrease in thickness at the margin (Fig. 72). Cells the size and shape of the upper epidermal cells extend around to the lower surface where there is a gradual transition in size and shape to typical lower epidermal cells. The palisade cells extend to the margin.

Petiole

The petiole cross section of this species measures approximately .88 mm. in width and .84 mm. in thickness, being in the shape of an inverted dome with the lower surface rounded and the upper surface slightly concave (Fig. 123). The epidermis of both the upper and lower surface is densely beset with trichomes measuring from .08 to .50 mm. in length. There are two rows of multicellular trichomes, measuring approximately 1.5 mm. in length, on the winged edges of the petiole. The outer walls of the epidermal cells are decidedly projecting and overlaid by a thin cuticle. These cells measure approximately .02 mm. radially and .016 mm. tangentially. There
are from one to three cell layers of bast fibers bordering the outer edge of the phloem. The three separate vascular bundles are arranged in an arc at the base of the petiole, but fuse on passing to the blade to form a single vascular bundle bent in the shape of a semicircle.
General features

This species has a three lobed, palmately-veined leaf with a dentate margin. The leaf is ovate in shape, measuring from 14 to 50 mm. in length, from 7 to 30 mm. in width, and approximately .16 mm. in thickness. The midrib and main branches from the midrib are very prominent on the lower surface (Fig. 105). The petiole measures 16 mm. in length, .74 mm. in width, and .64 mm. in thickness. Its upper surface is concave and its lower surface is rounded, (Fig. 120).

Epidermis

Both the upper and lower epidermis of the leaf have simple, slightly curved hairs. The hairs are larger on the lower surface and also larger and more abundant on the veins and along the margin; they measure from .04 to .25 mm. in length (Figs. 7-13). The radial walls of both the upper and lower epidermal cells are slightly undulated, their outer walls are projecting, and their radial walls are pitted. The lower epidermal cells measure approximately .03 mm. in length, .02 mm. in width, and .02 mm. in height. The cells of the upper epidermis measure approximately .04 mm. in length, .02 mm. in width, and .021 mm. in height. The stomata occur only in the lower epidermis where their frequency is approximately 310 per square mm.

Mesophyll

There are from 1 to 2 layers of palisade cells composing
from 1/3 to 1/2 of the mesophyll volume (Fig. 71). The palisade cells measure approximately .04 mm. in length and .011 mm. in width. There are approximately 5,616 palisade cells per square mm. of leaf area in the upper palisade layer. The cells of the spongy mesophyll are irregularly arranged.

Midrib

The midrib measures .35 mm. in thickness and .40 mm. in width; its upper surface is V-shaped and the under surface is rounded. Its epidermal cells are rectangular in shape and those of its lower surface are overlaid by a roughened cuticle (Fig. 108). The single vascular bundle is elliptical in shape with radially arranged xylem and phloem elements. The parenchyma cells of the midrib measure approximately .02 mm. in cross diameter.

Venation

The veins extending through the blade gradually diminish in size as they approach the tip giving off numerous side branches. There are approximately 35 meshes per square mm. of leaf area and 26 veinlet ends terminating within the mesophyll per square mm.

Margin

The thickness of the leaf as seen in cross section gradually tapers down to a point at the margin (Fig. 71). Cells the size and shape of the upper epidermal cells extend around to the lower surface and there abruptly join with the typical lower epidermal cells. The palisade cells extend nearly into the margin.
Petiole

The petiole cross section of this species measures .74 mm. in width and .64 mm. thick, being in the shape of a three quarter moon with the upper surface concave and the under surface rounded, (Fig. 120). The epidermis is beset with slender curved trichomes measuring from .08 to .72 mm. in length. The epidermal cells are projecting and overlaid by a cuticle about .003 mm. thick. These cells measure approximately .05 mm. vertically, .025 mm. tangentially, and .02 mm. radially. There are from 2 to 3 cell layers of bast fibers bordering the phloem. The three separate vascular bundles are arranged in a semicircle at the base of the petiole, and on passing to the blade they fuse into a single bundle bent in a semicircle. The xylem and phloem elements are radially arranged. The radial breadth of the phloem area is approximately .05 mm. and that of the xylem .12 mm.
SUMMARY OF LEAVES

The leaves of all of the fifteen species of Ribes studied have the following features in common: three to five lobed, palmately veined leaves with dentate margins; three main veins extending from the base of the blade to the tips of the lobes, giving off numerous side branches; the upper epidermal cells the larger and with walls thicker than those of the lower epidermis; the outer wall of the epidermal cells of the blade and petiole projecting and overlaid by a thin cuticle; stomata occurring only in the lower epidermis in all species except R. aureum; no bast fibers in the leaf blade; the mid-rib with relatively thin walled strengthening tissue extending from epidermis to epidermis; from 1 to 3 layers of palisade cells composing from 1/3 to 1/2 of the mesophyll volume; either a single 3 lobed vascular bundle or 3 separate vascular bundles entering the petiole; the lobes or bundles tending to fuse on passing to the blade.

