COMPARATIVE ANATOMICAL RESEARCH WITHIN THE GENUS ROSA.

by

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Rosa and Its Allied Genera (1)

The family to which Rosa belongs is composed of about 100 genera and 2000 species distributed throughout the world but found chiefly within the temperate zones. Within this family are herbs, shrubs and trees, both deciduous and evergreen. Leaves mostly alternate rarely opposite; stipules usually conspicuous, rarely wanting; flowers perfect, rarely unisexual, mostly regular. Sepals are 4 to 5, imbricate; petals as many, imbricate, sometimes wanting, stamens 5 to many; carpels 1 to many, distinct or more or less united. Styles are as many as carpels; fruit a follicle, achene, drupe, hip of pome.

The genus Rosa supplies one of our most favorite flowers, if not the most favorite. The species hybridize very easily and botanists differ widely in their conception of various species.

Generally the species of Rosa are found throughout the temperate and sub-tropical regions of the northern hemisphere; in North America to northern Mexico, in Africa to Abyssinia, in Asia to the Himalayas, and in the Philippine Islands. Between one and two hundred species occur throughout this region.

(1). Compiled from Rehder, Manual of Cultivated Trees and Shrubs.

The species of Rosa are shrubs, chiefly deciduous, sometimes evergreens, with upright, climbing or trailing stems, usually prickly, rarely unarmed; leaves are alternate and odd-pinnate, rarely simple. Flowers are solitary or corymbose, at the end of short branches; sepals and petals chiefly 5; stamens numerous; pistils numerous, enclosed in an urn-shaped receptacle (hip) which becomes fleshy and berry-like at maturity, enclosing several or many bony achenes.

Key to Species

Leaves, pinnate, stipulate

A. Styles much exserted beyond mouth of the receptacle; stipules adnate

B. Styles united in a column, usually almost as long as stamens ------ Section Gynstylae

C. Stipules entire or denticulate; prickles scattered

D. Habit upright, usually with arching branches

E. Leaflets, 3-5 on flowering branchlets, pubescent, at least on veins beneath

F. Fls. small, about one cm across; lfts. linear-lanceolate

----- R-Watsoniana

FF. Fls. about 5 cm across; lfts. usually ovate-oblong --- R-Setigera

DD. Habit trailing or prostrate

E. Lvs. evergreen or half-evergreen, lustrous on both sides; fls. usually several.

F. Lfts. usually 9, obtuse, 8-20 mm long, stipules (sharply) dentate.

--- R-wichuraiana

AA. Styles little or not exserted, forming a head closing the mouth of the receptacle (slightly exserted in omeiensis)

B. Stipules adnate more than one half of their length; usually upright shrubs

C. Receptacle smooth or hispid

D. Lvs of flowering branchlets 5-11 foliolate (if 3-foliolate, fls short-stalked with smooth receptacle)

E. Fls. usually corymbose; if solitary pedicels with one or more branchlets; upper stipules usually di-lated.

F. Stems with usually one kind of prickles, sometimes mixed with glandular bristles; prickles usually hooked, stout, scattered, outer sepals usually pinnate

Section -- coninae

G. Lfts. more or less glandular beneath or often doubly-serrate, with gland-tipped leaf.

H. Prickles hooked; lfts. glabrous or pubescent beneath.

I. Lfts. ovate or oval, acute or short-acuminate, eglandular above; styles glabrous or nearly so; sepals soon deciduous. ---- R-micrantha

GG. Lfts. not glandular, except sometimes on midrib; teeth usually simple

H. Styles little or not exserted

I. Lfts. pubescent, at least beneath

R-dumetorum

FF. Stems, at least at base, with usually straight, often slender, prickles and numerous bristles gradually passing into prickles; infrastipular prickles present; sepals usually entire.

GG. Sepals after flowering, upright, usually persistent, achenes inserted on wall and on bottom, prickles sometimes lacking.

Section --- cinnamomeae

H. Infrastipular prickles not present

I. Bracts and prickles tomentose; lfts. thick, rugose above --- R-rugosa

HH. Infrastipular prickles present

I. Stipules flat

J. Sepals present

K. Lfts.3-7, branchlets prickly not bristly

L. Stipules not exserted

M. Fls.usually several, less than 5 cm across

N. Prickles curved, lfts.doubly serrate, villous beneath

R-californica

EE. Fls.usually solitary, without bracts, only exceptionally corymbose; sepals persistant; lfts. small; stipules narrow with usually spreading dilated auricles.

F. Petals 5, styles not exserted; prickles scattered

G. Lfts.usually 9, on flowering branchlets; sepals entire; fls.white, pink or yellow; prickles straight, usually slender and mixed with bristles

Section Pimpinellifoliae

H. Flowering branchlets prickly and bristly; fr, black; fls.white to pink, rarely yellow ---- R-spinosissima

HH. Flowering branchlets without bristles; fr. scarlet; fls.yellow.

I. Lfts.glandular, simply serrate

J. Shoots, at least at base, bristly; lfts.glabrous, rather sharply serrate,

R-hugonis

II. Lfts.with glandular dots beneath, slightly doubly glandular serrate, aromatic

R-ecae

FF. Petals 4, only occasionally 5, white; styles somewhat exserted; infrastipular prickles present; lfts.7-17; sepals upright

Section Sericeae

R-omeiensis

K. Prickles much enlarged at base

R-omeiensis pteracantha

Geographical Distribution and Introduction into Cultivation.

Only the species studied in this thesis are listed below:

Rosa hugonis:- Found in Central China and introduced into cultivation in 1899.

Rosa rugosa:- Native to North China, Korea, and Japan. Introduced into cultivation about 1845.

Rosa setigera:-Indigenuous to North America from Ontario to Nebraska, Texas, and Florida. Introduced into cultivation in 1800.

Rosa wichuraiana:- Found wild in Japan, Korea, Formosa, and East China. Introduced into cultivation in 1891.

Rosa dumetorum:- At home in Europe, Western Asia, and Africa. First cultivated in 1838, rarely escaped.

Rosa dumatorum:- Native to Western Asia and introduced into cultivation in 1893.

Rosa koreana:- Discovered wild in Korea and introduced into cultivation in 1917. One of our latest cultivated wild roses.

Rosa sericea:- Native of the Himalayas of India. Introduced into cultivation in 1822.

Rosa micrantha:- Growing naturally in Europe and around the Mediterranean Sea. Often escaped from gardens throughout North America.

Rosa californica:- Native, from Oregon to Lower California. Introduced into cultivation in 1878.

Rosa watsoniana:- Found cultivated in Japan. Introduced into America in 1870.

Rosa ecae:- Introduced from Central Asia.

Rosa omeiensis pteracantha:- Discovered wild in Western China. Introduced into cultivation in 1890.

Rosa omeiensis:- Native to Western China and introduced into cultivation in 1901.

Rosa spinosissima:- At home in Europe and Western Asia. A very old rose, cultivated sometime before 1600.

NATURE OF PUBLISHED ANATOMICAL RESEARCH (1)

Much of the anatomical work that has been done within the Rosaceae order is reported by Solereder. (1). He says that constant anatomical features are almost lacking in this Order. The only constant anatomical characters are: (a) the lack of simple uniseriate clothing hairs, and (b) the presence of bordered pits in the prosenchymatous groundwork in all the woody species. However there is a tendency towards scalariform perforations in the vessels of the woody plants. He says the bast fibers in woody plants occur either in isolated groups or in a continuous sclerenchymatous ring. Calcium oxalate crystals found in the wood are either in the form of solitary or clustered crystals. According to Möller the primary cortex of the Roseae contains clustered crystals or solitary and clustered crystals.

In the leaves of Rosa there is a gelatinization of the inner walls of the epidermal cells. He finds there is either a parenchyma or sclerenchyma sheath around the small veins.

In many species tannin has been found in the pith, medullary rays, and cortical parenchyma, although it is rarely deposited in special receptacles.

(1). Solereder: Systematic Anatomy of the Dicotyledons.

Glandular shaggy hairs, with stalks of varied lengths and spherical or club-shaped head, are found on vegetative and reproductive shoots of Rosa. In this genus the hairs occur not only on the leaf surface but on the teeth and even the spines. Solereder reports that the phellogen originates from the epidermis. The secondary hard bast fibers (see Moller) are irregularly distributed or form bundles or small tangential plates. Throughout the Rosaceae, with exception of Chrysobalaneae and in Quillaja, Solereder found scalariform perforations of the side walls to be present in addition to the predominant circular perforations. The walls of the prosenchymatous groundwork of the wood, as a rule, bear bordered pits and occasionally are (Rosa) also provided with tertiary thickenings.

Joseph Mueller ('82) says the phellogen in Rosa is formed by the epidermis the second year or later and the cork never becomes sclerotic. He also finds crystal clusters occurring within the primary cortex. No stone cells are present and the bast fibers occur in isolated bundles. He takes up three species of Rosa giving the sizes and contents of the cells.

Mr. Marcel Brandza ('90) discusses the relationship of the hybrid Rosa rugo fimbriata with its parents. He finds the hybrid to be morphologically but not anatomically, inter-

mediate between its parents.

Kuster has observed the size of medullary rays of Rosa, Rubus, and other genera. He has measured the size of bordered pits in the walls and also has observed the spiral thickenings of the pitted vessels.

According to Gris (1870) the pith is heterogeneous. The active cells of the interior pith contain tannin frequently and in this case, are arranged in rows.

Louis Petit (1889) in studying Rosa canina traces the vascular system from the petiole into the leaflets. In the petiole the vascular system consists of an arc and a small bundle on each end of the arc. Farther up the small bundles fuse with the arc and then the arc detaches two bundles on each side. The two bundles next to the arc go into the first petiolules and the remaining small bundles continue in the rachis. This procedure is repeated for each pair of leaflets.

INTRODUCTION TO ANATOMICAL STUDY OF STEMS AND LEAVES

The purpose of this research is to point out and describe anatomical similarities and differences existing between fifteen species of the genus Rosa.

The species here described are : hugonis, rugosa, setigera, wichuraiana, dumetorum, dumatorum, koreana, sericea, micrantha, californica, watsoniana, ecae, omeiensis, pteracantha, omeiensis, spinosissima. The first four of these species were cut in June and placed in 70% alcohol. The other species were collected in August at the Arnold Arboretum and preserved in 4% formaldehyde.

The stem sections were made from one and two year branches, at about the same relative position within the internode. The stems were cut in lengths of about six millimeters and the air pumped from them while submerged in 70% alcohol. Then the pieces were placed in a solution of equal parts of glycerine and 80% alcohol for conditioning. Reserve material of all species was kept in 70% alcohol. For making cross sections, the stem sections were enclosed in paraffin consisting mainly of melting hard paraffin (52-54 C) into one face of a pine block, pressing the stem piece into this, and melting paraffin around it until covered. When the paraffin cooled, it was ready for

sectioning. With the exception of a few free-hand sections, all sections were made with Spencer microtome No. 2392 or with a Jung sliding microtome.

The two-year stem of Rosa dumatorum was so hard it had to be carried through the Jeffrey's vulcanizing process and embedded in celloidon.

The sections were cleared and bleached by putting them in a saturated solution of chloral hydrate, and in some cases, it was necessary to keep them for a few hours in calcium hypochlorite. When sufficiently bleached, the sections were treated with dilute hydrochloric acid and then transferred to saturated chloral hydrate solution. From this some sections were mounted in glycerine jelly and others in sandarac. In the latter process, the sections go from the chloral hydrate through 70% alcohol, 95% alcohol to a drop of sandarac on the slide, and then the cover glass is put on. The best results were secured by clamping the cover glass down with a spring clothespin and putting the slide in a paraffin oven for hardening the sandarac.

For studying fibrous tissues, relatively thick longitudinal sections were macerated in nitric acid and potassium chlorate according to Schultze's process.

Microchemical tests were used according to standard procedure.

Petiole sections were made just below the termination of the stipules, which, in most instances, was about the middle of the petiole. Sections of the midrib and margins were made at about the center of the leaf. Paraffin, having a melting point of 52 degrees centigrade, was better for mounting leaf parts than the harder paraffin used with the stems. These sections were cleared and mounted as the stem sections were excepting those leaf blade sections that were mounted in glycerine and some petiole sections in hyrax.

Whole leaves were bleached by the process already described and, in some cases, hydrogen peroxide was used. From these bleached leaves the frequency of the palisade cells and stomata and the pattern of the venation was determined.

Photomicrographs illustrating this thesis were made from glass negatives obtained by projecting the image by means of a projection microscope, equipped with an incandescent light. The time of exposure ranged from 10 seconds, in case of sections mounted in hyrax, to 1 minute, where the sections were so transparent little light could be used.

The inked drawings on the large plates were made by using a projection microscope. These drawings were arranged on a cardboard 17" x 28", and photographed with a large dry place camera, using 8" x 10" Cramer's Photo Dry Plates.

The inked drawings were reduced approximately three and one-half diameters in making the positive prints. Sheets of No. 31 hard Rito paper were used in making the positive prints, with a 75-watt lamp as the source of light for making the exposures.

INDEX TO STEMS

ANATOMICAL KEY TO STEMS

I. Pith cells of two distinct sizes

A. Collenchyma inner border distinctly undulated

1. Periderm formation within second year of growth

a. Cork formation within inner cortex --

Rosa micrantha

b. Cork formation not sub-epidermal --

(1). Xylem rays becoming more than 5mm vertically, cells of stem epidermis very irregular in shape --

Rosa setigera

(2). Xylem rays shorter than 5mm vertically, cells of stem epidermis more regular in shape.

(a). Protoxylem points protruding greatly into the pith --

Rosa omeiensis

(b). Protoxylem points protruding slightly into the pith --

Rosa dumetorum

2. No periderm formation within second year of growth -- Rosa wichuraiana

B. Collenchyma inner border not distinctly undulated

1. No periderm formation by August of second year, collenchyma 3 to 5 cell-layers -- Rosa rugosa

2. Periderm formation by August of second year

a. Collenchyma 7 to 8 cell-layers wide; xylem rays not exceeding 2mm in vertical length -- Rosa watsoniana

b. Collenchyma mostly 4 to 5 cells wide

(1). Xylem rays .16mm to .7mm in vertical length -- Rosa californica

(2). Xylem rays becoming greater than 1mm in vertical length -- Rosa koreana

II. Pith cells not of two distinct sizes

A. Collenchyma inner border distinctly undulated

1. Bast fibers relatively few; tracheal tube elements less than .5mm in length -- Rosa spinosissima

2. Bast fibers many; tracheal tube elements averaging .5mm in length

a. Pith cells quite uniformly .04mm in cross diameter -- Rosa sericea

b. Pith cells varying from .03mm to .08mm in cross diameter --Rosa omeiensis pteracantha

B. Collenchyma inner border not distinctly undulated, yet varying in width

1. Periderm formation in one-year growth -- Rosa dumatorum

2. Periderm formation later than first year of growth

a. Bast fiber cavity .003mm in diameter; tracheal tube elements averaging .5mm in length -- Rosa ecae

b. Bast fiber cavity .0015mm in diameter; tracheal tube elements averaging .2mm in length -- Rosa hugonis

ROSA HUGONIS

Primary Tissues

Epidermis

In surface view these cells are nearly square, with diameters of .021mm (Fig. 46). Radially they are .023mm, with radial and outer walls heavily cutinized. The outer wall is .011mm thick, covered with a cuticle .0018mm thick (Fig. 1).

Cortex

The collenchyma is generally 4 to 5 cell-rows wide, infrequently 2 cells wide. In cross section of the stem these cells are nearly round and average .02mm in diameter, having walls moderately thickened. In vertical extent the cells average .016mm (Fig. 1). The parenchyma of the cortex is 7 to 8 cell-layers or .16mm broad; its cells have vertical and radial diameters of .02mm and tangential diameter of .03mm.

Situated in the inner cortex are bast fibers which are laid down in groups about .02$\hat{2}$mm wide radially. The cell cavities are about .0015mm in diameter and the lignified walls are .005mm thick. These fibers average .5mm in length (see figures 1 and 31).

Phloem

The parenchyma cells of the phloem are .008mm radially and .04mm vertically. Much tannin is pre-

sent in these cells. The sieve plates are about .02mm across. No lengths could be determined for the sieve tube elements. The rays in the phloem region show much starch.

Xylem

The protoxylem points slightly project into the pith. The tracheal tubes are not numerous and in some points are not found in radial rows, as is the usual case. These tubes average .006mm radially and are usually flattened radially. When in radial rows, the outer tubes have the greater diameter. Situated between these tracheal tubes are thin-walled parenchyma cells .06mm long and .01mm wide radially (Fig. 1). Most of the metaxylem tracheal tubes are .02mm in cross diameter, but some are only .01mm. Associated with these tubes are fiber tracheids, having numerous pits in their walls. No xylem parenchyma cells occur between the tracheal tubes. Within the leaf trace, occur 3 to 8 xylem rays having 1 to 3 cell-rows of xylem elements between them.

Pith

The diameter of the pith is approximately two-fifths that of the one-year stem. Generally the pith cells are uniform in size; however, a few are smaller and relatively thicker walled. The larger cells are rounded and .06mm to .08mm in cross diameter, extending vertically .01mm to .04mm. The smaller cells are nearly cubical, having diameters of .01mm (Fig. 1). Some starch is present in the smaller cells.

Secondary Tissues

Periderm

Periderm formation is just beginning by July of the second year. The epidermis gives rise to the phellogen (see figure 2).

Phloem

The phloem is practically .09mm wide by July of the second year, the stem at that time being 2.35mm in diameter. Only the inner cells are regular in shape, the outer ones being crushed and irregular (see figure 2).

More tracheal tubes are formed in the early growth than in the late growth, and they are larger and more numerous the second year than the first year. The elements of the tracheal tubes are .011mm to .038mm in cross diameter and .2mm to .26mm long (Fig. 31). Fiber tracheids are quite numerous in the secondary xylem. These fibers are .28mm to .45mm long and have elliptic inclined pits (Fig. 31).

The xylem rays are formed at intervals of about .04mm when seen in cross section (Fig. 1). They extend from .06mm to 1.2mm vertically and .01mm to .04mm tangentially. The ray cells average .01mm tangentially, .03mm vertically, and .02mm radially. An abundance of starch is present in the xylem rays.

ROSA RUGOSA

Primary Tissues

Epidermis

When seen in surface view, these cells appear chiefly as squares and rectangles (Fig. 47). They range in tangential and vertical diameters from .013mm to .05mm and in radial diameter they approach .023mm (Fig. 3). The outer wall is .011mm thick and both outer and radial walls are cutinized. A cuticle .002mm thick is present.

Cortex

The collenchyma, composed of moderately thick-walled cells, occurs in 3 to 5 cell-layers. The cells are rounded and range from .01mm to .02mm in cross diameter. Vertically they vary from .025mm to .05mm (Fig. 3). The parenchyma, composed of rounded cells, is about .14mm wide. The cells range from .015mm to .03mm in diameter as seen in cross section; while vertically they extend about .02mm. Abundance of starch and some tannin occur in this region.

The bast fibers occur in strands about .04mm wide radially and .016mm tangentially. The fibers have cavities .0025mm wide, lignified cell walls .0066mm thick, and a length of .55mm (see figures 3 and 32).

Phloem

In a stem having a diameter of 2mm, the phloem is approximately .058mm wide (Fig. 3). The sieve tube elements are approximately .0088mm radially and .04mm long. The parenchyma cells are .005mm wide and average .03mm long. A large amount of starch and some tannin occur in many of these cells.