Table VI shows the variations in average length of leaves, average width and thickness of petioles in the different species. The leaf varies in width from less than 1/2 its length in R. stenocarpum and R. diacantha to nearly equal its length in R. missouriense. There is a fair correlation between the length of leaf, width of leaf, and length of petiole. There is considerable variation in the thickness of the leaf blade which ranges from .12 mm. in R. americanum to .26 mm. in R. diacantha. The variation in thickness of pet-
ioles ranges from .50 mm. in *R. vilmorinii* to 1.28 mm. in *R. sativum*. The radial walls of the epidermal cells are slightly undulated in all except the following five species: *R. holosericeum*, *R. aureum*, *R. diacantha*, *R. stenocarpum*, and *R. cynobasti*. All have trichomes except *R. aureum* and *R. diacantha*; however, there is considerable variation in amount, length, and distribution of trichomes in the different species.

Trichomes are sparse in the following species: *R. holosericeum*, *R. tenue*, *R. nigrum*, *R. alpinum*, and *R. luridum*; moderate in number in *R. americanum* and *R. hirtellum*; and abundant in the remaining species. The average length of trichomes in mm. in the various species is as follows: *R. americanum* .05; *R. alpinum*, *R. luridum*, and *R. vilmorinii* .10; *R. hirtellum* and *R. nigrum* .14 and .16 respectively; *R. stenocarpum*, *R. tenue*, *R. fasciculatum*, *R. missouriense*, and *R. cynobasti* .23, .24, .26, .28 and .29 respectively; *R. holosericeum* .35 and *R. sativum* .36. Trichomes are found on both the upper and lower epidermis of the blade and on the petioles of the following species: *R. holosericeum*, *R. americanum*, *R. nigrum*, *R. fasciculatum*, *R. sativum*, *R. stenocarpum*, and *R. vilmorinii*.

*R. alpinum* has a few trichomes mostly at the margin. *R. luridum* has a sparse amount of trichomes with the epidermis of the petiole, margin and upper epidermis of the blade. *R. missouriense* has a moderate amount with the epidermis of the petiole, margin and upper epidermis of the blade. *R. cynobasti* and *R. hirtellum* have trichomes with both the upper and lower epidermis of the blade. *R. tenue*, *R. americanum*, *R. nigrum*,
R. missouriense, and R. cynobasti have multicellular trichomes and R. sativum multicellular, branched trichomes along the borders of the groove of the petiole. There are multicellular sessile glands with the epidermis of R. americanum and R. nigrum, and multicellular stalked glands, with a several celled stalk, with the epidermis of R. alpinum and R. cynobasti. Table VII shows the number of stomata and palisade cells per square mm. of leaf area and the average length of palisade cells in the different species. There is a slight correlation between the number of stomata and palisade cells per square mm. of leaf area. The ratio of palisade cells to stomata varies from 14 to 1 in R. fasciculatum to 30 to 1 in R. tenue. The length of palisade cells varies from .03 mm. in R. tenue and R. aureum to .06 mm. in R. alpinum. It is interesting to note that R. tenue and R. aureum with the highest ration of palisade cells to stomata have the shortest palisade cells. The number of meshes per square mm. of leaf area varies from 12 in R. tenue to 35 in R. hirtellum. The number of veinlet ends terminating within the mesophyll per square mm. of leaf area varies from 5 in R. tenue and R. alpinum to 26 in R. hirtellum and R. vilmorinii. There is some correlation between the number of meshes and veinlet ends in the different species. There is considerable variation in size and shape of the midribs and vascular bundles as seen in cross sections. The midribs vary in thickness from .34 mm. in R. aureum, R. diacantha, R. americanum, and R. stenocarpum to .54 mm. in R. nigrum. The upper surface of the
midrib varies in shape from nearly flat to decidedly V-shaped, with the lower surface rounded. The midrib with relatively thin walled strengthening tissue extends from epidermis to epidermis. The leaf margin is rounded in all species except R. missouriense, R. vilmorinii and R. cynobasti which have pointed margins as seen in cross section.

The palisade cells extend to the margin in all species except R. holosericeum. In most species, cells the size and shape of the upper epidermal cells extend around to the lower surface where there is an abrupt transition in size and shape to that of the typical lower epidermal cells. There is considerable variation in size and shape of petioles in the different species. The upper surface of the petiole is concave in most species and ranges from nearly flat to distinctly V-shaped with the lower surface rounded. The upper surface is slightly convex in R. hirtellum, R. diacantha, R. missouriense, and R. aureum. The petiole is triangular in outline in R. nigrum and inverted dome shaped in R. sativum. Bast fibers bordering the outer edge of the phloem were found in all species except R. alpinum and R. stenocarpum; the number of cell layers varying from 1 to 6 among the different species. There are 3 separate vascular bundles entering the base of the petiole in all species except R. americanum, R. stenocarpum, and R. missouriense which have a single 3 lobed bundle. The lobes of the single bundle tend to disappear on passing to the blade, and the three separate bundles fuse into one in all species except R. diacantha and R. sativum. There is some variation in the rapidity and
amount of fusion of vascular bundles in the different species.
TABLE VI.