Xylem

The protoxylem points are quite rounded and do not extend far into the pith (Fig. 3). The protoxylem tubes are in 5 to 12 radiating rows, with 2 to 5 tubes in each row. In cross diameter the tubes are .005mm to .015mm. Xylem parenchyma cells occur between these tracheal tubes. These cells are moderately thick-walled, with radial diameter of .008mm and vertical length of .03mm. The metaxylem between the leaf traces is composed of fiber tracheids, xylem parenchyma and many tracheal tubes. In cross diameter the tubes vary from .015mm to .021mm. The parenchyma cells are .008mm radially and .04mm vertically. The xylem rays are 1 and sometimes 2 cells wide, and are .02mm to .04mm apart.

Pith

The pith is found in two distinct sizes of cells, both rounded in cross section (Fig. 3). The larger cells are .03mm to .06mm in cross section and .02mm to .04mm vertically. The smaller are relatively thick walled and

occur singly, in clusters or in chains. These cells are .01mm to .02mm in cross section and .02mm to .03mm in vertical length. The walls of the pith are slightly lignified.

Secondary Tissues

Periderm

There is no periderm formation by August of the second year.

Phloem

In a two year stem having a diameter of 3mm, the phloem is about .08mm wide, having the outermost cells greatly crushed (Fig. 4).

Xylem

The tracheal tubes are smaller and less frequent in the first year of growth than in the second (Fig. 4). The tracheal tube elements are .01mm to .05mm in cross diameter and .16mm to .44mm in length (see figure 32). A large part of the xylem is composed of fiber tracheids, which vary from .16mm to .52mm in length. The walls have elongated pits along the length of the fiber. No xylem parenchyma cells are present.

The xylem rays occur .02mm to .05mm apart as they radiate from the center of the stem (Fig. 4). In vertical extent they vary from .12mm to more than 1,65mm. Generally, they are not more than .04mm tangentially. The

cells of the xylem rays are .005mm to .016mm radially. In tangential diameter they vary from .006mm to .01mm. Vertically they extend .005mm to .03mm. In rays one cell wide, the cells are usually much greater vertically. Considerable starch is present in the xylem rays.

ROSA SETIGERA

Primary Tissues

Epidermis

In surface view these cells range from .008mm to .02mm in diameter, with cavities elliptic or ovoid (Fig. 49). Radially these cells are .026mm, having a cutinized outer wall .011mm thick (Fig. 5). The radial walls are slightly cutinized with a cuticle .001mm thick.

Cortex

The collenchyma is undulated and ranges from 1 to 3 cells wide in the narrow portion and 6 to 8 cells wide in the wider portion (Fig. 5). In cross section these cells are nearly round with diameters of .015mm; while vertically they are .05mm.

The parenchyma cells are somewhat flattened radially, having a tangential diameter of .03mm and a radial diameter of .018mm. Vertically they are about .01mm. Much starch is present in the parenchyma of the cortex.

Patches of bast fibers, occurring at inter-

vals of .04mm, are .08mm wide radially. The fibers are .6mm long, with cavities averaging .008mm in diameter, the largest found in my species (see figure 33). The lignified cell walls are .003mm thick.

Phloem

The radial width of phloem in one and two years old stem is about the same (compare figs. 5 and 6). The sieve tube elements are .011mm in radial diameter but vary from .03mm to .07mm in vertical length. Companion cells or phloem parenchyma cells could not be distinguished. No starch and only traces of tannin occur in the phloem.

The protoxylem points project slightly into the pith (Fig.5). The tracheal tubes of the protoxylem are arranged mostly in 3 to 6 radiating rows with 2 or 3 tubes in a row. These tubes are .006mm to .02mm in cross diameter. Between these tracheal tubes are thin-walled parenchyma cells, .01mm radially and .03mm vertically. The tracheal tubes of the metaxylem vary from .015mm to .03mm in diameter. Fiber tracheids averaging .011mm in diameter are frequent between the tracheal tubes. The xylem rays, which are mostly one cell wide, are separated by one to two cell rows of xylem elements.

Pith

The cells of the pith occur in two distinct sizes (see figure 5). The larger cells in the cross section

are rounded or oblong, with diameters of .06mm to .1mm, and .03mm to .05mm in vertical extent. The smaller cells are cubical with diameters of .02mm. Small amounts of tannin occur in these cells.

Secondary Tissues

Periderm

By the end of the second year, cork is formed in small areas, not exceeding 8 cells in radial width (Fig. 6). The epidermis has given rise to the phellogen.

Phloem

The outer cells of the phloem have become crushed by the end of the second year (Fig. 6).

Xylem

The greater number of tracheal tubes occur in the early growth and those of the second year are larger than those of the first (Fig. 6). The elements of these tubes are .015mm to .05mm in cross diameter and .2mm to .4mm long as seen in maceration. The larger part of the xylem is composed of fiber tracheids, which are .16mm to .55mm long and .011mm in cross diameter (see figure 33).

The xylem rays of this species vary from .012mm to .09mm tangentially and from .32mm to 10mm vertically. The cells of the rays are nearly cubical, ranging from .02mm to .04mm in diameters.

ROSA WICHURAIANA

Primary Tissues

Epidermis

In surface view these cells are rectangular, measuring .012mm by .02mm (Fig. 34). Radially they are .028mm. The outer wall is .01mm thick and is cutinized (Fig. 7). The radial walls are also cutinized, and a cuticle .001mm thick is present.

Cortex

The collenchyma is slightly undulated along its inner margin, being 2 cell-layers wide in the narrow portion and 4 to 5 cell-layers across the wider portion (Fig. 7). The cells are rounded in cross section and measure .011mm in width and .05mm in length. The parenchyma region is .16mm wide at the widest point. The cells are .02mm radially and vertically and .03mm tangentially. Very little starch is present in this tissue.

The bast fibers occur in groups extending .04mm to .2mm tangentially and .05mm radially. The fibers are 1.5mm in length and their cavities are elliptic and measure .004mm in the greatest diameter. (Figs. 7 and 34). The lignified cell walls are .008mm thick.

Phloem

In a stem 1.55mm thick the phloem is .035mm wide, having the outer cells somewhat crushed (Fig. 7).

The sieve tube elements average .016mm tangentially and .04mm vertically. No distinct parenchyma or companion cells could be made out. A small amount of starch is present in the parenchyma of the phloem.

Xylem

The protoxylem points of this species project relatively far into the pith (Fig. 7). The tracheal tubes of the protoxylem are arranged in radiating rows, the number of rows varying greatly from point to point. These tracheal tubes are .01mm to .015mm in cross diameter. Between the rows of tracheal tubes are parenchyma cells .015mm tangentially and .03mm vertically. There are many tracheal tubes of the metaxylem. They are elongated radially with a diameter of .02mm. Few fiber tracheids are found in the metaxylem. Xylem rays, occurring at approximately .02mm intervals, alternate with the rows of tracheal tubes.

Pith

The pith has a diameter of two-thirds that of a one-year stem. The cells occur in two distinct sizes. The larger ones are rounded and vary from .05mm to .08mm in diameter. The smaller ones, occurring in groups, are less rounded and range from .02mm to .03mm in cross diameter. In vertical diameter the larger cells extend .03mm, while the smaller cells extend .02mm (Fig. 7).

Secondary Tissues

Periderm

No periderm has been formed by August of the second year.

Phloem

At the end of the second year the phloem is .05mm wide and the stem 3.55mm in diameter. At this age the outer cells have become very much distorted (Fig. 8).

Xylem

The tracheal tube elements of the secondary xylem vary between .012mm and .04mm in diameter and average .4mm in length (Fig. 34). Fiber tracheids are abundant in the secondary xylem of this species. These have an average diameter of .009mm but vary from .2mm to .5mm in length.

The xylem rays are .02mm to .08mm wide and indefinite in length. I found part of a ray extending a vertical distance of 10mm. Some of them are only .08mm vertically. The ray cells are mostly .02mm vertically, .032mm radially and .12mm tangentially. In some cases, however, these cells have greater tangential than vertical diameters. The secondary rays are much less conspicuous than are the primary rays (Fig. 8). An abundance of starch is present in the xylem rays.

ROSA DUMETORUM

Primary Tissues

Epidermis

In surface view these cells are mostly four-sided, varying from .016mm to .03mm in diameter (Fig. 50). In radial diameter they average .026mm, having the cutinized outer wall .012mm thick. The radial walls are cutinized and a cuticle .0011mm thick is present (Fig. 9).

Cortex

The collenchyma is undulating, being 1 to 2 cells wide in the narrow portion and 4 to 6 cells wide in the wider portion. These wider areas occur at intervals of .2mm (see fig. 9). The cells have moderately thickened walls and average .02mm tangentially, .01mm radially and .03mm vertically. The parenchyma of the cortex is about .16mm wide, being composed of 6 to 8 cells. The cells are approximately .03mm vertically, .02mm radially, and vary from .008mm to .05mm tangentially (see fig. 9). Much starch and tannin are present in these cells.

The bast fibers occur in groups approximately 3 cells wide radially. The cells have cavities .0015mm in diameter and lignified walls .018mm thick. In length they average .32mm (Fig. 9 and 35).

Phloem

In a cross section of a stem having a diameter of 3mm, the phloem tissue measures .08mm in width. The outer cells are crushed even in the one year old sten (Fig. 9). The greater part of the phloem tissue is composed of phloem parenchyma cells, among which are a few sieve tubes measuring .01mm in cross section. A large amount of tannin and some starch and protein are found in the parenchyma cells.

Xylem

The protoxylem points, slightly indenting the pith, are composed of 6 to 7 radial rows of tracheal elements, between which are found thin-walled parenchyma cells containing a small amount of starch (Fig. 9). The tracheal tubes of the protoxylem measure .02mm in cross section. The metaxylem, which completes the xylem cylinder is found between the protoxylem points. The tracheal tubes of the metaxylem are distinctly larger than those of the protoxylem, measuring .03mm in cross diameter. Between the tracheal tubes of the metaxylem are fiber tracheids averaging .011mm in cross diameter.

Pith

The pith, composed of two distinct sizes of cells, is nearly one half the diameter of a one year stem (Fig. 9). The smaller of these cells are isodiametric, measuring .03mm. The larger cells average .06mm in cross

diameters and range from .03mm to .06mm vertically. A little tannin occurs in the small cells. All the cell walls are slightly lignified.

Secondary Tissues

Periderm

A phellogen, arising from the epidermis, has given rise to many lenticels in the 2-year stem (Fig. 10).

Phloem

In a two-year stem, measuring 3.1mm in diameter, the phloem tissue has become .14mm in width, having the outer cells much crushed (compare figures 9 and 10).

Xylem

In the second year of growth the tracheal tubes have larger diameters than those of the first year. The tracheal tube elements are .016mm in cross diameter and .1mm to .32mm in length. Fiber tracheids are quite abundant in this species. These cells average .008mm in cross diameter and are .5mm in length (see figures 10 and 35).

The xylem rays are .08mm wide and 3mm vertically. The cells of the rays are approximately .021mm vertically, .032mm tangentially and .02mm radially. Much tannin and starch are present in the rays.

ROSA DUMATORUM

Primary Tissues

Epidermis

In surface view the epidermal cells are nearly square, having a diameter of .038mm; while radially they are .025mm in diameter (see figures 55 and 11). The outer wall is heavily cutinized and .015mm thick. The radial walls are also cutinized and a cuticle .0012mm thick is present.

Cortex

The collenchyma is 2 to 5 cells wide, with cells averaging .03mm in radial diameter. Tangentially, the cells are .021mm and vertically .04mm. The parenchyma of the cortex is approximately .18mm wide and is composed of cells averaging .03mm in radial diameter, and .04mm in tangential diameter (Fig. 11). In a vertical direction these cells extend .03mm. They show the presence of tannin and starch. Calcium oxalate crystals are present in some of the cells.

The bast fibers do not form a continuous ring, but are in groups, measuring .04mm radially and .166mm tangentially. Generally the fibers are 1mm in length with cavities averaging .002mm in diameter. The lignified cell walls are approximately .008mm thick (see figures 11 and 36).

Phloem

By August of the first year the phloem is .065mm wide, the stem being 2.2mm in diameter. The outer cells are crushed and irregular (Fig. 11). The phloem is composed of parenchyma cells which are approximately .008mm in cross diameter and .042mm long. Some tannin and an abundance of starch are found in these cells.

Xylem

The protoxylem points are rounded, not projecting much into the pith, The inner tracheal tubes are .01mm in diameter and the outer ones are .02mm in diameter. The metaxylem is composed mainly of radial rows of tracheal tubes, averaging .025mm in diameter. Separating these rows are the xylem rays which are mostly one cell wide. Parenchyma cells .05mm vertically and .03mm radially occur between the leaf traces (Fig. 11).

Pith

The pith is .7mm in cross section and is nearly half the diameter of the one-year stem. The pith cells are rounded and average .06mm in cross section and .04mm vertically (Fig. 11). The walls are densely pitted and slightly lignified.

Secondary Tissues

Periderm

In this species cork is formed by August of the first year. The phellogen, formed by the epidermis, has given rise to as many as six cell-layers of cork, although the cork region does not completely circle the stem (Fig. 12).

Phloem

In a two-year stem 6mm in diameter, the phloem is .16mm wide, with the outer cells crushed (Fig. 12).

Xylem

Tracheal tubes are sparsely scattered throughout the xylem area (Fig. 12). The tracheal tube elements are .2mm to .4mm long and .02mm to .03mm in cross diameter with inclined elliptic pits (Fig. 36). No indication of end walls remains. Xylem parenchyma cells are absent. Most of the xylem is composed of fiber tracheids. These cells are slightly less than .02mm in diameter and average .5mm in length (see fig. 36). The xylem rays form a striking feature of this species (see fig. 12). Their greatest vertical length is 2.88mm and greatest radial width is .04mm. In tangential section the ray cells are mostly square with diameters of .018mm. Radially they are .02mm to .03mm.

ROSA KORMANA

Primary Tissues

Epidermis

In surface view these cells are almost square, having diameters of ,013mm and walls averaging ,005mm thick (see fig. 60). Radially the epidermal cells are .031mm in diameter, having a cutinized outer wall .015mm thick. The radial walls are also cutinized. A cuticle .0012mm thick is present (Fig. 13).

Cortex

This species has collenchyma cells with walls moderately thickened. The region is approximately .04mm wide. In radial diameter the cells average .01mm. Tangentially, they range from .01mm to .03mm, and vertically average .02mm in diameter. Some starch is present in these cells. The parenchyma of the cortex is .12mm wide and composed of approximately 10 radially flattened cells, averaging .02mm vertically and .016mm radially. Tangentially, they vary from .01mm to .04mm (Fig. 13). Tannin and starch give positive reactions with ferric chloride and KII.

The bast fibers do not form a continuous ring but occur in groups .04mm radially and .2mm tangentially. The fibers are approximately 1.2mm long, and have cavities averaging .0015mm in diameters and walls .01mm thick (see figures 13 and 42).

Phloem

The phloem is about .07mm wide by August of the second year and is composed of 13 cells. The outermost cells are so crushed that they cannot be distinctly viewed in cross and longitudinal sections (Fig. 13). An abundance of tannin and very little starch occur within the phloem. A few cells show the presence of protein.

Xylem

The xylem cylinder is composed of approximate-19 protoxylem points which project into the pith even farther than in Rosa dumetorum or dumatorum. Furthermore the width of the points is much greater than in the other two species, (Compare figure 13 with figures 9 and 11). The tubes range from .008mm to .012mm in diameter. The tracheal tubes of the metaxylem are arranged in radiating rows. These tubes average .02mm in cross diameter. Situated between the rows of tracheal tubes are xylem rays which are approximately .02mm apart. A few fiber tracheids occur in the metaxylem varying from .006mm to .02mm in diameter.

Pith

This region is outstanding in this species. Two distinct sizes of cells are found (see fig. 13). The larger ones are rounded and in cross diameter are .1mm; while vertically they are .08mm in diameter. Interspersed with these cells are smaller cells occurring in groups of 3 to 6. These are nearly square with diameters averaging .02mm and with walls slightly thicker than the larger cells.

The pith area is 1.7mm across, constituting about half the diameter of the one-year stem. The walls of all the cells are densely pitted and slightly lignified. Some starch is stored in these smaller cells as shown by reactions with KII.

Secondary Tissues

Periderm

By the end of the second year, cork is formed, but not all around the stem. The cork is initiated by the epidermis and in places there are as many as 12 cell-layers present. In most cases the cork has not yet begun to slough away (see fig. 14). No phelloderm has been formed.

Phloem

By the end of the second year the phloem is approximately .12mm wide, the stem being 3.5mm in diameter. The outer cells have been greatly crushed (see fig. 14).

Xylem

The tracheal tubes in this species are relatively numerous (Fig. 14). The tracheal tube elements vary from .016mm to .04mm in diameter and .16mm to .28mm in length (see fig. 42). Some of the elements overlap very much at the ends, while others do not, their end walls having been completely dissolved out. Very few xylem parenchyma cells are present in this species. These cells average .022mm vertically and .009mm radially. A large part of

the xylem is composed of fiber tracheids (Fig. 42). These cells average .008mm in diameter and range from .2mm to .32mm in length. The primary xylem rays are mostly four cells wide, becoming 2.75mm in length. The cells average .01mm radially and tangentially, and .02mm vertically. The secondary rays are mostly one cell wide and .04mm to .08mm apart (Fig. 14). Much starch is found in the rays.

ROSA SERICEA

Primary Tissues

Epidermis

In surface view the epidermal cells are nearly square, having diameters of .016mm (Fig. 59). As seen in cross section, the cells are .02mm in radial diameter, having their cutinized outer walls .01mm thick and bulging outward. In tangential diameter, these cells are .01mm. Part of the radial walls are cutinized and a cuticle .001mm thick is present (Fig. 15).

Cortex

The inner margin of the collenchyma is undulate, being two cells wide in the narrow portion and five cells wide in the wider portion. These cells are typical collenchyma cells with moderately thickened walls. The cells, varying from .06mm to .08mm vertically, have radial

diameters of .012mm and range from .02mm to .04mm tangentially (Fig. 15). The parenchyma of the cortex is approximately .12mm wide. The cells are progressively larger inwardly, the smaller cells averaging .012mm radially and the larger averaging .02mm. Tangentially they average .04mm and vertically .06mm. Small amounts of tannin as well as some starch is found in this region (Fig. 15).

The bast fibers occur in groups varying greatly in length tangentially, and having a width radially of three to five cells. The fibers are 1.2mm long and have cavities .0025mm in diameter and lignified walls .013mm thick (Fig. 37).

Phloem

By the end of the first year the phloem area is .035mm wide and the stem is 2mm in diameter. The outer cells are crushed and distorted, so that little can be said about them. Most of the later formed ones are nearly square, with diameters of approximately .009mm (Fig. 15). The sieve tube elements are .01mm across and .07mm long. No phloem parenchyma could be found.

Xylem

The protoxylem points protrude very little into the pith. In some points the amount of protoxylem is quite variable and the diameters of the tubes range from .008mm to .016mm. The tracheal tubes of the metaxylem

may be as great as .02mm in diameter. A few fiber tracheids averaging .01mm in diameter, constitute part of the metaxylem. Situated between the tracheal tubes are the radiating rows of xylem rays, averaging .02mm apart (Fig. 15).

Pith

In cross section the diameter of the pith is almost 1mm in a stem 3mm in diameter. The cells are quite uniform in size and are generally .04mm in cross diameter and .05mm vertically (Fig. 15). The walls are slightly lignified and have numerous pits.

Secondary Tissues

Periderm

There is no periderm formation until the second year, when the cork area has become as many as 8 cells wide radially, but with the test with Sudan III only the outer layers of cells are suberized. The phellogen arises in the epidermis (Fig. 16).

Phloem

By the end of the second year the phloem is .14mm wide, the stem being 3.5mm in diameter. At this age the outer cells have become irregular and crushed (Fig. 16).