TABLE SHOWING THE AVERAGE LENGTH OF LEAVES, WIDTH AND THICKNESS OF BLADES, AND LENGTH AND THICKNESS OF PETIOLES.

<table>
<thead>
<tr>
<th>Species</th>
<th>Length of leaf (mm)</th>
<th>Width of leaf blade (mm)</th>
<th>Thickness of blade (mm)</th>
<th>Length of petiole (mm)</th>
<th>Thickness of petiole (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R. holosericeum</td>
<td>55</td>
<td>40</td>
<td>.24</td>
<td>17</td>
<td>.92</td>
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<tr>
<td>R. tenue</td>
<td>25.5</td>
<td>17.5</td>
<td>.26</td>
<td>6</td>
<td>.64</td>
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<td>.68</td>
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<td>R. alpinum</td>
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<td>44.5</td>
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<td>55</td>
<td>29</td>
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<td>11.5</td>
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TABLE VII

TABLE SHOWING THE NUMBER OF STOMATA AND PALISADE CELLS PER SQUARE MM. OF LEAF AREA AND THE AVERAGE LENGTH OF PALISADE CELLS

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of Stomata</th>
<th>Number of Palisade Cells</th>
<th>Ave. Length of Palisade Cells</th>
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<td>R. holosericeum</td>
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<td>R. tenue</td>
<td>207</td>
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<td>.03</td>
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<td>R. aureum</td>
<td>245</td>
<td>6,831</td>
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<td>R. diacantha</td>
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<td>R. americanum</td>
<td>432</td>
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<td>.04</td>
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</table>
KEY TO STEMS

I. Collenchyma typical.

A. More than one ring of peridermal tissue in 2 year's growth, stem unarmed.

   R. missouriense

B. One ring of peridermal tissue in 2 year's growth, stem armed.

   1. Radial walls of the epidermal cells cutinized.

      R. stenocarpum

   2. Radial walls of the epidermal cells not cutinized.

      R. cynobasti

II. Collenchyma not typical.

A. Trichomes present.

   1. Radial walls of the epidermal cells cutinized.

      a. Multicellular, sessile glands present.

         (1) Average cross diameter of tracheal tubes less than .025 mm.

            R. americanum

         (2) Average cross diameter of tracheal tubes more than .025 mm.

            R. nigrum

      b. Glands absent.

         (1) Average less than 865 tracheal tubes per square mm. of xylem area.

            R. fasciculatum

         (2) Average more than 865 tracheal tubes per square mm. of xylem area.

            R. holosericeum

   2. Radial walls of epidermal cells not cutinized.
a. Average more than 1050 tracheal tubes per square mm. of xylem area.

R. tenue

b. Average less than 1050 tracheal tubes per square mm. of xylem area.

(1) Peridermal tissue formed at outer edge of phloem.

R. vilmorinii

(2) Peridermal tissue formed in midst of cortex.

R. sativum

B. Trichomes absent.

1. Radial walls of epidermal cells cutinized.
   a. Outer wall of epidermal cells hardly at all projecting.

R. alpinum

b. Outer wall of epidermal cells decidedly projecting.

(1) Largest tracheal tubes less than .022 mm. in cross diameter.

R. diacantha

(2) Largest tracheal tubes greater than .022 mm. in cross diameter.

R. luridum

2. Radial walls of epidermal cells not cutinized.
   a. Less than 13 protoxylem points in stem cross section.

R. aureum

b. More than 13 protoxylem points in stem cross section.

R. hirtellum
KEY TO PETIOLES

I. Bast fibers absent.
   A. Vascular bundle fan-shaped as seen in cross section.
      R. alpinum
   B. Vascular bundle circular as seen in cross section.
      R. stenocarpum

II. Bast fibers present.
   A. One vascular bundle at base of petiole.
      1. Sclerenchyma thick walled with small intercellular space.
         R. missouriense
      2. Sclerenchyma relatively thin walled with relatively large intercellular space.
         a. Vascular bundle in the shape of a circle, 3-lobed, and fan-shaped as seen in a cross section midway between leaf base and leaf blade.
            R. americanum
         b. Vascular bundle bent in the shape of a semi-circle and not 3-lobed as seen in a cross section midway between leaf base and leaf blade.
            R. fasciculatum