Xylem

Tracheal tubes are scattered throughout the first year's growth and the second year they are massed in the early growth (Fig. 16). The tracheal tube elements range from .02mm to .04mm in width and from .2mm to .32mm in length. The end walls are completely dissolved while the side walls are elliptically pitted. Fiber tracheids are abundant in this species. They are approximately .5mm long and average .013mm in diameter. Their walls are beset with elliptic pits. All the xylem area shows lignified walls (Fig. 37).

Rays

The xylem rays vary in vertical length from .24mm to 1.6mm, with 4 or 5 cells constituting their tangential width of .04mm. The cells are .01mm radially but vary from .012mm to .032mm vertically. Starch is present in the xylem rays (Fig. 16).

ROSA MICRANTHA

Primary Tissues

Epidermis

The epidermal cells are rectangular in surface view, having diameters .027mm by .04mm (Fig. 54). In cross section, the cells are seen to have radial diameters of .031mm, with the outer wall .021mm thick. Both the outer and radial walls are cutinized. A cuticle .0012mm thick is present in this species (Fig. 17).

Cortex

The collenchyma is very similar to that of the species sericea. However, the thicker portion of the undulation averages 6 cells wide radially, while the narrower portion is usually 1 cell wide. There are about 6 wider areas per millimeter of circumference (Fig. 17). The cells of the collenchyma are uniformly rounded being .015mm in cross diameters. These cells are .02mm to .04mm vertically. The parenchyma of the cortex is approximately .08mm wide. The inner cells of this region are somewhat elongated tangentially, while the outer cells are rounded, having diameters of .018mm. Tannin and starch are found abundantly in the cortex.

When viewed in cross section, the bast fibers tissue appears as a ring that is broken occasionally

by a few parenchyma cells. These groups of cells are .04mm wide, with 5 to 6 cells making up the width. These cells, varying from 1.1mm to 1.2mm in length, have cavities .002mm in diameter and lignified walls .015mm thick (see figures 17 and 43).

Phloem

The outer cells of the phloem are very much crushed; the inner are more regular in form. The more regular cells are .01mm tangentially and .006mm radially (Fig. 17). The phloem parenchyma cells are .006mm radially and the sieve plates are .02mm across. The phloem contains some starch and tannin.

Xylem

The protoxylem points in this species usually project very little into the pith and at times appear flattened (Fig. 17). In some points the tracheal tubes are in several rows, while in others only a few such cells are formed. The tracheal tube elements vary from .01mm to .02mm in diameter. Between the protoxylem elements are relatively large thin-walled parenchyma cells. These cells become .06mm long vertically and .03mm radially. The tracheal tubes of the metaxylem are usually .04mm in diameter; however, some of them are much smaller. Much of the metaxylem is composed of parenchyma cells averaging .014mm radially and .05mm vertically. Between the tracheal tubes of the metaxylem are

the xylem rays, having 1 to 2 cell-rows of xylem elements between them.

Pith

The pith cells occur in two distinct sizes. The larger, having no cell contents, are rounded and average .04mm in cross diameter. Vertically they are slightly more than .04mm. The smaller cells are almost cubical, being approximately .02mm in all diameters (Fig. 17). These cells show a tannin reaction. All the cell walls of the pith are enormously pitted and slightly lignified.

Secondary Tissues

Peridern

No cork is formed the first year but by the end of the second year, much of the second internode is covered with cork. This is the only species in which deep-lying cork has been formed. In some places cork is formed in the phloem. In this case it is approximately .2mm radially (Fig. 18).

Phloem

The phloem is approximately .08mm wide, by the end of the second year, having the outer cells very much crushed (Fig. 18).

Xylem

There is an enormous number of tracheal tubes found in this species. Except for the early growth these tubes are uniformly scattered throughout the xylem (Fig. 18). Tracheal tube elements vary somewhat in diameter but average .03mm, with approximate lengths of .5mm (see figure 43). The ends of the elements overlap in varying amounts. The walls have reticulate markings in some elements, in others rows of elliptic pits almost run parallel to the long axis of the tube. A large part of the xylem is composed of fiber tracheids .7mm long and .02mm across, with both ends long and tapering (Fig. 43). No parenchyma cells are present.

The xylem rays, 3 cells broad, are not an outstanding feature in this species. Their greatest tangential width is .04mm; and their greatest vertical length is 1.85mm. The cells of the rays range from .016mm to .04mm vertically. Radially they average .02mm and slightly less than that tangentially. Small amounts of tannin and starch are present in the rays.

ROSA CALIFORNICA

Primary Tissues

Epidermis

As seen in surface view these cells are nearly square, having diameters .014mm each way (Fig. 58). In radial diameter they are .024mm and have an outer cutinized wall .014mm thick. Part of the radial wall is cutinized and a cuticle approximately .0012mm thick is present (Fig. 19).

Cortex

This species has collenchyma cells with moderately thick walls. The region is generally 5 cells wide, the cells being .009mm in radial diameter. In vertical diameter, the cells range from .02mm to .05mm, while, tangentially, they average .018mm. The parenchyma area extends .06mm radially and is about seven cells wide. These cells are somewhat flattened radially and average .01mm vertically (Fig. 19). Tannin and much starch are found in them.

The bast fibers occur in groups measuring .12mm tangentially, .04mm radially, and standing about .08mm apart. The cell cavities average .0025mm in diameter while the walls are lignified and .009mm thick. These bast fibers average .7mm in length (see figures 19 and 38).

Phloem

By the end of the first year, the phloem is approximately .045mm wide and the stem is 2.4mm in diameter. The outer cells are somewhat crushed. The sieve tubes may attain a length of .07mm but they are only .005mm wide (Fig. 19). Some starch is in the cells and an abundance is found in the rays. The parenchyma of the phloem is composed of cells .004mm wide and .021mm long. Much tannin is present in these cells.

Xylem

The protoxylem points do not extend noticeably into the pith though they are quite distinguishable. The tracheal tubes of the protoxylem occur usually in five radiating rows of cells. The first formed elements are .008mm in diameter; while the last formed are .02mm. These tubes are altogether composed of spiral vessels. Between the rows of protoxylem elements are relatively thick-walled parenchyma cells. The tracheal tubes of the metaxylem are relatively numerous and vary from .02mm to .04mm in cross diameter. Bordering these tubes are the xylem rays which are approximately .04mm apart. Relatively few fiber tracheids are found in the metaxylem. These cells vary from .006mm to .01mm in cross diameter (Fig. 19).

Pith

The diameter of the pith area is about one-third that of the one-year stem (Fig. 19). As seen in cross section, the pith is composed of two distinct sizes of cells. The larger ones are rounded, having a diameter of .04mm and vertical lengths ranging from .02mm to .04mm. No cell content is present. In the small cells of the pith tannin is abundant. These cells are nearly cubical with diameters of .02mm, and are quite uniformly distributed among the larger cells. The walls of the pith cells are densely pitted and slightly lignified.

Secondary Tissues

Periderm

By the end of the second year a phellogen has been initiated by the epidermis and has formed 4 to 6 layers of cork cells, not extending, however, the entire circumference of the stem. The epidermis is still intact at this age (Fig. 20).

Phloem

The phloem is about .12mm wide by August of the second year, at the same time the stem being 3.65mm in diameter. The phloem elements are crushed and distorted almost the entire width of the phloem (compare figures 19 and 20).

Xylem

In the second year of growth the tracheal tubes are larger and more numerous than the first year's growth. More tubes are found in the spring growth area than later. The tracheal tube elements average .03mm in cross section and range from .16mm to .3mm in length (Fig. 38). The secondary thickening of the side walls is in the form of reticulate pits. The end walls have been completely dissolved. Fiber tracheids of this species vary from .24mm to .5mm in length and average .01mm broad. The walls have inclined pits (Fig. 38). The xylem rays are .04mm to .12mm wide tangentially and vary from .16mm to .7mm vertically, but vary from .006mm to .02mm radially. Tannin and starch are present in the rays.

ROSA WATSONIANA

Primary Tissues

Epidermis

In surface view these cells are four-sided though somewhat rounded, having an average diameter of .02mm (Fig. 53). In cross section the cells are nearly square and have radial diameters of .028mm with cutinized outer walls .016mm thick. The radial walls are cutinized and a cuticle .0018mm thick is present (Fig. 21).

Cortex

The zone of collenchyma is 7 to 8 cells wide and measures .12mm in radial width. The cell walls are approximately .0066mm thick, while the cavities vary greatly in size, the longest are .03mm in diameter. Some tannin is present in this tissue. The parenchyma of the cortex has a greater radial width than the collenchyma. These cells are more uniform in size than is the rule in the other species I have studied. These cells are .06mm tangentially, .02mm radially and .02mm vertically (Fig. 21) Much tannin is present in these cells.

In the inner cortex are patches of bast fibers. These patches average .05mm in radial width (see figure 21). The cell cavities are elongated, averaging .0025mm in diameter. An average fiber is .69mm long, with lignified cell wall .01mm thick (Fig. 21).

Phloem

The phloem area in the one year stem is .08mm wide, the stem being 4mm in diameter (Fig. 21). The outer cells are distorted and somewhat flattened radially but the cells of the phloem parenchyma are quite elongated, measuring .05mm long and .01mm wide. The sieve tube elements are .016mm in cross diameter. The parenchyma cells contain some tannin, while the ray cells in the phloem region contain starch.

Xylem

In this species the protoxylem points are relatively wide, not protruding into the pith (Fig. 21). The tracheal tubes formed here are less numerous and less definitely in radial rows than in the other species. The tracheal tubes average .012mm in diameter. Situated between the rows of protoxylem elements are very thin-walled parenchyma cells, quite irregular in shape and size. The tracheal tubes of the metaxylem have greater cross diameters than like elements of the protoxylem. A few fiber tracheids are in the metaxylem region. These cells average .01mm in diameter. Between the tracheal tubes occur the xylem rays, which are .01mm to .03mm apart (Fig. 21).

Pith

The pith of this species consists essentially of two sizes of cells. The smaller ones are almost cubical,

averaging .021mm in diameter, and containing some tannin. The larger are mostly rounded, varying from .03mm to .06mm in cross diameter. In vertical extent, they average .04mm. No food substance is found within these cells.(Fig. 21). The cell walls of the pith are slightly lignified.

Secondary Tissues

Periderm

The cork is formed in this species from phellogen arising from the epidermis. It is 3 to 5 cell-layers wide. As in the case of Rosa californica, the cork formation does not at this stage, surround the stem, nor does it occur on one-year growth (compare figures 21 and 22).

Phloem

In a stem 5mm in diameter the phloem is approximately .24mm wide, having the outer cells slightly flattened radially. Possibly no other species has the phloem cells more regular in shape (Fig. 22).

Xylem

The tracheal tubes are quite uniformly distributed throughout the xylem. Their elements are approximately .03mm in diameter and average .2mm in length. The end walls are completely dissolved and the side walls have reticulate secondary thickening (Fig. 39). Fiber tracheids with oblique pits are quite frequent, averaging .015mm in

their greatest cross diameter and .55mm in length (Fig. 39). The xylem rays become very large in this species, the greatest width being .08mm and the greatest vertical length is 1.7mm. The cells of the rays are nearly isodiametric, being approximately .02mm in diameter. There are approximately five rows of xylem elements between the xylem rays. An abundance of starch and some tannin are found in the rays of this species.

ROSA ECAE

Primary Tissues

Epidermis

In surface view, these cells are nearly square but vary from .01mm to .04mm in diameter (Fig. 57). In cross section the cells have a radial diameter of .036mm and an outer cutinized wall approximately .02mm thick (Fig. 23). The radial walls are also cutinized and a cuticle .0013mm thick is present.

Cortex

The collenchyma ring is 6 to 7 cell-layers wide and is made up of typical collenchyma cells with more or less thinkened walls. The cells are approximately .018mm radially and average .015mm vertically. In tangential diameter they vary from .015mm to .04mm (Fig. 23). The paren-

chyma of the cortex is about .14mm wide and is composed of large, uniform cells averaging .04mm in tangential diameter and .025mm in radial diameter. Starch and tannin are found throughout the cortex, but more abundantly near the ends of the rays.

The bast fibers occur in groups or bundles approximately 5 cells wide radially. The cells have lignified walls .01mm thick and cavities .003mm in diameter (Fig. 23). The fibers average .5mm in length (Fig. 40).

Phloem

The phloem is approximately .05mm wide in the first internode. The outer cells are so crushed little data could be made concerning the lengths of the sieve tube elements (Fig. 23). Tannin and starch occur in the phloem in very small amounts.

Xylem

The tracheal tubes of the protoxylem occur mostly in four radial rows, usually three to the row. These tubes are spirally marked and vary from .011mm to .02mm in diameter. Between the rows of protoxylem cells are thin-walled parenchyma cells which vary greatly in length. They are about .012mm in cross diameter and vertically they range from .03mm to .05mm. The tracheal tubes of the metaxylem are about .021mm in diameter and are less regular in form than those of the protoxylem. Very few

fiber tracheids occur between the tracheal tubes. These fibers are quite irregular in shape but average .01mm in cross diameter (Fig. 23).

Pith

The pith cells of this species are rounded in cross section ranging from .01mm to .06mm. Vertically they range from .02mm to .06mm in diameter (Fig. 23). The cell walls are numerously pitted and slightly lignified.

Secondary Tissues

Periderm

No periderm is formed the first year, and by the end of the second year 6 to 7 cell-layers of cork are formed, though not all around the stem. The cork is initiated by the epidermis (Fig. 24).

Phloem

The 2-year stem is approximately 2.1mm in diameter, having phloem .08mm wide. The outer cells of the phloem are greatly crushed. No secondary bast has been formed (Fig. 24).

Xylem

The tracheal tubes are quite uniformly scattered throughout the xylem area, though somewhat clustered in the early growth. The tracheal tube elements have an average diameter of .025mm and length of .45mm

(Fig. 40). The fiber tracheids are quite abundant, averaging .5mm in length and .013mm in diameter (Fig. 40). As seen in macerated material, some of them overlap at the ends more than others. The pits are mostly elliptical, sometimes oval and occur along the length of the fiber.

There is no outstanding feature of the xylem rays in this species. In longitudinal view, the rays are .16mm to 1.2mm, vertically and at most are .04mm wide radially. The cells are .012mm in tangential diameter and range from .02mm to .04mm radially and vertically.

ROSA OMEIENSIS PTERACANTHA

Primary Tissues

Epidermis

As seen in surface view, these cells are nearly square, with an average diameter of .02mm (Fig. 52). Radially they have a diameter of .028mm. The outer wall is .018mm thick. Both radial and outer walls are cutinized and a cuticle .0015mm thick is present (Fig. 25).

Cortex

The collenchyma is in the form of an undulating cylinder, the narrow portion being one cell wide and the wider portion 3 to 6 cells wide (Fig. 25). These wider areas occur at intervals of about .06mm. The cells are about the same in radial and tangential diameters, ranging from .005mm

to .009mm. Vertically they are .02mm. The cell walls are approximately .003mm thick. The parenchyma of the cortex is .22mm wide and is composed of cells .02mm radially, .03mm tangentially and .03mm vertically; though, in all dimensions the outer cells are slightly smaller than the inner. An abundance of starch and tannin is present in the cortical parenchyma.

The bast fibers occur in groups .24mm tangentially and .04mm radially. These fibers are 1mm in length and have cavities .0015mm across and lignified walls..01mm thick (see figures 25 and 44).

Phloem

In a stem 1.5mm in diameter the phloem is .036mm wide, having the outer cells more or less crushed (Fig. 25). The sieve tubes average .01mm in diameter and the phloem parenchyma cells are approximately .008mm across. A great amount of starch is present in the outer phloem cells mainly, and an abundance of tannin is found in the phloem.

Xylem

The protoxylem points protrude a little into the pith (Fig. 25). The tracheal tubes of the protoxylem occur in radial rows, with about 4 tubes in a row. In cross diameter, these tubes vary from .008mm to .018mm. Occurring within the protoxylem region are very thin-walled parenchyma cells, averaging .006mm in cross diameter. Most of the tracheal tubes of the metaxylem are slightly elongated

radially, having tangential and radial diameters of .02mm and .038mm respectively. Many fiber tracheids occur in this region, especially between leaf traces. The rays are usually 1 cell wide and .02mm to .04mm apart, having one or two rows of xylem elements between them.

Pith

The cells of the pith vary greatly in size, though no two distinct sizes occur as in the case of koreana and ecae. In cross section, the cells are rounded, having diameters ranging from .03mm to .08mm (Fig. 25). Vertically, the cells range from .02mm to .04mm in diameter. The walls are pitted and slightly lignified. In some of the pith cells tannin is found.

Secondary Tissues

Periderm

The occurrence of periderm in this species is restricted to lenticel formation, up to August of the second year (Fig. 26). However, material three years old has other cork cells formed, though not completely circling the stem.

Phloem

By the end of the second year the phloem area is approximately 17 cells wide, the outer cells being much crushed (Fig. 26).

Xylem

The tracheal tubes are more numerous in the early growth than in the later growth (Fig. 26). The tubes formed in the later growth are almost round, having diameters of .02mm; while, those first formed are elongated radially, having a diameter of .05mm. The tracheal tube elements are .4mm to .5mm long (Fig. 44). Xylem parenchyma was not evident. Fiber tracheids comprise a large part of the xylem area. These cells average .5mm in length and .012mm in cross diameter (Fig. 44). The xylem rays vary from .16mm to 2.2mm in vertical length and from .01mm to .07mm in tangential width. The cells of these rays are as variable as the rays, but they average .02mm radially, .022mm vertically and .01mm tangentially. Starch and tannin occur in the rays.

ROSA OMEIENSIS

Primary Tissues

Epidermis

In surface view these cells are four-sided and nearly square, though in some instance they may be irregularly six-sided. They average .02mm in diameter (Fig. 56). In cross section these cells average .02mm radially, with the outer walls heavily cutinized and .012mm thick.

The radial walls are also cutinized and a cuticle .0016mm thick is present (Fig. 27).

Cortex

The outer cortex is composed of collenchyma cells, having moderately thickened walls. The inner border of the tissue is undulating, the narrow part being 1 cell wide and the wider part 3 to 4 cells wide. These wider areas occur at intervals of .1mm. The greatest radial width of the collenchyma is approximately .04mm (Fig. 27). The collenchyma cells are very irregular as to diameters. Radially they vary from .007mm to .011mm. In tangential diameter they measure .007mm to .02mm. Vertically they are uniformly .02mm. At its greatest width the cortical parenchyma is composed of 10 cell-layers, measuring .15mm radially. The inner cells are .014mm radially, .036mm tangentially and .021mm vertically. Going outward the cells become smaller. Tannin and small amounts of starch are present in this tissue (Fig. 27).

The bast fibers occur in strands measuring .04mm radially and approximately .3mm tangentially, with few parenchyma cells between them. The bast fiber cavities average .0015mm in diameter, while the lignified walls average .01mm thick. The fibers are approximately 1.5mm in length (see fig. 45). The fact that the cavities have almost been filled by thickening of the cell walls, is outstanding in this species.

Phloem

The phloem is .04mm wide at the end of the first year, the stem being 2.16mm in diameter (Fig. 27). At this age the outer cells are not so crushed as in the two-year old sections. The sieve tube elements of the phloem are approximately .015mm in radial diameter. The parenchyma cells are quite small having a width of .0045mm and a vertical length of .016mm. An abundance of tannin is found in the parenchyma cells. No starch is present in the phloem area excepting in the xylem rays.

Xylem

The distance the protoxylem points project into the pith is an outstanding feature of this species. About 24 points are present in the first internode (see fig. 27). Very few tracheal tubes are found composing the protoxylem of this species and those that are found are not arranged in definite radial rows as in the case of most species. These tubes average .009mm in cross diameter. A few parenchyma cells occur amongst the protoxylem elements. These cells are .05mm long and .009mm across. The tracheal tubes of the metaxylem are numerous and range from .015mm to .025mm in cross diameter. As seen in longitudinal section the tracheal tube elements vary from .16mm to .43mm in length. Many fiber tracheids are found among the tracheal tubes of the metaxylem. Originating within this

region are xylem rays, having one or two cell rows of xylem elements between them.

Pith

The pith of this species occurs in two distinct sizes of cells (Fig. 27). The smaller cells are nearly cubical, having diameters of .02mm. The larger cells are almost round in cross section but vary from .05mm to .1mm in diameter. Vertically they are slightly less than radially. The cell walls of the pith cells are slightly lignified.

Secondary Tissues

Periderm

By the end of the second year, periderm occurs completely circling the stem. The phellogen is initiated by the epidermis, and by August of the second year, has given rise to 6 to 14 cell-layers of cork forming a width of .1mm. At some points part of the cork has sloughed off (Compare figures 27 and 28).

Phloem

By August of the second year the phloem is .12mm wide or approximately three times the width of the one year growth. This width is approximately 24 cells radially, with the outer ones flattened radially (Fig. 28).

Xylem

The tracheal tubes are more numerous in the early growth than in the later growth. Generally those tracheal tube elements formed the second year have greater cross diameters than those of the first year. These elements range from .018mm to .05mm across and are on the average .32mm long (see figures 27 and 45). Many fiber tracheids occur in this species. These fibers are approximately .012mm in diameter and average .5mm in length. No xylem parenchyma cells are present. The xylem rays afford another outstanding character of this species. They are .02mm to .05mm wide and may extend a distance of 1.7mm vertically. The cells are almost cubical, having approximate diameters of .01mm. The secondary rays seem never to be more than two cells wide. Usually they are one cell in diameter. These cells have radial and tangential diameters slightly less than those mentioned above. Much tannin and very little starch are present in the rays.

ROSA SPINOSISSIMA

Primary Tissues

Epidermis

In surface view the epidermal cells are rectangular, and are .036mm long and .021mm wide (Fig. 51). Radially these cells are .031mm, the outer wall is .02mm thick. A cuticle .0008mm thick is present (Fig. 29).

Cortex

The collenchyma of the cortex is undulated, being 2 to 3 cell-layers wide in the narrow portion and 5 to 6 cell-layers wide in the wider portion (see fig. 29). These cells have uniform radial diameter of .014mm but vary from .012mm to .03mm tangentially. Vertically they average .012mm in diameter. The parenchyma tissue is approximately .12mm wide. The cells of this region are .01mm vertically and slightly less radially (Fig. 29). In tangential diameter they vary from .01mm to .015mm. Abundance of tannin and starch is found in these cells.

Very few bast fibers are present in this species. Usually 5 or 6 cells occur in a group. These fibers are lignified and vary from .32mm to .4mm in length. The walls are .01mm thick and cavities are .0015mm in diameter (see figures 29 and 41).

Phloem

In a stem 1.8mm in cross section the phloem is approximately .05mm wide. The outer phloem cells are somewhat crushed and irregular.(Fig. 29). Sieve tube elements average .01mm in cross diameter and phloem parenchyma cells are about .008mm in cross diameter. Much tannin is present in these cells, and starch is found in the rays of the phloem.

Xylem

Some protoxylem points protrude farther into the pith than others. The tracheal tubes occur in radiating rows with 2 to 5 tubes in each row (Fig. 29). These tubes vary from .009mm to .015mm in diameter. Thin walled parenchyma cells occur between the rows of protoxylem elements. The tracheal tubes of the metaxylem measure .013mm to .02mm in cross diameter. Very few fiber tracheids occur in the metaxylem. Situated between the xylem rays are 2 to 5 cell-rows of xylem elements.

Pith

The pith cells are mostly rounded when seen in cross section, having diameters from .02mm to .04mm. Vertically these cells extend .04mm (Fig. 29). The cell walls are abundantly pitted and slightly lignified. No food substances are present in the pith.

Secondary Tissues

Periderm

Generally cork has been formed during the second year of this species, but almost without exception its formation is that of lenticels and prickles (Fig. 30). The epidermis has given rise to the phellogen. In some cases the cork amounts to 2 cell-layers. In the formation of a prickle cork occurs at the base.

Phloem

In a 2-year stem 3mm in diameter, occurs phloem .07mm wide, having the outer cells crushed (Fig. 30).

Xylem

The tracheal tubes are more numerous in the early growth than in the late growth (Fig. 30). The tracheal tube elements average .02mm in cross diameter and .3mm in length (Fig. 41). The end walls are completely dissolved out and the side walls have inclined pits. Most of the xylem is composed of fiber tracheids, averaging .32mm in length and .008mm in width. Aside from the xylem rays xylem parenchyma is absent.

The xylem rays range from .12mm to 2mm in vertical extent and from .008mm to .03mm wide tangentially. The size and shape of the ray cells vary greatly. Vertically they range from .01mm to .055mm in diameter, tangentially from .008mm to .01mm in diameter, and radially they average .01mm in diameter. An abundance of starch and tannin occur in the xylem rays.

SUMMARY OF ANATOMICAL FEATURES FOUND IN STEMS.

Having given in the foregoing pages a detailed description of the histological characters of the various species of Rosa included in this research, I will now, in a comparative summary, call attention to the differences and likenesses existing among them in order that the taxonomic value of internal structure, even of minute cell characters, as well as tissue organization, may the better come to light.

In surface view, the cells of the stem epidermis are square or somewhat rhomboidal, rarely six-sided, with the exception of Rosa setigera, that has cells more or less irregularly ovoid or elliptic, and rarely round. In all the species, the cells range from .008mm in diameter in setigera to .05mm in rugosa; however, within each species, there is generally a range in size of cells. Throughout the species a cuticle is present, ranging from .001mm to .002mm in thickness. These heavily cutinized outer walls vary in thickness from .01mm in sericea and Wichuraiana to .021mm in micrantha.

The inner margin of the collenchyma of the outer cortex is distinctly undulate in species setigera, wichuraiana, koreana, sericea, micrantha, omeiensis pteracantha, omeiensis, and spinosissima, the feature being most pro-

nounced in setigera, where the narrow portion is .015mm to .045mm wide, and the wider portion .09mm to .12mm. In the species in which no undulations occur, the greatest width of .12mm, is found in watsoniana. The cells of the collenchyma have only moderately thick walls.

The parenchyma region of the cortex is generally wider than the collenchyma region, and is composed of cells that range widely in diameters.

No secondary bast fibers are found in any of the fifteen species. The primary bast fibers are in the inner cortex and are formed in groups or strands rather than in a continuous ring. These strands vary in size but not in a way to be taxonomically useful. The cavities of the bast fibers vary from .0015mm in hugonis, omeiensis, and spinosissima to .008mm in setigera; while the walls range from .003mm in thickness in setigera to .018mm in dumetorum. Setigera is outstanding in having such relatively thin walls and broad cavities. The fibers range in length from approximately .32mm in dumetorum and spinosissima, to 1.5mm in wichuraiana and omeiensis. In each species, however, there is a wide range in fiber length.

The extent to which the protoxylem points project into the pith does not vary greatly with the species. In wichuraiana and omeiensis they vary slightly, while, in micrantha and californica, they do not project noticeably,

appearing almost flattened. In all species, the protoxylem elements have spiral thickenings.

The pith region offers outstanding differences within the species. The pith cells occur in two distinct sizes in rugosa, setigera, wichuraiana, dumetorum, koreana, micrantha, californica, watsoniana, and omeiensis, where the smaller cells average .015mm in diameter and are found in clusters or chains, sometimes singly, and have relatively thick walls, usually containing starch and tannin. The larger cells, however, are nearly square or rectangular in cross section, and possess a diameter 2 to 4 times greater than the smaller cells. These larger cells have relatively thin walls and are usually empty. In hugonis, dumatorum, sericea, ecae, omeiensis pteracantha and spinosissima the pith cells are about equal in size ranging from .01mm to .08mm in diameter. In sericea these cells are nearly uniform in size, with an approximate diameter of .04mm, while in omeiensis pteracantha, the pith cells range from .03mm to .08mm in cross diameter.

The presence or absence of periderm and the amount formed offer good anatomical differences for I found no periderm formation by August of the second year in the species rugosa and wichuraiana. On the other hand, the stem of omeiensis is entirely covered with cork by the end of the second year, ranging from 6 to 14 cell-layers thick by mid-

summer, and, in some cases, part of the tissue has been sloughed away. Rosa micrantha is the only species in which deep-lying cork is formed, in some instances, being as deep as the outer edge of the phloem. In dumatorum, cork is formed the first year, but in all the species not already mentioned, cork does not appear until the second year. Of the latter species, dumetorum, omeiensis pteracantha, and spinosissima have cork formation limited, mainly, to the base of the prickles and lenticels.

The xylem rays of the species I have studied, give a few marks of distinction between the species. In tangential width, the xylem rays range from .005mm in rugosa to .12mm in californica, and they range in vertical extent from .12mm in rugosa and spinosissima to 10mm in setigera and wichuraiana; however, I did not find the vertical limits of wichuraiana, the greatest extent found being 10mm. The species setigera, wichuraiana, californica, watsoniana, and omeiensis have conspicuous rays in that they become .05mm or more in tangential width. In practically all the species, starch and tannin occur in the xylem rays.

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ROSA HUGONIS

General Features

All the species of Rosa that I have considered here are pinnately compound. The leaflets of hugonis are from 5-13 in number, oval to obovate or elliptic, and finely serrate, averaging .32mm in thickness. They measure 8-20mm in length and more than half as wide.

Epidermis

There is no outstanding difference in size of the cells of the epidermises, their diameters being .01mm (Figs. 62 and 64). No trichomes are found on the upper surface, but a few are on the midrib and veins of the lower side (Fig. 63). There are 210 stomata per square millimeter on the lower surface, but none on the upper. A relatively thin cuticle is present on both surfaces.

Chlorenchyma

The palisade cells, occurring mostly in two layers, are closely packed, there being 17,500 per square millimeter in the upper layer. The palisade cells measure .035mm in width, those of the upper layer being the longer. The spongy chlorenchyma is not at all compact, and is .01mm in thickness. Border parenchyma extends

around the veins with collenchyma on both sides, above and below (Fig. 61).

Venation

There are approximately twenty eight vein endings and 5 closed meshes per square millimeter of leaf surface (Fig.66).

Midrib

This midrib is concave on the upper surface and rounded to a point on the lower surface (Fig. 137). The lower epidermis is composed of cells elongated radially. The collenchyma is not distinctively thickened at the angles; however, there is some collenchyma towards the upper surface, about two cells in thickness. The radial and tangential diameters of the cells are .12mm and .1mm respectively. No bast is present. Beside the main bundle is found a small bundle, which follows the condition found in the petiole.

Margin

The leaf is .32mm thick with a margin that is decidedly pointed towards the lower surface. There is a group of collenchyma cells in the margin against the epidermis (Fig. 61). The chlorenchyma cells have the same relative position at the margin as elsewhere.

Petiole

The petiole is .88mm in radial diameter and .8mm in tangential diameter (Fig. 152). The upper side has more or less pointed ridges at the lateral margins. The stipules extend about .5mm laterally on each side of the petiole. In cross section the petiole is dome-like on its lower surface though slightly pointed. On the upper surface it is flat and a little rough. There is a continuous layer of bast around the central bundle, with one, two or many cells thick on the upper and lower sides. The bast cells range around .02mm in diameter, with walls .0015mm thick.

ROSA RUGOSA

General Features

There are 5-9 leaflets, elliptic to obovate, 2-5 centimeters long and about half as wide, rugose, serrate, thick and firm. They are .1mm to .16mm thick.

Epidermis

In surface view the cells of the upper and lower epidermises have very much the same shape (Figs. 68 and 69). In radial view the cells of the upper epidermis have a diameter of .03mm and are regular in shape. The outer walls are covered with a relatively thin cuticle. The cells of the lower epidermis are smaller in radial diameter and more irregular, (Fig. 70). Trichomes are restric-

ted to the midrib and veins (Fig. 67). About 210 stomata are found per square millimeter of leaf surface, these being only on the lower side. Glandular hairs, associated with the veins, are found on the lower surface of the leaf (Fig. 65).

Chlorenchyma

The palisade cells form a layer about .02mm thick (Fig. 70). There are approximately 16,250 per square millimeter of leaf surface, thus forming a very compact layer; however, this is not so noticeable in the marginal drawing as it is farther back within the leaf. The spongy tissue is compact with small air spaces and has a width of .03mm to .04mm. A bundle sheath one cell thick completely surrounds the bundle and extends to the epidermis in some cases.

Venation

There are 12-16 vein endings and 1 to 2 closed meshes for each square millimeter of surface (Fig. 71).

Midrib

The midrib is rounded with some irregularities of its surface. It is .4mm tangentially and .38mm radially. The xylem occupies a very small portion of the area. The collenchyma has a thickness of 3 to 6 rows of cells on both surfaces. Only 3 to 5 bast fiber cells are

in an entire section (Fig. 138).

Margin

The margin is uniformly rounded with palisade cells extending to the lower side of the leaf. The epidermal cells become smaller towards the lower side of the leaf (Fig. 70).

Petiole

The petiole is quite rounded with a small hemispherical concavity on the upper surface. It measures 1.28mm tangentially and radially 1.16mm. The epidermis is .01 to .005mm thick with collenchyma underneath 2 to 3 cells thick. A continuous layer of bast is around the central bundle, one, two, to many cells thick next the upper surface. The bast fiber diameters range from .0025mm to .022mm with walls .0026mm thick. There are two separate bundles, one on each side of the main bundle (Fig. 153).

ROSA SETIGERA

General Features

Leaflets mostly five, ovate to oblong, 3 to 4 centimeters long, acuminate and serrate. They are slightly less than .16mm thick.

Epidermis

As seen from the surface view, the cells

of the upper epidermis are more regular and rectangular than those of the lower (Figs. 72 and 73). In radial section the upper epidermal cells are .03mm thick with a heavy outer wall. The lower epidermis is not so thick (Fig. 75). Trichomes are found on the lower surface (Fig. 76). Approximately 160 stomata occur per square millimeter of lower epidermis. A relatively thick cuticle is present on both surfaces. Few glandular hairs occur along the margin of the leaf (Fig. 77).

Chlorenchyma

The palisade tissue is in two layers, each .02mm thick and closely compact, there being approximately 16,250 per square millimeter of leaf surface. About half of the chlorenchyma is spongy tissue which is compact in places, but large air spaces are often found. Border parenchyma is found around the veins (Fig. 75).

Venation

There are some sixteen vein endings per square millimeter with an average of less than one closed mesh for the same area (Fig. 74).

Midrib

The midrib measures .48mm tangentially and .4mm radially. The lower side is rounded, with irregular surface, while the upper side is concave. In cross section of the midrib, the epidermal cells appear very irregular with heavy walls. There are one to two rows of collen-

chyma cells present. There are no bast fibers but a bundle sheath is present. The xylem is arching with a small bundle at the side (Fig. 139).

Margin

The margin is blunt and reflexed towards the lower surface. The epidermal cells at the margin are very much smaller than the other epidermal cells. Just back of these is found a group of collenchyma cells extending to both surfaces. The cells of the palisade do not extend to the lower side as they do in many species (Fig. 75).

Petiole

The diameters of the petiole are .7mm radially and .68mm tangentially. It is broadly dome-shaped in cross section, with stipules extending .8mm laterally on each side (Fig. 154). The central bundle is near the lower side, while the two small lateral bundles are marginal and near the upper surface. The bast forms an arc half as thick as the xylem with cell walls .002mm thick and cavities averaging .006mm in diameter. A layer of collenchyma 2 to 3 cells thick is present outside the bast.

ROSA WICHURAIANA

General Features

Leaflets mostly nine, ovate, short acuminate one and one half to two and one half centimeters long, one half as broad, coarsely serrate and lighter beneath. They average .14mm thick. The stipules extend nearly the length of the petiole.

Epidermis

The upper epidermis is .03mm radially with an outer wall .005mm thick; while the lower epidermis has dimensions less than these (Figs. 79 and 80). No trichomes are present. A very thin cuticle is present on both surfaces. In surface view there is a striking resemblance in the shapes of the cells of the epidermises. Possibly the lower cells are less regular (Fig. 78). There are approximately 210 stomata per square millimeter on the lower surface of the leaf.

Chlorenchyma

The upper layer of palisade cells is .02mm thick with cells compact, 14,125 occurring per square millimeter. The second layer is about half as thick and not nearly so compact. The spongy region is composed of rounded, loose cells, with many air spaces. Around the veins is found sclerenchyma, also border parenchyma, although this does not extend to the upper epidermis (Fig. 78).

Venation

There are 12 to 18 vein endings and 2 closed meshes per square millimeter of leaf surface (Fig. 84).

Midrib

The radial diameter of this midrib is .32mm and the tangential diameter .36mm (Fig. 140). The outer walls of the epidermal cells is about .005mm thick. There is a one-celled layer of collenchyma, chiefly; but two-celled layers occur on both the upper and lower sides. It is striking how close the chlorenchyma from both sides comes together at the upper surface of the midrib. No bast is present.

Margin

The palisade cells extend to the lower surface of the leaf. Epidermal cells at the margin are smaller than elsewhere, with outer walls very much thickened. No collenchyma is present (Fig. 78).

Petiole

The radial and longitudinal diameters are .96mm and 1.06mm respectively, with the lower side dome-shaped in cross section and the upper flat (Fig. 155). The epidermal cells are uniform in their appearance and somewhat rounded. The outer wall is slightly thickened while the cavity measures .01mm in radial diameter. The

collenchyma is two to three cells thick. The bast arc extends to the lower surface of the bundle. The walls of the bast fibers are .018mm thick with cavities chiefly much smaller. The contrast between the walls and cavity of the cells of this tissue is one of the outstanding conditions of the petiole.

ROSA DUMETORUM

General Features

There are five to seven leaflets, which are broad ovate, 3 to 4 centimeters long, .16mm thick, and mostly doubly serrate. The stipules extend more than half the length of the petiole.

Epidermis

In cross section the epidermis is wavy, the cells slightly elongated. The upper epidermal cells are larger and more regular than the lower (Fig. 89). In surface view the cells are about the same size for the two epidermises (Figs. 88 and 91). Stomata are found on the lower side only, there being 78 per square millimeter of surface. Trichomes are on both upper and lower surfaces, probably more numerous on the lower (Fig. 87). Some trichomes have cavities, others do not. A very thin cuticle is present on both surfaces.

Chlorenchyma

The palisade cells are .05mm to .06mm long and closely compact ---- 12,875 per square millimeter. The width of the spongy chlorenchyma is less than that of the palisade. The cells vary in size but have a diameter averaging .01mm. Some sclerenchyma cells are found on the upper and lower side of the veins. (Fig. 89).

Venation

There are six to seven vein endings and approximately 3 closed meshes per square millimeter of surface (Fig. 90).

Midrib

This is rounded below and concave above with jagged m rgins, and measures .32mm in both diameters (Fig. 141). The epidermis is about .012mm radially and has a heavy outer wall. The collenchyma is one to two cells thick at both surfaces. A continuous arc is not formed by the bast fibers whose cell walls are .003mm thick and cavities ranges from .003mm to .01mm in diameter.

Margin

The margin is rounded, but points slightly downward. The outer walls of the epidermis become thickened at the margin and the palisade cells extend to the lower surface. Just back of the layer of palisade cells at the margin there are a few cells of collenchyma (Fig. 89).

Petiole

This petiole is .88mm radially and more than one millimeter in tangential diameter. The stipules measure 1.5mm laterally on each side of the petiole. The epidermal cells are rounded, though somewhat elongated radially, giving the petiole section a jagged appearance. Collenchyma cells are one to three rows in thickness. An arc is formed by the bast fibers extending to the extreme edges of the bundle. This arc is one to several cells thick, the cell cavities ranging from .001mm to .005mm in diameter and the walls are .0025mm in thickness (Fig. 156).