B. Three vascular bundles at base of petiole.
   1. Two or more distinct bundles at apex of petiole.
      a. A closed bundle system of three equal sized, triangularly arranged bundles, with entire outer edge of phloem bordered by sclerenchyma.
         R. sativum
      b. An open bundle system consisting of unequal sized bundles not triangularly arranged, with only part of outer edge of phloem bordered by sclerenchyma.
         R. diacantha
2. One bundle at the apex of petiole
   a. Bundle 3-lobed at apex of the petiole.
      (1) Petiole cross section is triangular in outline at a point midway between leaf base and leaf blade.
         \[ R. nigrum \]
      (2) Petiole cross section is inverted dom-shaped at a point midway between leaf base and leaf blade.
         \[ R. holosericeum \]
   b. Bundle cross section not 3-lobed at apex of petiole.
      (1) Bundle cross section at apex of petiole is only slightly bent.
         (a) Three separate bundles bordered by relatively thick walled sclerenchyma midway between leaf base and leaf blade.
         \[ R. luridum \]
         (b) One bundle bordered by relatively thin walled sclerenchyma midway between leaf base and leaf blade.
            1. Bundle cross section midway between leaf base and blade is circular in outline.
               \[ R. aureum \]
            2. Bundle cross section midway between leaf base and blade is 3-lobed and fan-shaped.
               \[ R. vilmorinii \]
      (2) Bundle cross section at apex of petiole is bent in the shape of a semi-circle.
         (a) One fan-shaped bundle seen in a cross section midway between leaf base and blade.
         \[ R. cynobasti \]
(b) Three separate bundles midway between leaf base and blade.

1. Sclerenchyma relatively thin walled with relatively large intercellular space.
   
   R. hirtellum

2. Sclerenchyma relatively thick walled with relatively small intercellular space.
   
   R. tenue
KEY TO MIDRIBS

I. Upper surface of midrib U-shaped.
   R. nigrum

II. Upper surface of midrib narrow to broadly V-shaped.
   A. Palisade cells one layered throughout the leaf.
      R. missouriense
   B. Palisade cells ranging from one to two layers throughout the leaf.
      a. Vascular bundle fan-shaped as seen in cross section.
         1. Lower epidermis beset with multicellular, sessile glands.
            R. americanum
         2. Glands absent.
            R. sativum
      b. Vascular bundle nearly a circle in outline as seen in cross section.
         1. Leaf blade sharply decreasing in thickness on approaching the midrib.
            R. holosericeum
         2. Leaf blade not decreasing in thickness on approaching the midrib.
            (a) Vertical thickness of midrib more than twice that of the blade.
                R. vilmorinii
            (b) Vertical thickness of midrib less than one and a half that of the blade.
                R. stenocarpum
   C. Palisade cells two layered throughout the leaf.
      a. Two thirds of the midrib projecting below the leaf blade.
         R. hirtellum
b. About one third of the midrib projecting below the leaf blade.

R. tenue

III. Upper surface of midrib nearly flat.
A. Midrib decidedly projecting below the leaf blade.

R. cynobasti

B. Midrib not decidedly projecting below the leaf blade.
   a. Outer walls of the upper epidermal cells decidedly projecting.

R. aureum

b. Outer walls of the upper epidermal cells only slightly projecting.
   1. Tangential diameter of vascular bundles greater than vertical diameter.

R. luridum

   2. Vertical diameter of vascular bundle greater than tangential diameter.

R. diacantha

IV. Upper surface of midrib slightly concave.
A. Outer walls of upper epidermal cells decidedly projecting.

R. fasciculatum

B. Outer walls of upper epidermal cells only slightly projecting.

R. alpinum
KEY TO MARGINS

I. Blade cross section rounded at the margin.

A. Blade cross section less than .11 mm. thick at a point .125 mm. from the margin.

R. americanum

B. Blade cross section between .11 and 1.16 mm. thick at a point .125 mm. from the margin.

a. Margin roughened.

R. hirtellum

b. Margin not roughened.

1. Outer walls of epidermal cells relatively thick.

R. fasciculatum

2. Outer walls of epidermal cells relatively thin.

(a) Palisade cells not extending to the margin.

R. holosericeum

(b) Palisade cells extending to the margin.

(1) Lower epidermis beset with multicellular, sessile glands.

R. nigrum

(2) Glands absent.

* Mostly two layers of palisade cells.

R. stenocarpum

** Mostly one layer of palisade cells.

R. sativum

C. Blade cross section greater than .16 mm. at a point .125 mm. from the margin.

a. Average length of cells in the upper palisade layer greater than .035 mm.

1. Blade cross section less than .21 mm. thick at a point .125 mm. from the margin.
R. alpinum

2. Blade cross section greater than .21 mm. at a point .125 mm. from the margin.

(a) Outer walls of epidermal cells relatively thick.

R. diacantha

(b) Outer walls of epidermal cells relatively thin.

R. liridum

b. Average length of cells in the upper palisade layer less than .035 mm.

1. Stomata present in the upper epidermis.

R. aureum

2. Stomata absent in the upper epidermis.

R. tenue

II. Blade cross section pointed at the margin.

A. Upper epidermal cells relatively thick

R. cynobasti

B. Upper epidermal cells relatively thin.

a. Upper surface of margin curved and lower surface plain.

R. missouriense

b. Margin wedge-shaped.

R. vilmorinii
PLATE I

TRICHOMES (X 135)

Fig. 1    Stem trichome of R. americanum.
Fig. 2    Stem trichome of R. Vilmorinii.
Fig. 3    Stem trichome of R. stenocarpum.
Fig. 4    Stem trichome of R. holosericeum.
Fig. 5    Stem trichome of R. sativum.
Fig. 6    Stem trichome of R. fasciculatum.
Fig. 7    Leaf trichome of R. missouriense.
Fig. 8    Leaf trichome of R. nigrum.
Fig. 9    Leaf trichome of R. fasciculatum.
Fig. 10   Leaf trichome of R. cynobasti.
Fig. 11   Leaf trichome of R. stenocarpum.
Fig. 12   Leaf trichome of R. vilmorinii.
Fig. 13   Leaf trichome of R. hirtellum.

EPIDERMISES (X 135)

Fig. 14   Stem epidermis of R. tenuo.
Fig. 15   Stem epidermis of R. fasciculatum.
Fig. 16   Stem epidermis of R. aureum.
Fig. 17   Stem epidermis of R. hirtellum.
Fig. 18   Stem epidermis of R. sativum.
Fig. 19   Stem epidermis of R. missouriense.
Fig. 20   Stem epidermis of R. vilmorinii.
Fig. 21   Stem epidermis of R. alpinum.
Fig. 22   Stem epidermis of R. stenocarpum.
Fig. 23   Stem epidermis of R. holosericeum.
Fig. 24   Stem epidermis of R. nigrum.
Fig. 25   Stem epidermis of R. luridum.
Fig. 26   Stem epidermis of R. cynobasti.
Fig. 27   Stem epidermis of R. diacanthia (female).
Fig. 28   Stem epidermis of R. americanum.
EPIDERMISES ( X 135 )

Fig. 29 Lower leaf epidermis of R. luridum.
Fig. 30 Upper leaf epidermis of R. hirtellum.
Fig. 31 Lower leaf epidermis of R. stenocarpum.
Fig. 32 Upper leaf epidermis of R. stenocarpum.
Fig. 33 Lower leaf epidermis of R. americanum.
Fig. 34 Upper leaf epidermis of R. americanum.
Fig. 35 Lower leaf epidermis of R. holoosericeum.
Fig. 36 Upper leaf epidermis of R. luridum.
Fig. 37 Lower leaf epidermis of R. hirtellum.
Fig. 38 Upper leaf epidermis of R. cynobasti.
Fig. 39 Lower leaf epidermis of R. cynobasti.
Fig. 40 Lower leaf epidermis of R. alpinum.
Fig. 41 Upper leaf epidermis of R. alpinum.
Fig. 42 Lower leaf epidermis of R. fasciculatum.
Fig. 43 Upper leaf epidermis of R. holoosericeum.
Fig. 44 Upper leaf epidermis of R. vilmorinii.
Fig. 45 Lower leaf epidermis of R. vilmorinii.
Fig. 46 Lower leaf epidermis of R. sativum.
Fig. 47 Upper leaf epidermis of R. nigrum.
Fig. 48 Lower leaf epidermis of R. nigrum.
Fig. 49 Upper leaf epidermis of R. fasciculatum.
Fig. 50 Upper leaf epidermis of R. diacanthia.
Fig. 51 Upper leaf epidermis of R. sativum.
Fig. 52 Upper leaf epidermis of R. missouriensis.
Fig. 53 Lower leaf epidermis of R. missouriensis.
Fig. 54 Lower leaf epidermis of R. diacanthia.
PLATE II

EPIDERMISES (X 135)

- Fig. 55 Lower leaf epidermis of R. aureum.
- Fig. 56 Upper leaf epidermis of R. aureum.
- Fig. 57 Lower leaf epidermis of R. tenue.
- Fig. 58 Upper leaf epidermis of R. tenue.

MARGINS OF THE LEAVES (X 165)

- Fig. 59 Leaf margin of R. americanum.
- Fig. 60 Leaf margin of R. nigrum.
- Fig. 61 Leaf margin of R. vilmorinii.
- Fig. 62 Leaf margin of R. stenocarpum.
- Fig. 63 Leaf margin of R. fasciculatum.
- Fig. 64 Leaf margin of R. missouriense.
- Fig. 65 Leaf margin of R. alpinum.
- Fig. 66 Leaf margin of R. holosericeum.
- Fig. 67 Leaf margin of R. diacanthia.
- Fig. 68 Leaf margin of R. aureum.
- Fig. 69 Leaf margin of R. luridum.
- Fig. 70 Leaf margin of R. tenue.
PLATE III

MARGINS OF THE LEAVES  (X 165)

Fig. 71 Leaf margin of R. hirtellum.
Fig. 72 Leaf margin of R. cynobasti.
Fig. 73 Leaf margin of R. sativum.

LEAF VENATION  (X 28)

Fig. 74 Leaf venation of R. nigrum.
Fig. 75 Leaf venation of R. diacanthia.
Fig. 76 Leaf venation of R. aureum.
Fig. 77 Leaf venation of R. fasciculatum.
Fig. 78 Leaf venation of R. holosericeum.
PLATE IV

LEAF VENATION  ( X 28 )

Fig. 79 Leaf venation of R. tenue.

Fig. 80 Leaf venation of R. cynobasti.

Fig. 81 Leaf venation of R. luridum.

Fig. 82 Leaf venation of R. vilmorinii.