ROSA DUMATORUM

General Features

The leaves of this species are six and one half to nine centimeters long with stipules 7 to 8mm long, or more than half the length of the petiole. There are usually 9 leaflets, the first two being much smaller than the others. Leaflets are oval, serrate, darker above than beneath, averaging 2 centimeters long, three fourths as wide and .12mm thick.

Epidermis

In surface view both epidermises have the same shaped cells, though the lower are smaller (compare figures 93 and 94). In cross section of the leaf, the upper epidermal cells give the surface a smoother appearance than the lower. There are approximately 140 stomata per square millimeter of lower leaf surface, and a very thin cuticle is present on both surfaces. Trichomes are wanting in this species. A few glandular hairs occur along the margin of the leaf (Fig. 95).

Chlorenchyma

The palisade region is mostly in one cell-layer, the cells having a length of .05mm; though in the case of two layers of cells, the upper layer is much the wider (Fig. 92). The palisade cells have a frequency of 11,625 per square millimeter of leaf surface. The spongy tissue is about .02mm broad with rather small air spaces.

Venation

There are 15 to 20 vein endings and one to two closed meshes per square millimeter of leaf blade (Fig. 97).

Midrib

On the lower side the midrib is dome-shaped in cross section and a little flattened; while the upper side is slightly concave (Fig. 142). Radially the midrib

has a diameter of .3mm and about the same tangentially. The outer walls of the epidermal cells are strongly outward and are .0133mm thick. The collenchyma is one cell wide on the lower side, while on the upper side the cells are only collenchymatous. The bast fibers occur sparingly, not forming a continuous ring. Their walls are .0025mm thick while cavities are approximately .012mm in diameter. On the upper side of the midrib there are two rows of sclerenchyma cells having three cells to the row.

Margin

The epidermal cells are smaller at the margin than elsewhere and have thickened outer walls (see figure 92). The palisade cells extend to about the middle of the leaf margin. No collenchyma is present.

Petiole

This petiole has a radial diameter of .8mm and tangential diameter of .96mm with stipules extending laterally on each side a distance of .5mm (Figure 157). Generally the lower portion is rounded and the upper flattened. The cells of the epidermis have thick and bulging outer walls, giving the surface a scalloped effect. The collenchyma is one to three cells wide and extends around the petiole. The arc formed by the bast fibers is comparatively long and narrow, extending to the upper edge of the xylem. These cells have walls .003mm thick and cavities .0035mm in diameter.

ROSA KOREANA

General Features

The leaves are five to six centimeters in length. The leaflets are mostly eleven, 10mm long and about half as wide, slightly obovate, serrate, grayish beneath. The lower leaflets are smaller than the upper, as seems to be the case in all the species I have considered. They are .08mm thick.

Epidermis

In surface view, the cells of the upper epidermis are more uniform in shape than the lower (see figures 98 and 99). The outer wall of the upper epidermis, when seen in cross section, is .002mm thick. Approximately 200 stomata are found per square millimeter of lower leaf surface. A moderately thin cuticle occurs on both surfaces. No trichomes are present. A few glandular hairs occur along the margin of the leaf (Fig. 101).

Chlorenchyma

The palisade region is about .02mm wide and is composed of one layer of short and very compact cells (Fig. 96). This species has 25,750 palisade cells per square millimeter of leaf surface, which is the greatest number occurring in any of the species studied in this research. The spongy cells are rounded to oblong with re-

latively small air spaces betwenn them. This tissue measures nearly half the thickness of the leaf.

Venation

There are approximately 8 vein endings and 5 closed meshes per square millimeter of leaf blade (see figure 100).

Midrib

The midrib projects decidedly on the lower surface of the leaflet blade. When seen in cross section, it is .17mm radially and .2mm tangentially and has a rounded lower surface (Fig. 143). Relatively few collenchyma cells are present. The bast fibers occur in small groups. These cells have walls .0025mm thick and cavities .0075mm in diameter. Only a few rows of xylem cells are present.

Margin

The palisade tissue at the margin extends to the middle of the leaf where the spongy tissue begins. No difference is seen in the epidermal cells at the margin and elsewhere (Fig. 96).

Petiole

The lower side of the petiole is dome-shaped in cross section, while the upper side is slightly concave. Radially it is .4mm and tangentially .64mm, with stipules extending slightly more than one millimeter later-

ally on each side (Fig. 158). The epidermis is composed of rectangular cells uniform in size and shape. Just one cell layer of collenchyma is present. Just back of the tips of the stipules, the vascular system is in five distinctive bundles, with groups of bast fibers arching these separate bundles. The fibers have walls .004mm thick and cavities as great as .005mm in diameter. In the larger cells the cavities are somewhat elongated. There is a bundle sheath around each separate bundle.

ROSA SERICEA

General Features

This species is closely related to omeiensis which is discussed later in the paper. Its leaves vary from 2 to 3 centimeters long with stipules half the length of the petiole. Leaflets, numbering 7 to 11, are oval to obovate, pubescent beneath, 1 to 2 centimeters long and .14mm thick.

Epidermis

The cells of the upper epidermis have thinner walls than those of the lower, and in cross section the upper surface is smoother.(see figures 102 and 104). The stomata of this species have a frequency of 420, which is the greatest of any species considered here. They are

characteristic in being sunken entirely below the level of the epidermis (Fig. 102). This leaf is destitute of trichomes, but a relatively thick cuticle is present on both surfaces. Glandular hairs occur along the margin and also along the veins of the lower surface (Fig. 103).

Chlorenchyma

Palisade cells occur in two layers, the upper cells are about .03mm long and so close together that approximately 17,500 occur per square millimeter of leaf surface (Fig. 105). The cells composing the second layer are much shorter and less regular in shape than those of the upper. The spongy tissue is 2 to 3 cells deep, amounting to .01mm, with relatively small air spaces. A bundle sheath is present around the veins extending in some instances to both surfaces.

Venation

There are approximately 14 vein endings and 7 closed meshes per square millimeter of leaf surface (Fig. 106).

Midrib

In cross section this midrib is uniformly rounded, measuring .24mm in diameter (Fig. 144). The cells of the epidermis are nearly square or rectangular with the outer wall quite thickened. The collenchyma is 1 to 2 cells thick. No bast fibers are present, a rather unique fact for the genus Rosa.

Margin

The margin is rounded and reflexed towards the lower surface (Fig. 105). The epidermal cells are smaller than elsewhere, and the palisade cells extend to the lower side of the leaf.

Petiole

On the under side the petiole is dome-shaped, while on the upper it is flattened (Fig. 159). It is .48mm in radial diameter and 1mm in tangential diameter with stipules extending 1.2mm on either side. The epidermis is composed of cells of uniform size and are almost square in cross section. On both lower and upper surfaces of the petiole is found collenchyma tissue three cell-layers wide. The central vascular bundle is rounded, with small bundles present on both sides of it. The bast arc is found only on the lower side of the bundle and is one to five cells wide radially. The fibers are .04mm in cross diameter having walls .003mm thick.

ROSA MICRANTHA

General Tissues

The leaflets of the species, ranging from 5 to 7, are broad-ovate to oval, 2 to 3 centimeters long, and glandular or serrate. Glands are scattered over the lower surface. In cross section the leaflets are .16mm thick.

Epidermis

As seen in surface view, the cells of the lower epidermis are much smaller and more irregular than those of the upper surface.(Figs. 119 and 121). Stomata only on the lower side, average 128 per square millimeter of leaf surface. In leaf cross section the epidermis is about .03mm wide with the outer cell walls .0055 thick. A relatively thin cuticle appears on both surfaces. Trichomes occur mainly on the lower surface along the midrib (Fig. 118). Glandular hairs are on the lower surface, along the veins, midrib and margin (Figs. 122 and 123).

Chlorenchyma

The palisade cells are about .04mm long, with intercellular spaces unusually pronounced. There are approximately 7,726 such cells per square millimeter of leaf surface. Seldom is the palisade tissue more than one cell deep. The spongy region is approximately .06mm wide and is composed of rounded or loosely arranged cells (Fig. 120).

Venation

There are about 7 vein endings and 5 to 6 closed meshes per square millimeter of leaf surface (Fig. 123).

Midrib

The midrib is rounded, and about .26mm in diameter, though the tangential diameter may be slightly greater than the radial (Fig. 145). The cells of the epidermis have thick outer walls and vary greatly in size. On the lower surface the collenchyma is 1 to 2 cells wide and a few such cells occur on the upper side. Seen in cross section the bast fiber region is 1 to 2 cells wide and extends half way around the sides of the xylem, while in some species this region extends to the upper side of the xylem, and in others it does not arch but remains wholly on the lower side. The fibers have walls .004mm thick and cavities about .004mm in diameter.

Margin

This leaf is not uniform in thickness but averages .16mm with a tapering margin reflexing slightly towards the lower surface (Fig. 120). All the cell walls are thickened and several collenchyma cells are found here. The palisade and spongy tissues have the same relative position here as elsewhere in the leaf.

Petiole

In cross section, this petiole is somewhat flattened, measuring .6mm radially and 1.6mm tangentially (Fig. 160). The stipules have lateral expanse on each side of approximately 1 millimeter. The cells of the epidermis are small and thick-walled, resembling collenchyma. Collenchyma beneath the epidermis is 2 to 3 cells wide. The bast fiber arc is restricted to the under side of the xylem and is 4 cells wide, although in instances parenchyma cells are intermixed. The bast fibers have cell cavities as great as .02mm in diameter and walls that are .0025mm thick.

ROSA CALIFORNICA

General Features

The leaflets are mostly 7, broad to ovate-oblong, 2 centimeters long, serrate, pubescent on the lower surface and .16mm thick.

Epidermis

In surface view the upper epidermal cells are found larger and more regular than those of the lower epidermis (Figs. 111 and 112). In cross section, the former are much thicker than the latter, and the entire surface has a wavy or scalloped appearance (Fig. 113). A moderately thick cuticle appears on both epidermises.

Approximately 147 stomata per square millimeter occur on the lower epidermis. Trichomes are present on the midrib, veins and veinlets, more abundantly on the lower side than the upper (Fig. 117). A few glandular hairs occur along the veins and the margin (Fig. 116).

Chlorenchyma

The palisade tissue is composed of one layer of closely set cells, with an average of .05mm. There are approximately 10,017 palisade cells per square millimeter of surface. The spongy region has relatively small intercellular spaces and there are 5 to 7 rows of cells composing the total width of .05mm (Fig. 113).

Venation

This species is very striking in its network of venation, in having 1 to 2 vein endings and an average of one closed mesh per square millimeter of leaf surface (Fig. 115).

Midrib

As seen in cross section, it appears quite flattened, having a radial diameter of .3mm and more than three times that tangentially. The outer walls of the epidermal cells are .005mm thick and conspicuously bulging (Fig. 146). The collenchyma underneath the epidermis is one to two cells thick. The bast fibers form an almost

continuous arc on the lower side of the xylem. Their walls are .29mm thick and cavities approximately .005mm in diameter.

Margin

The margin is bluntly rounded with the epidermal cells much smaller and nearly iso-diametric. The palisade and spongy cells have the same relative position at the margin as they do within the leaf (Fig. 113).

Petiole

The petiole is somewhat oval and flattened in cross section.(Fig. 161). It is .72mm radially and 1.36mm tangentially, unusually large dimensions among the species of this study. The cells of the epidermis are conspicuously small and the bulging outer walls give the section a jagged appearance. The collenchyma has a width from 2 to 4 cells. The vascular system may or may not be divided into separate bundles. In some cases it is composed of five distinct parts, and then groups of bast fibers subtend each part separately. The fibers are .02mm in diameter with walls .005mm thick.

ROSA WATSONIANA

General Features

The usually 3 to 5 leaflets of this species are linear lanceolate, entire, 3 to 6 centimeters long, 5 millimeters wide and approximately .12mm thick.

Epidermis

In surface view the cells of the upper and lower epidermises are about the same size, though the upper are more regular (Figs. 81 and 82). In cross section the cells are mostly elongated tangentially, although some are rounded (Fig. 83). Approximately 82 stomata are found per square millimeter in the lower epidermis. A relatively thick cuticle occurs on both epidermises. Spinose trichomes are present on both surfaces (Fig. 86). These trichomes may have cavities extending the entire length.

Chlorenchyma

The palisade cells occur in 2 rows, the outer being .03mm wide and the inner varying around .02mm. The inner cells are not so compact as the outer, the latter having a frequency of 7,280 per square millimeter of leaf surface. This is the smallest frequency of the species here considered. Rosa micrantha, however, approaches this with a frequency of 7,725. The spongy tissue has many large air spaces in it. The cells range

from rounded to oblong and curved. There is a parenchyma sheath around the veins (Fig. 83).

Venation

Approximately 2 vein endings occur per square millimeter of leaf area. Very few closed meshes are found in this species (Fig. 85).

Midrib

The midrib is rounded and slightly projecting outward. Radially it is .24mm and .28mm tangentially. The outer walls are heavy (Fig. 147). No distinct collenchyma is present. The bast fiber arc is 1 to 4 cells wide and is composed of fibers whose walls are .0025mm thick and cavities .006mm in diameter. About four rows of xylem cells are present in the vascular bundle of the midrib.

Margin

The margin is rounded and slightly reflexed towards the upper surface (Fig. 83). The epidermal cells at the margin are somewhat smaller than the others, and the palisade cells extend almost to the lower side of the leaf.

Petiole

In cross section this petiole appears half-moon or crescent shape (Fig. 162). It measures .32mm

radially and one millimeter tangentially. No stipules are present. The epidermis is composed of small, regular rounded cells. The collenchyma occurs 1 to 2 cells wide. The vascular system is composed of a large central bundle with two smaller ones occurring on each side of it. The bast-fiber area does not arch over the xylem but is only on the lower side. Its cell walls are .01mm thick and its cavities average .0045mm in diameter.

ROSA ECAE

General Features

There are 7 to 15 elliptic-oblong leaflets, 6mm to 20mm long, 4mm to 10mm wide, mostly obtuse and doubly serrate. In cross section, the leaflets are .13mm wide.

Epidermis

There is not much difference in shape and size of the epidermal cells when seen in surface view, which is not the usual case. (Figs. 108 and 110). In cross section the upper epidermal cells have a greater radial diameter than the lower ones, and are, on the whole, larger. The outer walls of the upper epidermis are thicker than those of the lower (Fig. 107). Glandular hairs are

present on the veins and margin; no trichomes are present (Fig. 109 and 114). A relatively thin cuticle is found on the epidermises. Approximately 179 stomata occur per square millimeter of the leaf's lower surface.

Chlorenchyma

Generally there are two layers of palisade cells and sometimes there are three, making a total depth of this tissue of .04mm. The upper layer of cells is deeper than the others and the cells have a frequency of 10,017 per square millimeter. In contrast to this the spongy cells are looser and less frequent. There is a bundle sheath of parenchyma cells surrounding the veins that in some cases, extends to the epidermis of both surfaces (Fig. 107).

Venation

There are approximately 18 vein endings and 2 to 3 closed meshes per square millimeter of leaf blade (Fig. 114).

Midrib

The midrib is dome-shaped in cross section and is .3mm in radial diameter and .32mm in tangential diameter (Fig. 148). The collenchyma is 2 to 3 cells wide on the lower side of the midrib and only a small group is present on the upper side. No distinct bast fibers are present.

Margin

The margin is uniformly rounded and slightly tapering (Fig. 107). The epidermal cells at the margin are nearly square and have an outer wall .0035mm thick. The spongy and palisade have the same relative position at the margin as elsewhere.

Petiole

In cross section the petiole is rounded on the lower surface and flat on the upper (Fig. 163). Radially it is .48mm and tangentially .56mm across. Stipules are present. On the lower side, the cells of the epidermis are quite uniform in size, with rounded cavities; while on the upper surface the cavities are more nearly square. The collenchyma is one to several cells wide. Bast fibers subtend the vascular bundle and extend to the upper edge of the xylem. Their walls have a thickness of .01mm and cavities .038mm in diameter. The xylem is composed of a solid group of cells that are formed in radial rows.

ROSA OMEIENSIS PTERACANTHA

General Features

The leaflets are 9 to 17, oblong-elliptic, serrate, 8 to 20mm long, 4 to 8mm wide and .12mm thick.

Epidermis

There is a very great difference in size of upper and lower epidermal cells when seen in surface view (Compare figures 133 and 135). The upper cells are about three times greater in diameter, and in cross section the same proportion is found for the radial diameters (Fig. 134). Approximately 350 stomata occur per square millimeter of leaf surface, these being found only on the lower side. A moderately thin cuticle is present on both epidermises. Trichomes are present (Fig. 132).

Chlorenchyma

The palisade cells occur in two rows, the upper cells, with a length of .02mm, being the longer. These cells are relatively loosely set and average 13,750 per square millimeter of surface. The spongy tissue has cells quite rounded with a width of .02mm (Fig. 134). Many small air spaces are found between these cells. A parenchyma sheath is present around the veins.

Venation

There are 12 to 16 vein endings and an average of one closed mesh per square millimeter of leaf blade (Fig. 136).

Midrib

In cross section the midrib had a diameter of .24mm each way. It is dome-shaped and slightly pointed in cross section. The cells of the epidermis are sharply bulging and have thickened outer walls (Fig. 149). There is no collenchyma present in the lower portion of the midrib, but 4 or 5 cells occur on the upper surface just under the epidermis. No bast fibers are present. The xylem occurs in 6 to 7 radial rows of a few cells each. The area of the phloem region is greater than that of the xylem.

Margin

The margin is rounded and slightly reflexed towards the lower side. The epidermal cells of the margin are small and nearly square (Fig. 134). Palisade cells extend around the margin to the lower side.

Petiole

In cross section, this petiole is .64mm radially and 1.1mm tangentially (Fig. 164). It is quite flat on the upper surface and broad rounded on the lower. Cells of the lower epidermis are much smaller than those

of the upper. The collenchyma is uniformly 2 cells thick and is found beneath both upper and lower epidermises. The vascular system is in three portions with an arc of bast fibers subtending each, nearly to the upper part of the xylem. This bast region is 1 to 4 cells wide, having cell walls .01mm thick and cavities .015mm in diameter. The main part of the bundle is not so rounded but quite broad. Stipules are present extending laterally 1.5mm on each side.

ROSA OMEIENSIS

General Features

In these respects this species is the same as Rosa omeiensis pteracantha.

Epidermis

There are no outstanding differences between the epidermises in this species (Figs. 124 and 125). In surface view they average .045mm in diameter. The upper cells are more regular both in surface view and in cross section, and in the latter case are about .02mm in radial diameter (Fig. 129). A relatively thin cuticle is present on the epidermises. Approximately 84 stomata occur per square millimeter of leaf surface, occurring only on the

lower epidermis. These are sunken below the general level (Fig. 124). Trichomes are lacking.

Chlorenchyma

The palisade region is composed of one layer of compact cells .025mm long. There are approximately 15,625 of these per square millimeter of leaf surface. The spongy tissue is .035mm wide and is made up if irregular, somewhat compact cells, with relatively small air spaces (Fig. 129). A parenchyma sheath is formed around the veins, the smaller veins having four large cells around them.

Venation

There are approximately 16 vein endings and 1 to 2 closed meshes per square millimeter of leaf area (Fig. 126).

Midrib

This midrib, when seen in cross section, is rounded on the lower side and concave on the upper (Fig. 150). It is .24mm in both diameters. The epidermis is uniformly regular and somewhat thickened outer walls. The collenchyma is one cell thick on the lower side, but two cells thick on the upper. No true bast fibers are present and only a few xylem cells are found.

Margin

The margin of the leaf is rounded, with epidermal cells not unlike those away from the margin, in size and shape. The palisade cells extend to the lower surface at the margin (Fig. 129).

Petiole

Radially this petiole is .48mm and tangentially .8mm (Fig. 165). The upper side is flat while the lower is rounded and somewhat flattened. Stipules extend .8mm laterally on each side of the petiole. The epidermis is smooth, but there is a striking difference in the cells themselves. Some of the cells of the upper epidermis appear as two V's fitted together at their open ends, with a wall in between them. The collenchyma is 1 to 2 cells thick, some cells .025mm in diameter. The bast fiber sheath extends to the upper side of the xylem. There is a striking difference between the walls and the cavities of the bast fibers, since the walls are .01mm thick and cavities .0025mm in diameter. There is a relatively broad area of xylem cells arranged in many radial rows. The phloem is approximately .04mm wide. A bundle sheath of parenchyma cells is present around the veins.

ROSA SPINOSISSIMA

General Features

Leaflets number 7 to 9, mostly 9, chiefly oval, 1 to 2 centimeters long and nearly half as broad, serrate and .12mm thick. Stipules extend about half the length of the petiole.

Epidermis

In surface view the cells of the upper epidermis are more regular than those of the lower, and all the cells are somewhat elongated (Figs. 127 and 131). The cells average .05mm in diameter in surface view; while they are .017mm in radial diameter. The outer wall is approximately .002mm thick having a relatively thick cuticle (Fig. 128). Stomata occur with a frequency of 68 per square millimeter on the lower surface. Trichomes are lacking.

Chlorenchyma

Generally there are two layers of palisade cells, the upper layer, .035mm in length of cells, being deeper than the seconnd layer (Fig. 128). There are approximately 12,875 such cells per square millimeter of leaf surface. The spongy cells are rounded to oblong in cross section, separated by air spaces that vary in size. This tissue is .04mm wide and has veins enclosed by a parenchyma

sheath that in some veins extends to both surfaces.

Venation

Approximately 16 vein endings and 3 to 4 closed meshes occur per square millimeter of leaf area (Fig. 130).

Midrib

In cross section this midrib has diameters .28mm each way, though it is by no means perfectly round (Fig. 151). The outer walls of the epidermis measure .005mm thick. Usually the collenchyma is 1 to 2 cells broad with walls .0075mm thick and relatively large cavities. Collenchyma cells occur on both surfaces of the midrib. Only a few bast fibers are present. The phloem is approximately .03mm wide.

Margin

The epidermal cells at the margin are more nearly square than the other epidermal cells. The palisade cells extend to the lower side of the leaf (Fig. 128).

Petiole

In cross section, the petiole is flat on the upper surface and broadly rounded on the lower (Fig. 166). Radially it is .5mm and nearly twice that in tangential diameter. The epidermis is composed of small cells of comparatively uniform size. On the lower side, the

collenchyma is three cells wide, but going towards the upper side the width is reduced to one cell. On the upper surface it is 1 to 2 cells in thickness. The bast fibers are arranged in an arc, extending to the upper surface of the xylem. Occasionally this arc is broken by some parenchyma cells. The cell walls are .006mm thick and the cavities average .075mm in diameter.

SUMMARY OF THE ANATOMICAL FEATURES FOUND IN LEAVES.

In recording the data of the leaves in the preceding pages, the contrasting features were not emphasized. The purpose of this summary is to call attention to these features and to point out the characters of individual species.

The leaflets are serrated and oval or elliptic in all the species, excepting Rosa watsoniana, which has entire, linear-lanceolate leaflets. These latter leaflets are 30mm to 60mm long and average 5mm wide. The leaflets of the other fourteen species range from 6mm to 20mm in length in ecae, to 20mm to 50mm in rugosa. The leaflets of Rosa koreana are the smallest leaflets of any species studied, averaging 10mm in length and 5mm in width.

The epidermal cells of all the species have relatively thickened cutinized outer walls and a moderately thin cuticle. Clothing hairs are found on the leaves of californica, dumetorum, hugonis, watsoniana, rugosa, and setigera; and, in case of the latter two, these hairs are found only on the lower surface. The walls of the hairs on dumetorum and hugonis have thickened so as to close the cavities.

Glandular hairs are present on the leaflets of ecae, californica, micrantha, koreana, dumetorum, and sericea. These hairs consist essentially of a foot, stalk, and head;

and, in most cases, the stalk is relatively long. In ecae, however, the hairs have a very short stalk. In koreana, the head is distinctly rounded, with a very short stalk.

The frequency of stomata varies from 68 in spinosissima to 420 in koreana. In all the species the stomata occur only on the lower side of the leaf.

The palisade tissue occurs in two cell-layers in hugonis, setigera, wichuraiana, sericea, ecae, watsoniana, omeiensis pteracantha, and spinosissima; while, it is one cell-layer in the remaining species. The frequency of palisade cells is quite outstanding. In watsoniana, there are 7,200 palisade cells per square millimeter of leaf area; while in koreana there are 23,750. Next in order come hugonis and sericea with 17,500 each. Not only do these species show a wide range in frequency of palisade cells but also in the number of free vein endings and closed meshes. In hugonis, there are approximately 28 vein endings and 5 closed meshes per square millimeter of leaf surface; while in watsoniana, there is an average of 2 vein endings per square millimeter and very seldom does a closed mesh occur. Approaching this species is californica with 1 to 2 vein endings and 1 closed mesh per square millimeter. As shown by the chart I, there is no positive correlation between the number of free vein endings and closed meshes,

and the frequency of stomata and palisade cells.

The midribs of the various species are usually rounded on the lower surface and concave on the upper; however, in koreana the midrib projects downward relatively more than in the other species. In californica the lower surface is almost flattened.

Bast fibers are present in the midribs of rugosa, dumetorum, dumatorum, koreana, micrantha, californica, watsoniana, and spinosissima; however, in dumatorum and koreana these fibers are very sparse. In all the other species studied bast fibers are absent in the midrib. In most species collenchyma occurs on the upper and lower sides of the midrib; however, in case of omeiensis pteracantha, collenchyma occurs only on the upper side; and in watsoniana no distinct collenchyma cells are present.

Throughout the species, the petioles have about the same relative shapes as do the midribs. All the petioles have stipules, but in watsoniana, they are relatively small, though in all cases the stipules become broader at the apex. In dumetorum, omeiensis pteracantha, spinosissima, and rugosa the stipules extend laterally a distance of 1.5mm on each side of the petiole. Generally the petioles have 2 to 3 cell-layers of collenchyma, but koreana has only one cell-layer, while in californica there are 2 to 4 cell-layers.

The collenchyma of omeiensis pteracantha is uniformly 2 cell-layers in width. As seen in cross section the bast fibers in the petioles usually extend some distance upwards on the sides of the bundle. In micrantha and watsoniana, however, the bast is restricted definitely to the lower side.

The vascular system is in a single bundle, or in several bundles about midway the petiole, with bast subtending each bundle, in the latter case. There is a single bundle in hugonis, ecae, spinosissima, dumatorum, micrantha, and dumetorum, while in omeiensis there is a tendency towards separate bundles. In koreana, there are 5 distinct bundles. In setigera, wichuraiana, sericea, and watsoniana there is a small bundle on each side of a larger central bundle.

The leaf margins of hugonis, setigera and micrantha have a group of collenchyma cells underneath the epidermis. These margins are quite pointed, especially in hugonis and micrantha. The remaining species have rounded margins without collenchyma.

CHART SHOWING THE NUMBER OF CLOSED MESHES, VEIN ENDINGS, STOMATA, AND PALISADE CELLS PER SQUARE MM OF LEAF SURFACE

	Meshes	Vein endings	Stomata	Palisade cells
hugonis	5	28	210	17,500
rugosa	1-2	14	210	16,250
setigera	less than 1	16	160	16,250
wichuraiana	2	16	210	14,125
dumetorum	3	6-7	78	12,875
dumatorum	1-2	18	140	11,625
koreana	5	8	200	23,750
sericea	7	14	420	17,500
micrantha	5-6	7	147	7,726
californica	1	1-2	147	10,826
watsoniana	seldom found	1-2	82	7,288
ecae	2-3	18	179	10,017
omeiensis pteracantha	1	12	350	13,750
omeiensis	1-2	16	84	15,625
spinosissima	3-4	16	168	12,875

Plate I

STEM CROSS SECTIONS

(x 45)

Fig. 1 R. hugonis, one year

Fig. 2 R. hugonis, two year

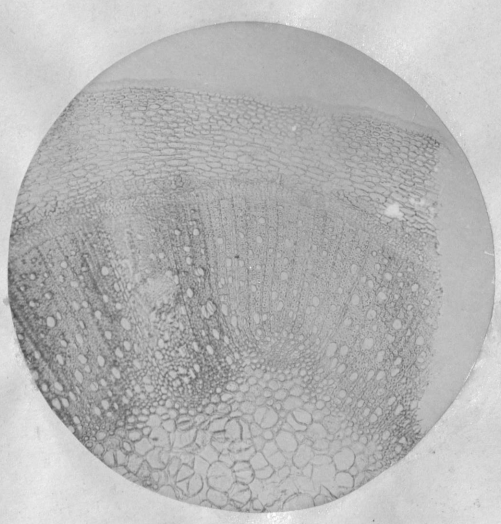


Fig. 1

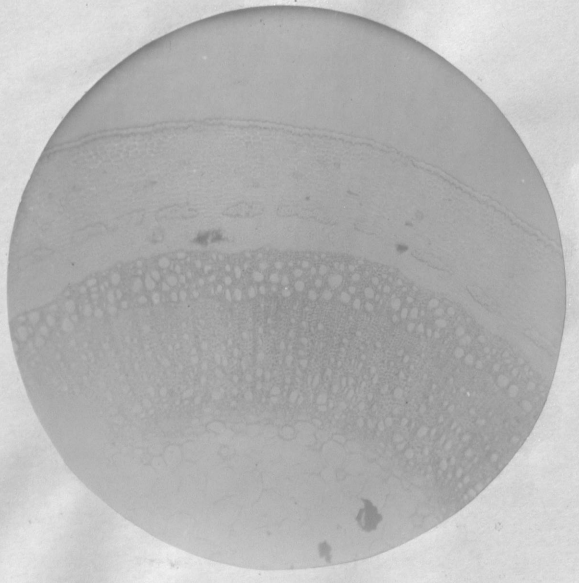


Fig. 2

STEM CROSS SECTIONS

(x 45)

Fig. 3 R. rugosa, one year

Fig. 4 R. rugosa, two year

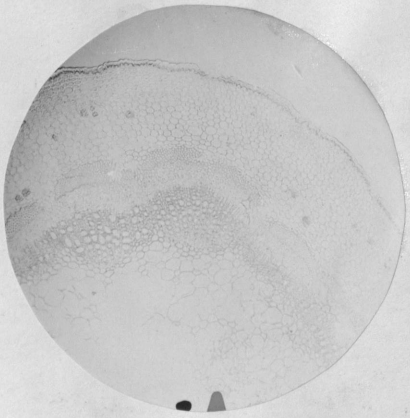


Fig. 3

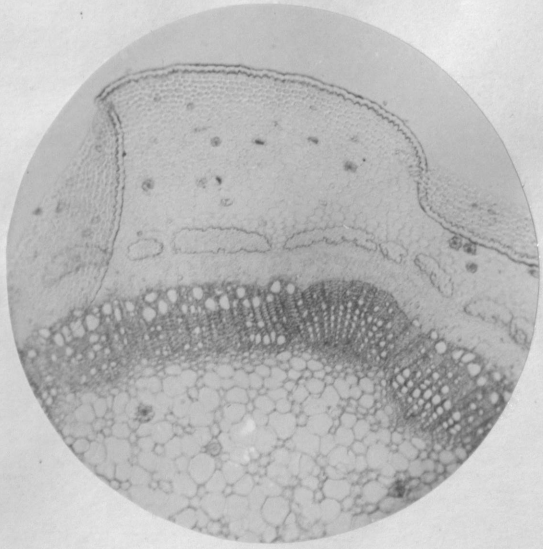


Fig. 4

STEM CROSS SECTIONS

(x 45)

Fig. 5 R. setigera, one year

Fig. 6 R. setigera, two year

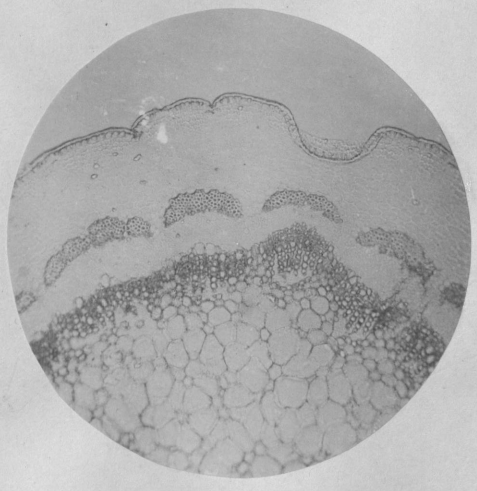


Fig. 5

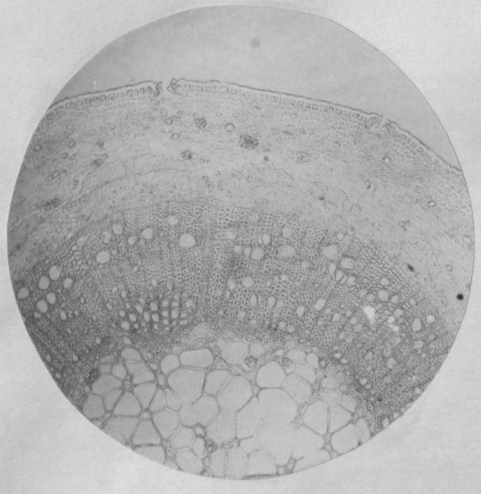


Fig. 6

STEM CROSS SECTIONS

(x 45)

Fig. 7 R. wichuraiana, one year

Fig. 8 R. wichuraiana, two year

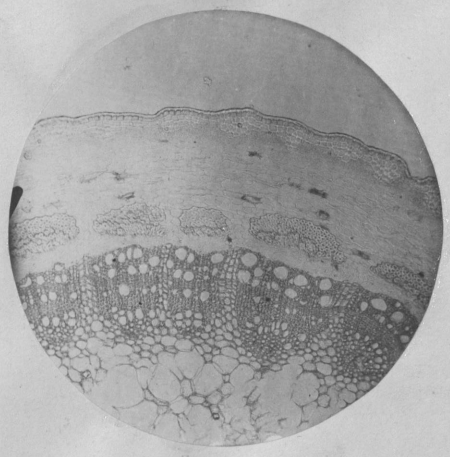


Fig. 8

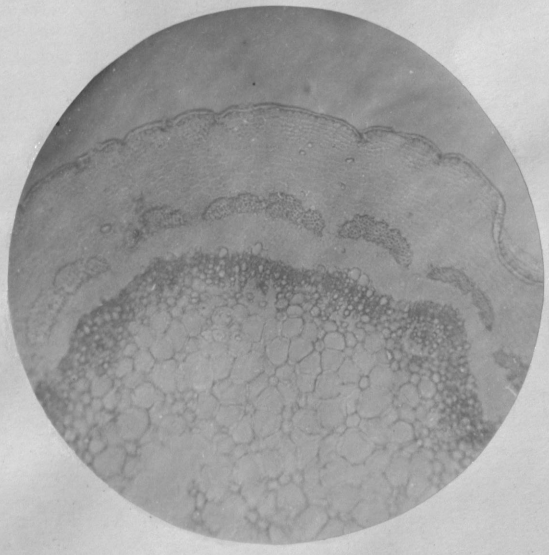


Fig. 7

STEM CROSS SECTIONS

(x 45)

Fig. 9 R. dumetorum, one year

Fig. 10 R. dumetorum, two year

Fig. 11 R. dumatorum, one year

Fig. 12 R. dumatorum, two year

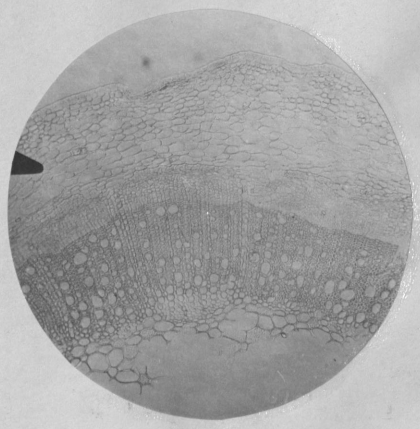


Fig. 9

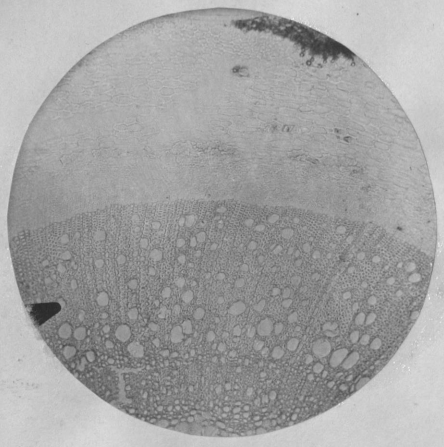


Fig. 10

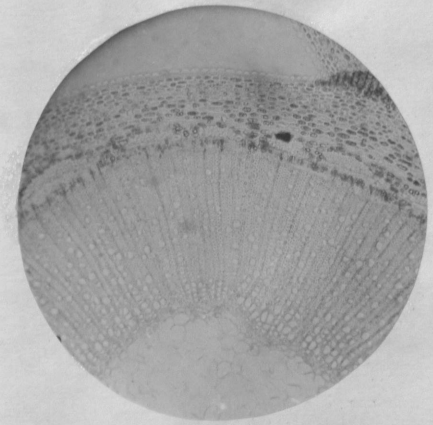


Fig. 11

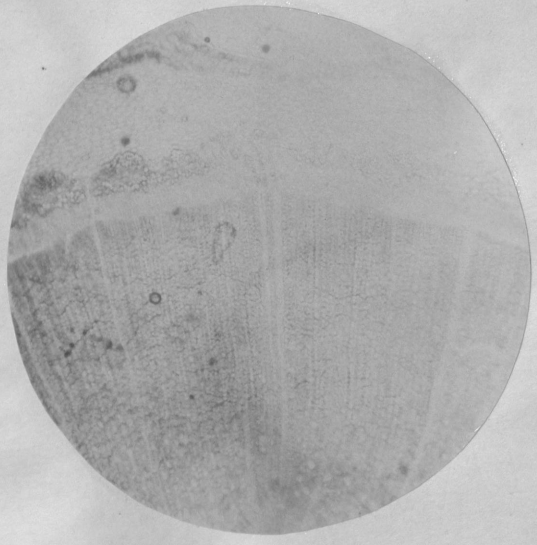


Fig. 12

STEM CROSS SECTIONS

(x 45)

Fig. 13 R. koreana, one year

Fig. 14 R. koreana, two year

Fig. 15 R. sericea, one year

Fig. 16 R. sericea, two year
(x 42)