Fig. 83 Leaf venation of R. missouriense.
PLATE V

LEAF VENATION (X 28)

Fig. 84 Leaf venation of R. alpinum.

Fig. 85 Leaf venation of R. stenocarpum.

Fig. 86 Leaf venation of R. americanum.

Fig. 87 Leaf venation of R. hirtellum.

Fig. 88 Leaf venation of R. sativum.
PLATE VI

ELEMENTS OF THE XYLEM (X 165)

Fig. 89 Xylem elements of R. holosericeum.
Fig. 90 Xylem elements of R. tenue.
Fig. 91 Xylem elements of R. aureum.
Fig. 92 Xylem elements of R. diacanthia.
Fig. 93 Xylem elements of R. americanum.
Fig. 94 Xylem elements of R. nigrum.
Fig. 95 Xylem elements of R. fasciculatum.
Fig. 96 Xylem elements of R. alpinum.
Fig. 97 Xylem elements of R. sativum.
Fig. 98 Xylem elements of R. luridum.
Fig. 99 Xylem elements of R. stenocarpum.
Fig. 100 Xylem elements of R. vilmorinii.
Fig. 101 Xylem elements of R. missouriense.
Fig. 102 Xylem elements of R. cynobasti.
Fig. 103 Xylem elements of R. hirtellum.
MIDRIB CROSS SECTIONS

( x 43 )

Fig. 104  R. missouriense.
Fig. 105  R. sativum.
Fig. 106  R. nigrum.
Fig. 107  R. cynobasti.
Fig. 108  R. hirtellum.
MIDRIB CROSS SECTIONS
( x 48 )

Fig. 109  R. luridum.
Fig. 110  R. stenocarpum.
Fig. 111  R. tenue.
Fig. 112  R. aureum.
Fig. 113  R. alpinum.
MIDRIB CROSS SECTIONS

( x 48 )

Fig. 114  R. americanum.
Fig. 115  R. diacanthia.
Fig. 116  R. vilmorinii.
Fig. 117  R. fasciculatum.
Fig. 118  R. holosercicum.
PETIOLE CROSS SECTIONS

(X 48)

Fig. 119 R. americanum.
Fig. 120 R. hirtellum.
Fig. 121 R. juridum.
Fig. 122 R. stenocarpum.
Fig. 123 R. cynobasti.
PETIOLE CROSS SECTIONS

( x 48 )

Fig. 124  R. tenue.
Fig. 125  R. diacanthia.
Fig. 126  R. sativum.
Fig. 127  R. vilmorinii.
Fig. 128  R. holosericeum.
PETIOLE CROSS SECTIONS
( x 48 )

Fig. 129 R. missouriense.
Fig. 130 R. nigrum.
Fig. 131 R. aureum.
Fig. 132 R. alpinum.
Fig. 133 R. fasciculatum.
STEM CROSS SECTIONS OF R. HOLOSERICEUM
(X 48)

Fig. 134 Section taken from current year's growth.

Fig. 135 Section taken from two year's growth.
STEM CROSS SECTIONS OF R. TENUE

(x 48)

Fig. 136  Section taken from current year's growth.

Fig. 137  Section taken from two years' growth.
STEM CROSS SECTIONS OF R. AUREUM

( X 48 )

Fig. 138 Section taken from current year's growth.

Fig. 139 Section taken from two year's growth.
STEM CROSS SECTIONS OF *R. DIACANTHIA* (x 48)

Fig. 140 Section taken from current year's growth.

Fig. 141 Section taken from two year's growth.
STEM CROSS SECTIONS OF *R. AMERICANUM*  
(*) 48  *)

Fig. 142 Section taken from current year's growth.

Fig. 143 Section taken from two years' growth.
STEM CROSS SECTIONS OF R. NIGRUM
( x 48 )

Fig. 144 Section taken from current year's growth.

Fig. 145 Section taken from two years' growth.
STEM CROSS SECTIONS OF R. FASCICULATUM

( x 48 )

Fig. 146  Section taken from current year's growth.

Fig. 147  Section taken from two years' growth.
STEM CROSS SECTIONS OF *R. ALPINUM*  
( *x* 48 )

**Fig. 148** Section taken from current year's growth.

**Fig. 149** Section taken from two year's growth.
STEM CROSS SECTIONS OF *R. SATIVUM*

( x 48 )

Fig. 150 Section taken from current year's growth.

Fig. 151 Section taken from two year's growth.
STEM CROSS SECTIONS OF *R. LURIDUM*  
( x 48 )

Fig. 152  Section taken from current year's growth.

Fig. 153  Section taken from two year's growth.
STEM CROSS SECTIONS OF R. STENOCARPUM

( X 48 )

Fig. 154  Section taken from current year's growth.

Fig. 155  Section taken from two years' growth.
STEM CROSS SECTIONS OF R. VILMORINII
(x 48)

Fig. 156 Section taken from current year's growth.

Fig. 157 Section taken from two years' growth.
STEM CROSS SECTIONS OF R. MISSOURIENSIS

( x 48 )

Fig. 168 Section taken from current year's growth.

Fig. 159 Section taken from two year's growth.
STEM CROSS SECTIONS OF R. CYNOBASTI
( x 48 )

Fig. 160 Section taken from current year's growth.

Fig. 161 Section taken from two year's growth.
STEM CROSS SECTIONS OF R. HIRTELUM

Fig. 162 Section taken from current year's growth.

Fig. 163 Section taken from two year's growth.
CONCLUSION

An examination of the data given in the summary of stem and leaf features leads one to the conclusion that all fifteen species agree in the general plan of their anatomical structure. It is also evident from the summary that some species, as compared with others, not only agree in more of their tissue characters, but also show a more exact agreement in their larger morphological features.

A good correlation between two structural details in a number of different species, from different geographical origins and evidently different genealogical relationships, is infrequent. Such a correlation, for example, between the number of stomata and palisade cells per square mm. of leaf area may have a physiological explanation; although such a functional relationship may not require a good correlation between structures for it's efficiency. Such is probably the case in the relationship existing between them. In comparing a large number of species which are similar in some structural features and dissimilar in others, we may divide them into two or more groups on the basis of this situation. By using many such features, a large number of different groupings may be obtained. Assuming the inheritance of
these different features to be of equal persistence, and knowing the plants have been raised under the same environmental conditions, then the frequency with which any two species fall within the same group may be used as an indication of the closeness of their genealogical relationship. Table VIII, based on eighteen anatomical features not common to all species, shows at a glance the frequency with which each species falls in the same group with each of the other species. The eighteen following features were used in making the table; amount and distribution of trichomes of the leaf epidermis; absence or kinds of glands of the epidermis present; shape of leaf epidermal cells; shape of leaf tip; shape of leaf margin; shape of midrib; number of layers of palisade cells; number of vascular bundles entering the petiole; presence or absence of bast fibers in the petiole; presence or absence of trichomes of the stem epidermis; stem armed or unarmed; shape and size of stem epidermal cells; cutinization of radial walls of stem epidermal cells; kinds of collenchyma; number of rings of peridermal tissue in the two years' growth; number of protoxylem points; length of xylem elements; and the distribution of starch, tannin and cluster crystals of calcium oxalate in the tissues of the stem and leaf. There are many other features that are common to all species given in the summary of stems and leaves. The table indicates that there are many instances of similarities of anatomical features.
between American and European species. The three highest frequencies obtained are between some American and European species, and the lowest between some American species and between American and European species. *R.* missouriense shows but little correspondence with other American species. *R.* cynobasti also shows but little correspondence with other American species, with the exception of a slight correspondence with *R.* hirtellum. These three American species show similarities in the majority of their features to *R.* vilmorinii, a species of West China. *R.* hirtellum and *R.* aureum (American) show similarities to each other in the majority of their features, and to *R.* alpinum and *R.* diacantha of North Asia. *R.* aureum, which seems to be in especially close correspondence with *R.* diacantha (North Asia), also shows similarities in the majority of it's features to *R.* nigrum (Europe and Asia), *R.* fasciculatum (North-east Asia), *R.* luridum (West China), and *R.* sativum (West Europe). *R.* americanum corresponds more closely with *R.* nigrum (Europe and Asia) and *R.* fasciculatum (North-east Asia) than with other species, but shows similarities in half of its features to *R.* aureum and in nearly half to *R.* hirtellum. The following four species show similarities to each other in the majority of their features: *R.* aureum (American), *R.* nigrum (Europe and Asia), *R.* diacantha (North Asia), and *R.* fasciculatum
(North-east Asia). R. luridum (West China) shows similarities in the majority of its features to R. aureum, R. fasciculatum, and R. diacantha of the above group, and to T. sativum (West Europe), R. alpinum (Europe to North Asia), and R. tenue (West China). R. alpinum shows similarities in the majority of its features to R. aureum, R. hirtellum, and R. tenue (West China). R. sativum (West Europe) corresponds more closely to R. fasciculatum, R. luridum, and R. aureum than to others. R. stenocarpum (North-west China) shows comparatively little correspondence in the majority of its features with other species, but most with R. cynobasti (American). R. holosericeum (hybrid of unknown origin) corresponds closely to R. sativum.

It is interesting to note that R. missouriense, which shows the least correspondence to other species, has two outstanding features peculiar to itself; radial walls of the stem epidermal cells greatly thickened and three rings of peridermal tissue in the two years' growth. R. aureum, which in other respects shows a high correspondence to other species, is the only species having stomata in both the upper and lower epidermis.