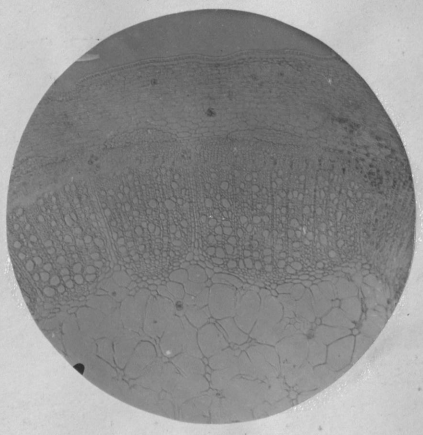


Fig. 13

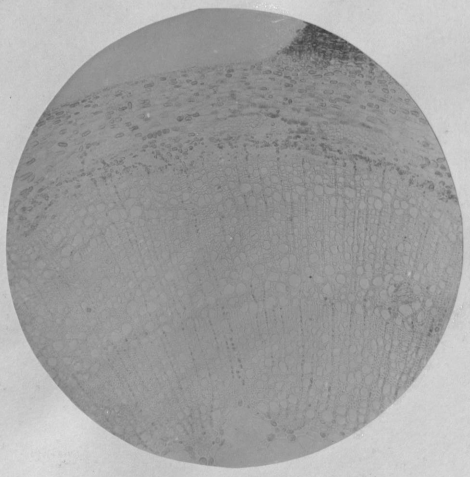


Fig. 14

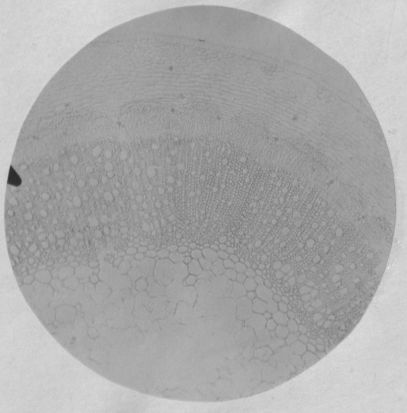


Fig. 15

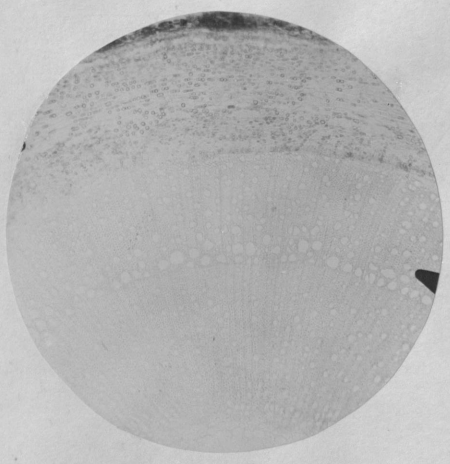


Fig. 16

STEM CROSS SECTIONS

(x 45)

Fig. 17 R. micrantha, one year

Fig. 18 R. micrantha, two year

Fig. 19 R. californica, one year

Fig. 20 R. californica, two year

Fig. 21 R. watsoniana, one year

Fig. 22 R. watsoniana, two year
(x 28)

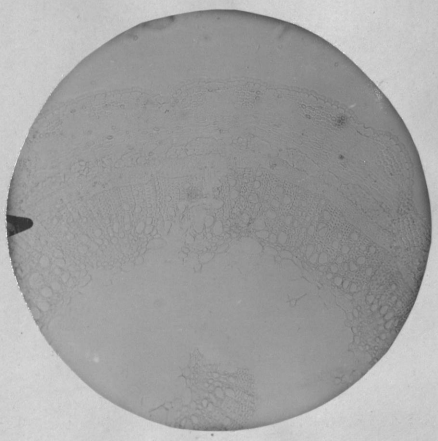


Fig. 17

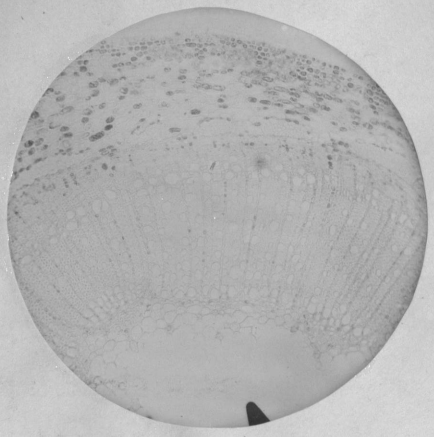


Fig. 18

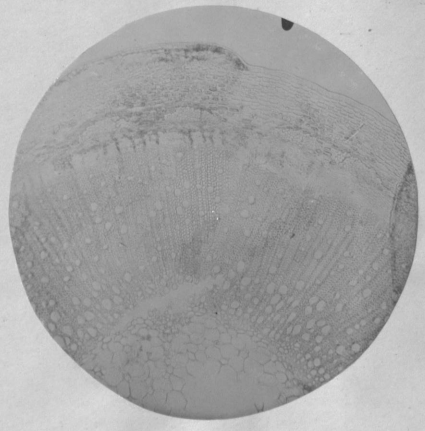


Fig. 19

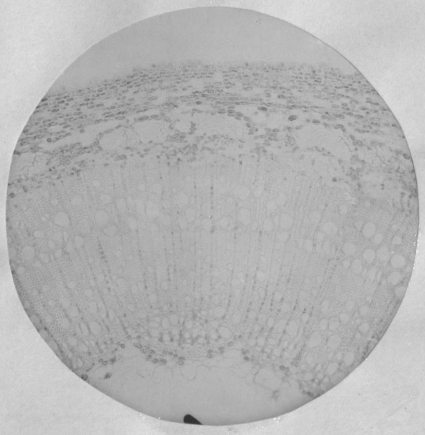


Fig. 20

Fig. 21

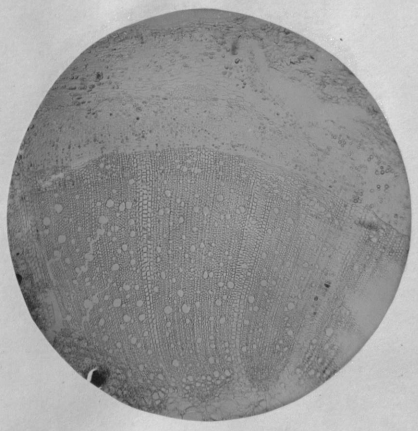


Fig. 22

STEM CROSS SECTIONS

(x 46)

Fig. 23 R. ecae, one year

Fig. 24 R. ecae, two year

Fig. 25 R. omeiensis pteracantha, one year

Fig. 26 R. omeiensis pteracantha, two year

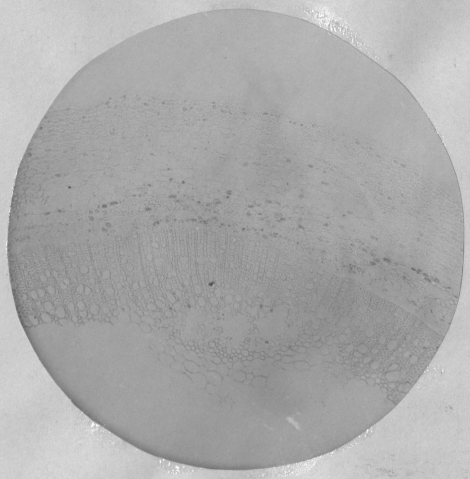


Fig. 23

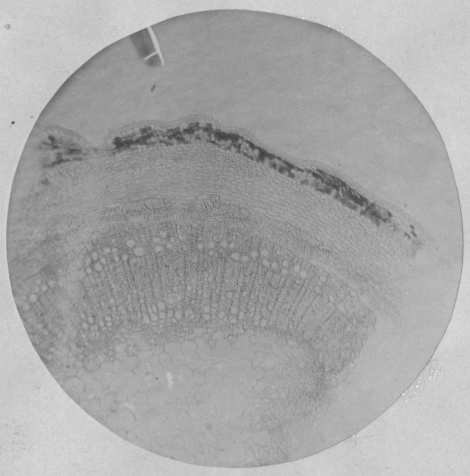


Fig. 24

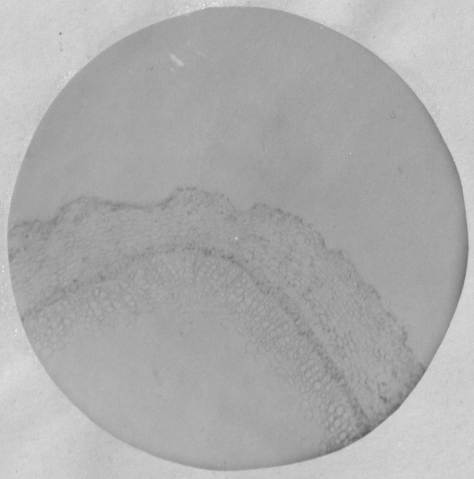


Fig. 25

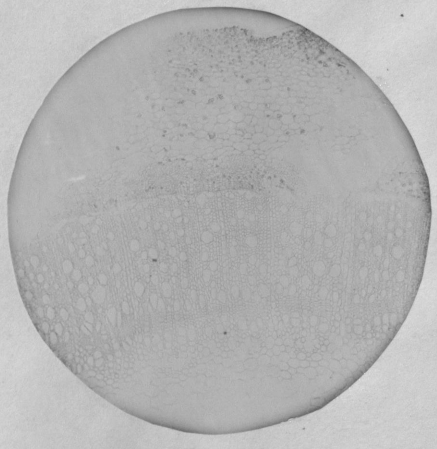


Fig. 26

STEM CROSS SECTIONS

(x 45)

Fig. 27 R. omeiensis, one year

Fig. 28 R. omeiensis, two year

Fig. 29 R. spinosissima, one year

Fig. 30 R. spinosissima, two year
(x 42)

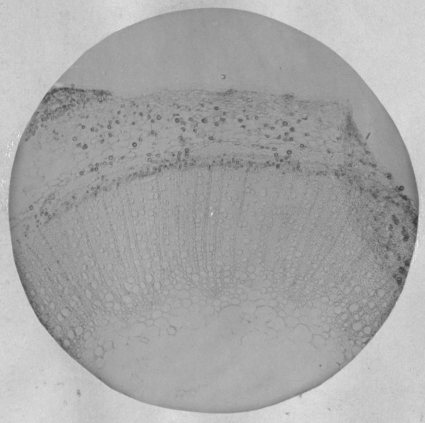


Fig. 27

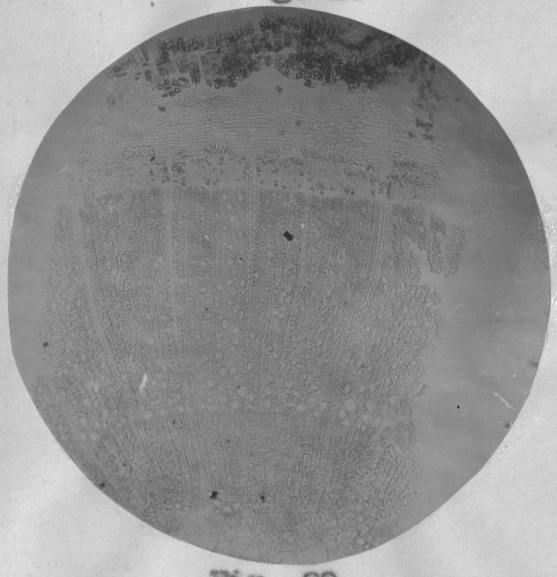


Fig. 28

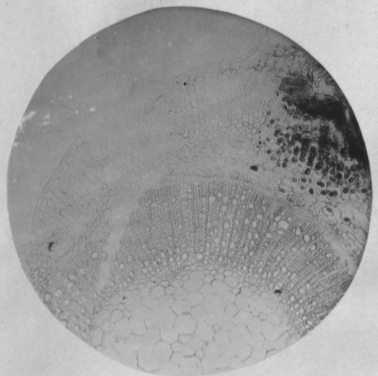


Fig. 29

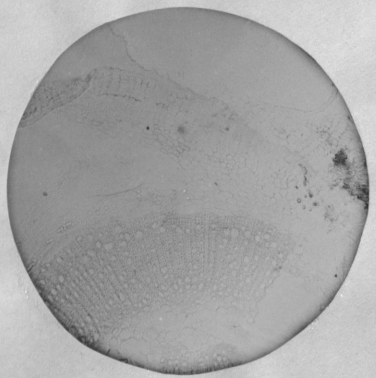


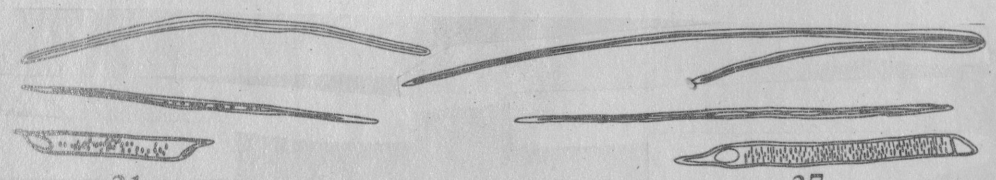
Fig. 30

ELEMENTS OF XYLEM AND PRIMARY

HARD BAST FIBER

(x 100)

Fig. 31	R. hugonis
Fig. 32	R. rugosa
Fig. 33	R. setigera
Fig. 34	R. wichuraiana
Fig. 35	R. dumetorum
Fig. 36	R. dumatorum
Fig. 37	R. sericea
Fig. 38	R. californica
Fig. 39	R. watsoniana
Fig. 40	R. ecae
Fig. 41	R. spinosissima



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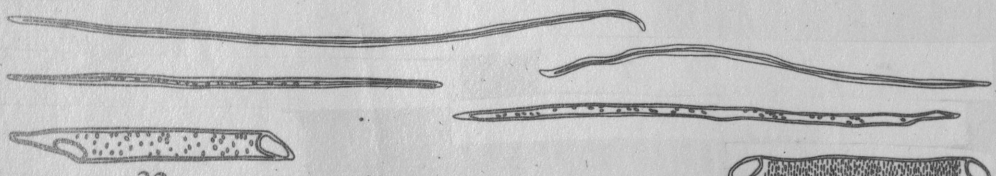

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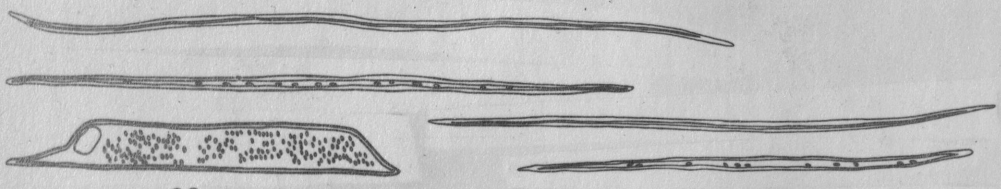

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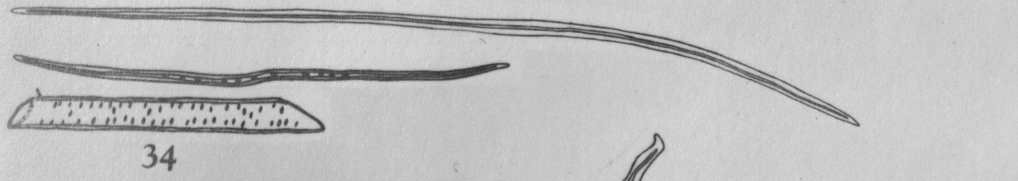

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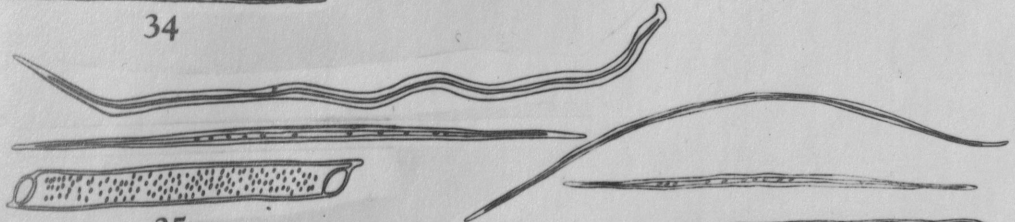

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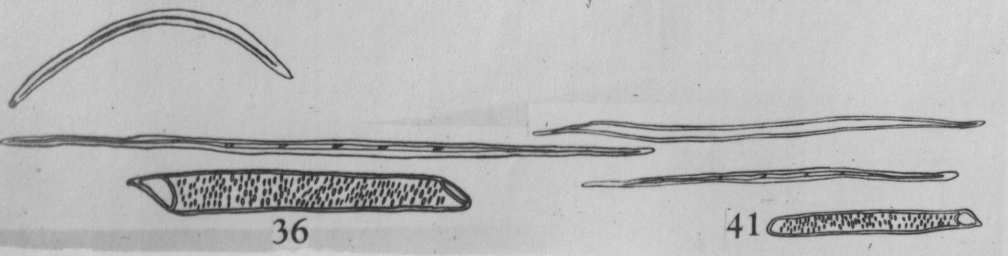

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41

ELEMENTS OF XYLEM AND PRIMARY

HARD BAST FIBER

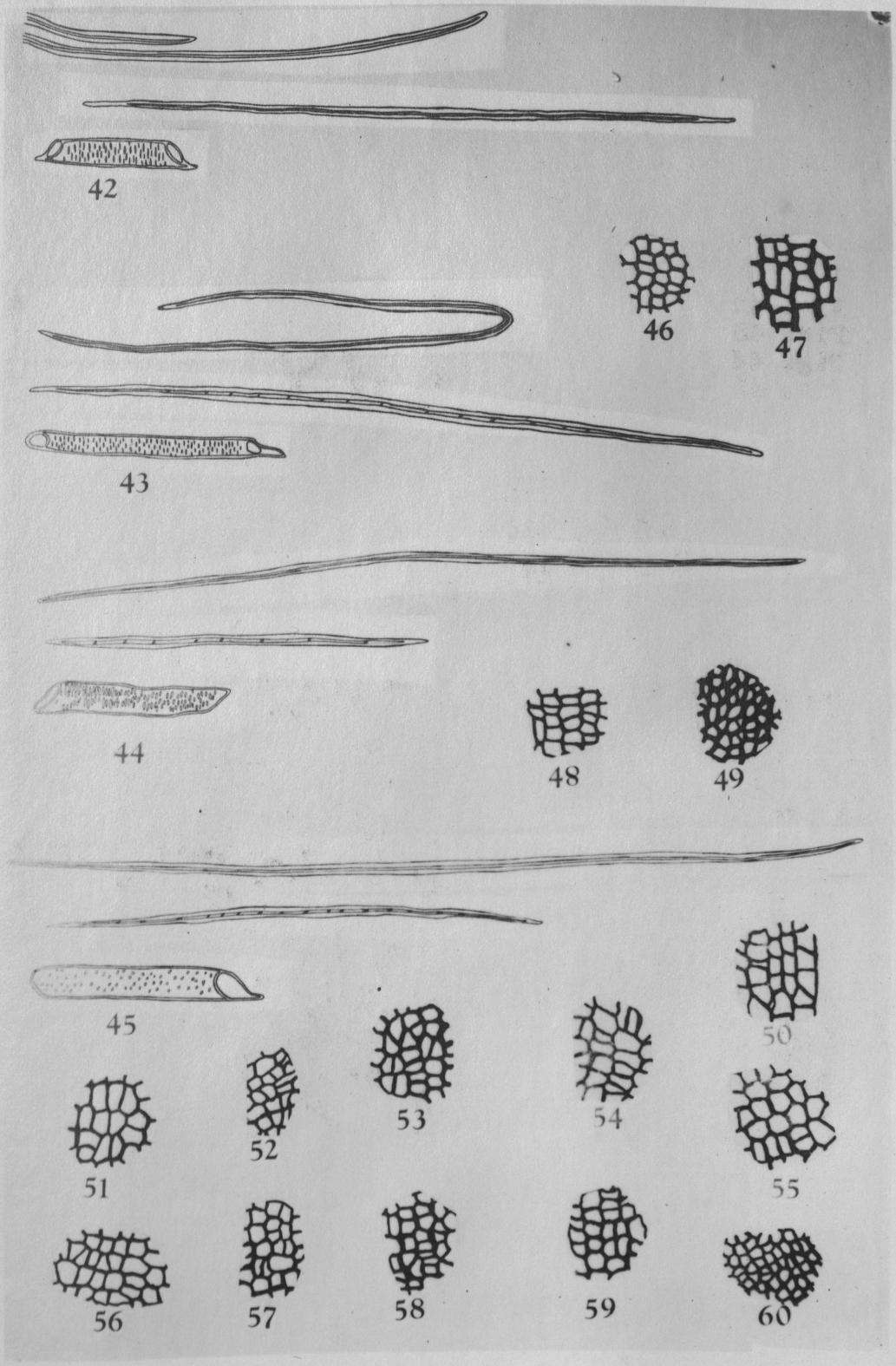
(x 127)