To further show the close correspondence between American and European species which comes to light in Table VIII, I may call attention to the fact that R. americanum (American) and R. nigrum (Europe and Asia) are alike in the following respects: 3-5 lobed leaves with pointed tips and
dentate margins; a close correlation between length of leaf (petiole and blade), width of leaf, and length of petiole; palmate venation; V-shaped midrib prominent on lower surface of blade; unicellular trichomes, these two being the only species having multicellular sessile glands of the epidermis; multicellular trichomes on the thin projected edge of the petiole; outer wall of both upper and lower epidermal cells of the blade projecting and radial walls undulated; length and number of layers of palisade cells; palisade cells extending to margin; bast fibers in petiole; unicellular trichomes and multicellular sessile glands with the stem epidermis; size and shape of epidermal cells; outer wall of epidermal cells cutinized and projecting; radial walls cutinized and pitted; non-typical collenchyma; formation of periderm within the inner part of cortex; length of xylem elements; number of protoxylem points; and the distribution and amount of tannin, starch, and cluster crystals of calcium oxalate within the tissues of the stem and leaf.

The above comparisons seem to warrant the following suggestions as to origin and genealogical relationships of the various species. R. aureum (American) undoubtedly belongs to the original stock of Ribes existing before continental isolation, as indicated by its close anatomical correspondence with many other species. It corresponds especially close with R. diacantha (North Asia) which may
**TABLE VIII**

TABLE SHOWING THE FREQUENCY WITH WHICH ANY TWO SPECIES FALL INTO THE SAME GROUP ON THE BASIS OF THEIR SIMILARITY OF FEATURES.

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**Notes:**

- * Indicates American species
- Nos. 1-15 outside the square are used as symbols for the different species.
- The numbers inside the square represent frequencies.
also be placed with the original stock. R. nigrum (Europe and Asia), R. fasciculatum (North Asia), R. luridum (West China), and R. hirtellum (American) show a close correspondence with both R. aureum and R. diacantha. In addition to their correspondence with aureum and diacantha, each of the above species corresponds in the majority of its features with from two to three other species, and would therefore be placed with the original stock of Ribes. Two of the above species are American and the remainder are native to Asia. Each of the five American species shows a closer correspondence to species of Asia than to other American species. These anatomical relationships existing between species isolated on different continents cannot be explained by hybridization after isolation and it is very improbable that they occurred by mutation in the same direction. A more probable explanation is furnished by the theory of continental drift which has been accepted by most geologists and is supported by many scientific facts.

The basic concept upon which the theory of continental drift rests originated with Suess who first distinguished sial and sima by name. Petrographers had long recognized the lighter and the denser igneous rocks. Nevertheless, in naming them as belonging to two distinct classes, Suess laid the foundation for the theory that
they form separate layers of the earth's outer crust. It was a fundamental principal with Suess that gravitation was the all-controlling force. The idea of gravitative arrangement was, therefore, a logical outcome of his thought. The distinction has received a great deal of support from the studies of isostasy and seismology.

That there are large masses whose average constitution corresponds respectively to that of sial or of sima is generally recognized and they are thought to be represented by continental masses and the oceanic bodies. The extension of the sima under the sial also appears to be a fact.

The sharp distinction between sial and sima was emphasized by correlating the one with granite and the other with basalt, the two extremes of the petrologic series. And granite and basalt theoretically assumed to each other somewhat the relation that ice and water have, at least as regards relative densities and viscosities. The flotation of granitic continents in the basaltic shell thus became a natural suggestion. Why then, should continents not move or drift in the medium in which they are assumed to be floating?

Wegener observed that the eastern coast of South America closely resembled the western coast of Africa, suggesting to him that the two continents had once formed a single continental mass and had separated from each other
along a rift without change of outline. Upon this resemblance of coast lines he founded the theory of continental drift.

According to this theory in the Archean and perhaps the early Proterozoic, the sial crust was more or less equally distributed over the entire earth, being a gigantic scum that had segregated out of the primeval silicate magna, and on account of its lower density floated on top. A universal ocean of a depth averaging 2,640 meters then covered this crust. Gradually this gigantic scum was rolled up into an ancient continent which Wegener (1924) has given the name "Pangaea" (Pan = all, ge = the earth). The increased thickness of the rolled-up sial caused its surface to emerge and become a continent. Gradually during the Mesozoic and Tertiary, this original continent rifted and its fragments drifted apart, creating in the process the Atlantic, Arctic, and western Indian oceans, the continents drifting away from the poles toward the equator. This would mean that the Western coast of North America was in former contact with the east coast of Asia and the Eastern coast of North America was in contact with Europe. The close correspondence of R. aureum (Western U.S.) with R. diacantha (North Asia) and
R. americanum (Eastern U. S.) with R. nigrum (Europe and Asia) is very well accounted for by the above theory.

R. sativum and R. alpinum each show a correspondence in the majority of their features with several species belonging to the hypothetical original stock and they probably originated from the latter by hybridization or mutation. R. holosericeum (hybrid) shows its closest correspondence with R. sativum from which it probably originated by hybridization. R. tenue shows a correspondence with R. luridum in particular, suggesting that the former may have originated from the latter by mutation or hybridization. R. stenocarpum and R. missouriense show but little correspondence with other species and probably originated by mutation. R. vilmorinii shows its closest correspondence with R. cynobasti and R. hirtellum (American) from which it may have originated by hybridization or mutation before continental isolation.

No doubt other lines of genealogical relationship would have come to light had more of the many species of Ribes been included in this work.
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