Fig. 42	R. koreana
Fig. 43	R. micrantha
Fig. 44	R. omeiensis pteracantha
Fig. 45	R. omeiensis

STEM EPIDERMISES

(x 92)

Fig. 46	R. hugonis
Fig. 47	R. rugosa
Fig. 48	R. wichuraiana
Fig. 49	R. setigera
Fig. 50	R. dumetorum
Fig. 51	R. spinosissima
Fig. 52	R. omeiensis pteracantha
Fig. 53	R. watsoniana
Fig. 54	R. micrantha
Fig. 55	R. dumatorum
Fig. 56	R. omeiensis
Fig. 57	R. ecae
Fig. 58	R. californica
Fig. 59	R. sericea
Fig. 60	R. koreana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LEAF VENATION

(x 32)

Fig. 66	R. hugonis
Fig. 71	R. rugosa
Fig. 74	R. setigera

MARGINS OF THE LEAVES

(x 143)

Fig. 61	R. hugonis
Fig. 70	R. rugosa
Fig. 75	R. setigera

LEAF EPIDERMISES

(x 92)

Fig. 62	R. hugonis, upper
Fig. 64	R. hugonis, lower
Fig. 68	R. rugosa, upper
Fig. 69	R. rugosa, lower
Fig. 73	R. setigera, upper
Fig. 72	R. setigera, lower

TRICHOMES

(x 92)

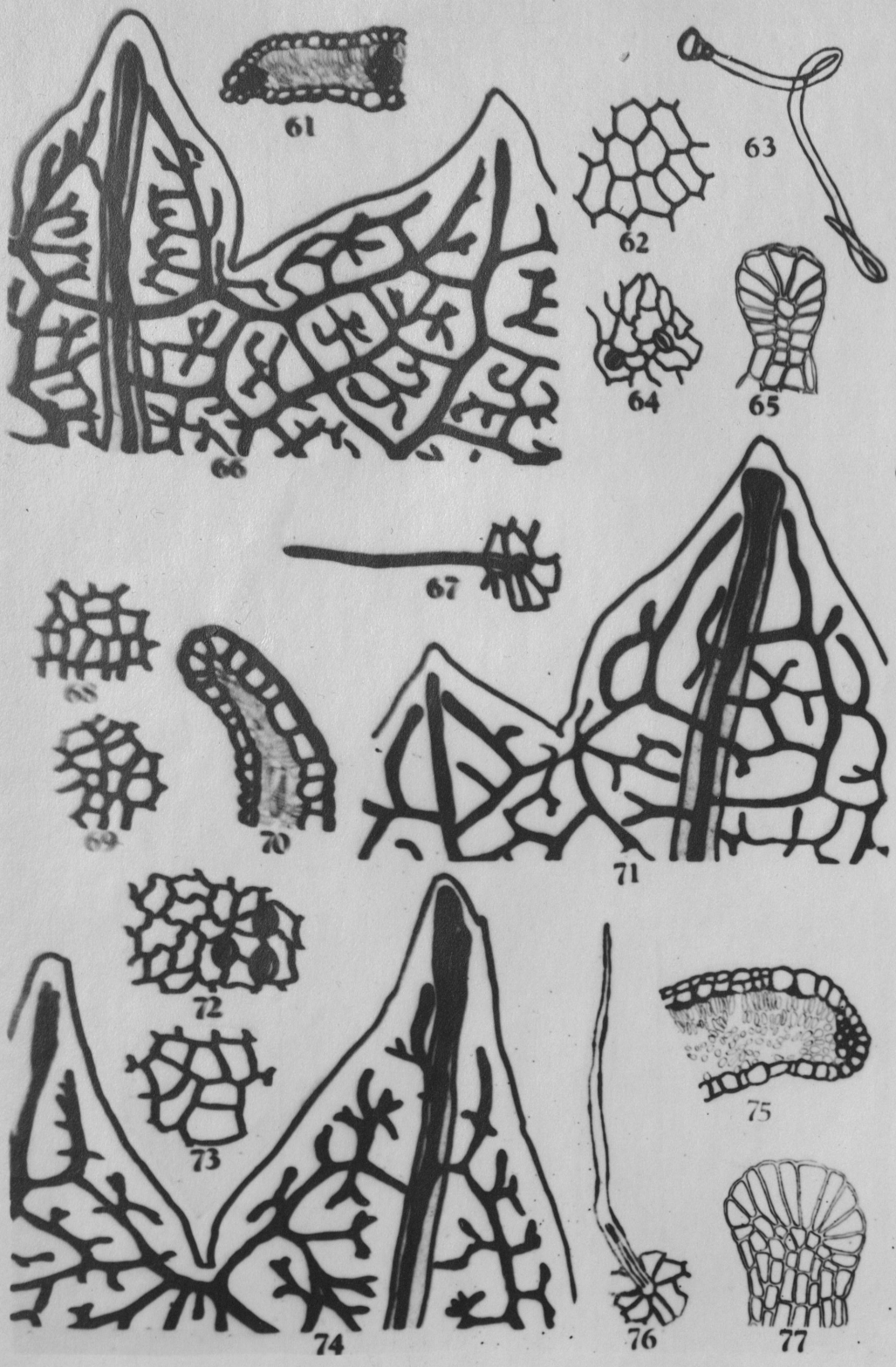
Fig. 63	R. hugonis
Fig. 67	R. rugosa
Fig. 76	R. setigera

GLANDULAR HAIRS

(x 255)

Fig. 65 R. rugosa

Fig. 77 R. setigera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LEAF VENATION

(x 32)

Fig. 84 R. wichuraiana
Fig. 85 R. watsoniana
Fig. 90 R. dumetorum

MARGIN OF THE LEAVES

(x 143)

Fig. 78 R. wichuraiana
Fig. 83 R. watsoniana
Fig. 89 R. dumetorum

LEAF EPIDERMISES

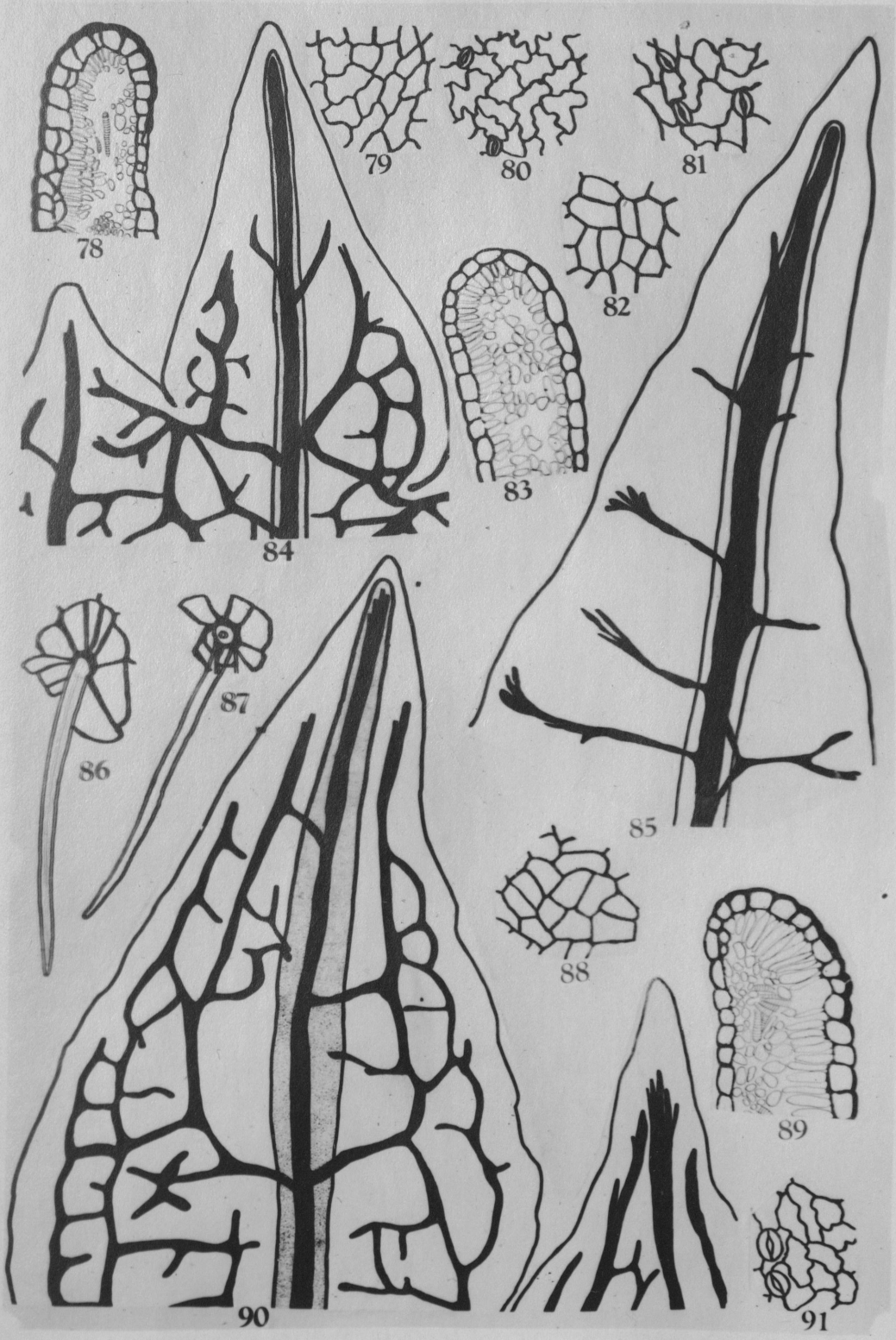
(x 92)

Fig. 79 R. wichuraiana, upper
Fig. 80 R. wichuraiana, lower
Fig. 82 R. watsoniana, upper
Fig. 81 R. watsoniana, lower
Fig. 88 R. dumetorum, upper
Fig. 91 R. dumetorum, lower

TRICHOMES

(x 92)

Fig. 86 R. watsoniana
Fig. 87 R. dumetorum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LEAF VENATION

(x 32)

Fig. 97	R. dumatorum
Fig. 100	R. koreana
Fig. 106	R. sericea

MARGINS OF THE LEAVES

(x 143)

Fig. 92	R. dumatorum
Fig. 96	R. koreana
Fig. 105	R. sericea

LEAF EPIDERMISES

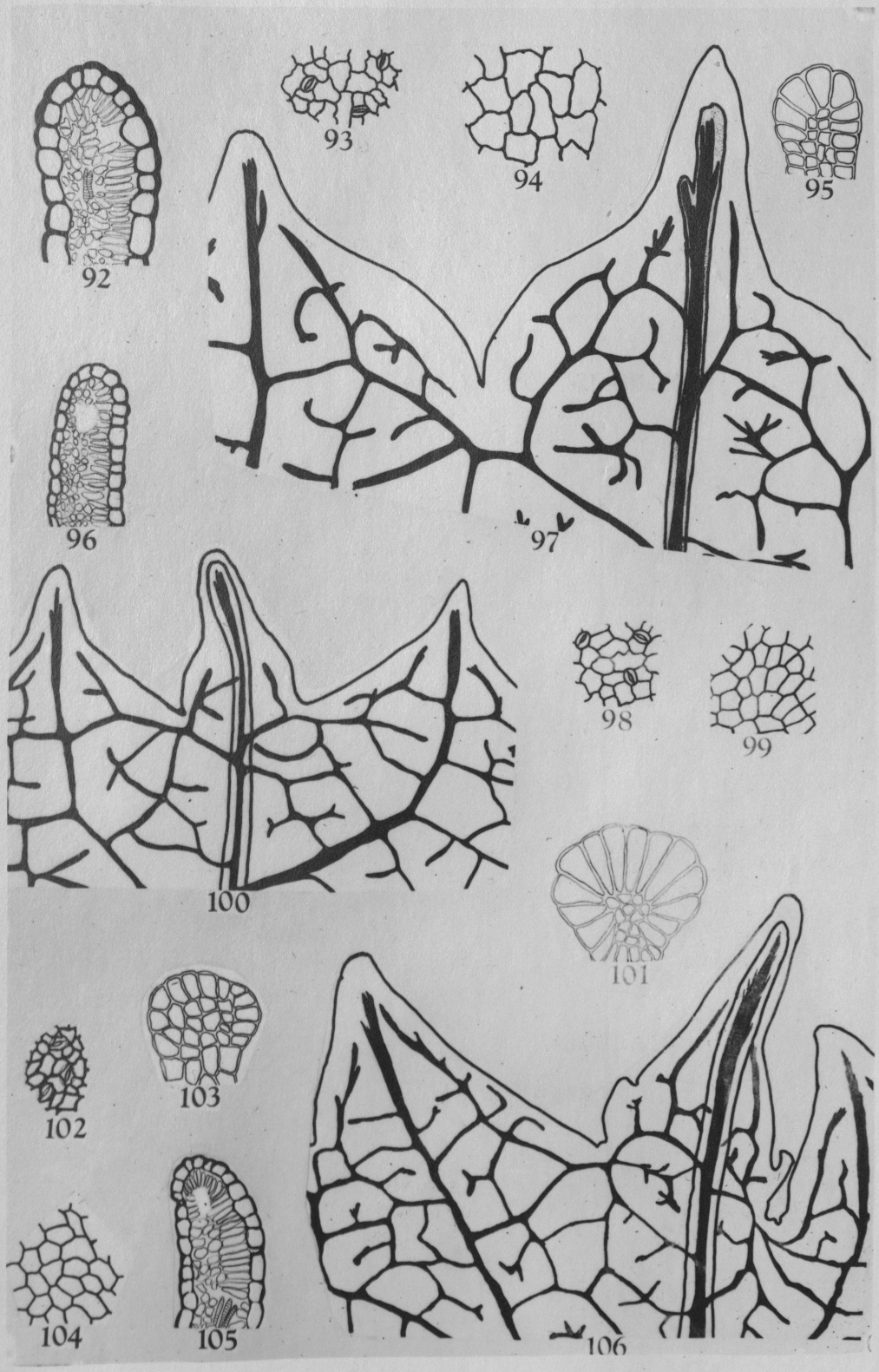
(x 92)

Fig. 94	R. dumatorum, upper
Fig. 93	R. dumatorum, lower
Fig. 99	R. koreana, upper
Fig. 98	R. koreana, lower
Fig. 104	R. sericea, upper
Fig. 102	R. sericea, lower

GLANDULAR HAIRS

(X 255)

Fig. 95	R. dumatorum
Fig. 101	R. koreana
Fig. 103	R. sericea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LEAF VENATION

(x 32)

Fig. 114	R. ecae
Fig. 115	R. californica
Fig. 123	R. micrantha

MARGINS OF THE LEAVES

(x 143)

Fig. 107	R. ecae
Fig. 113	R. californica
Fig. 120	R. micrantha

LEAF EPIDERMISES

(x 92)

Fig. 108	R. ecae, upper
Fig. 110	R. ecae, lower
Fig. 111	R. californica, upper
Fig. 112	R. californica, lower
Fig. 119	R. micrantha, upper
Fig. 121	R. micrantha, lower

TRICHOMES

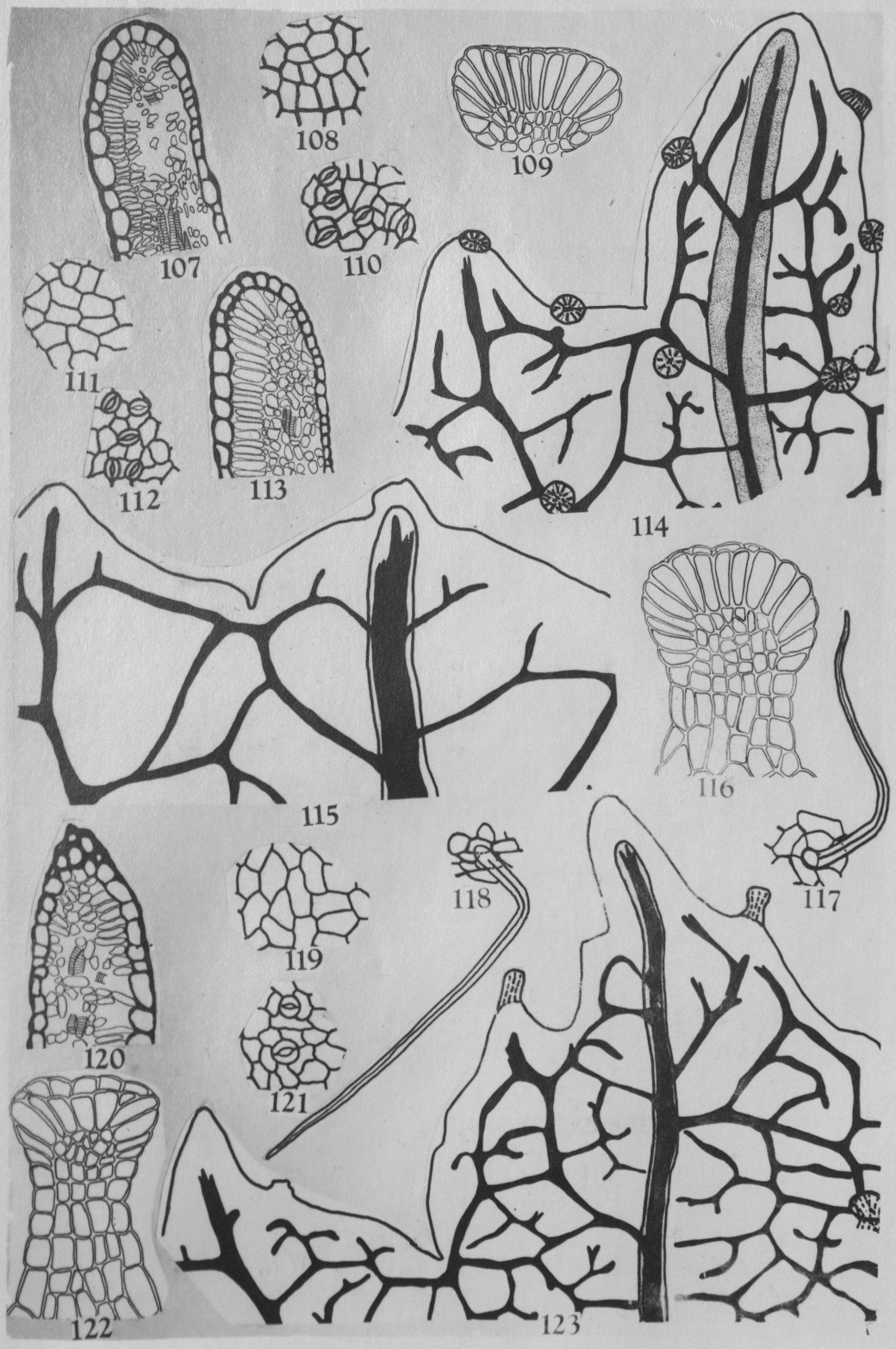
(x 92)

Fig. 117	R. californica
Fig. 118	R. micrantha

GLANDULAR HAIRS

(x 255)

Fig. 109	R. watsoniana
Fig. 116	R. californica
Fig. 122	R. micrantha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LEAF VENATION

(x 32)

Fig. 126	R. omeiensis
Fig. 130	R. spinosissima
Fig. 136	R. omeiensis pteracantha

MARGINS OF THE LEAVES

(x 143)

Fig. 129	R. omeiensis
Fig. 128	R. spinosissima
Fig. 134	R. omeiensis pteracantha

LEAF EPIDERMISES

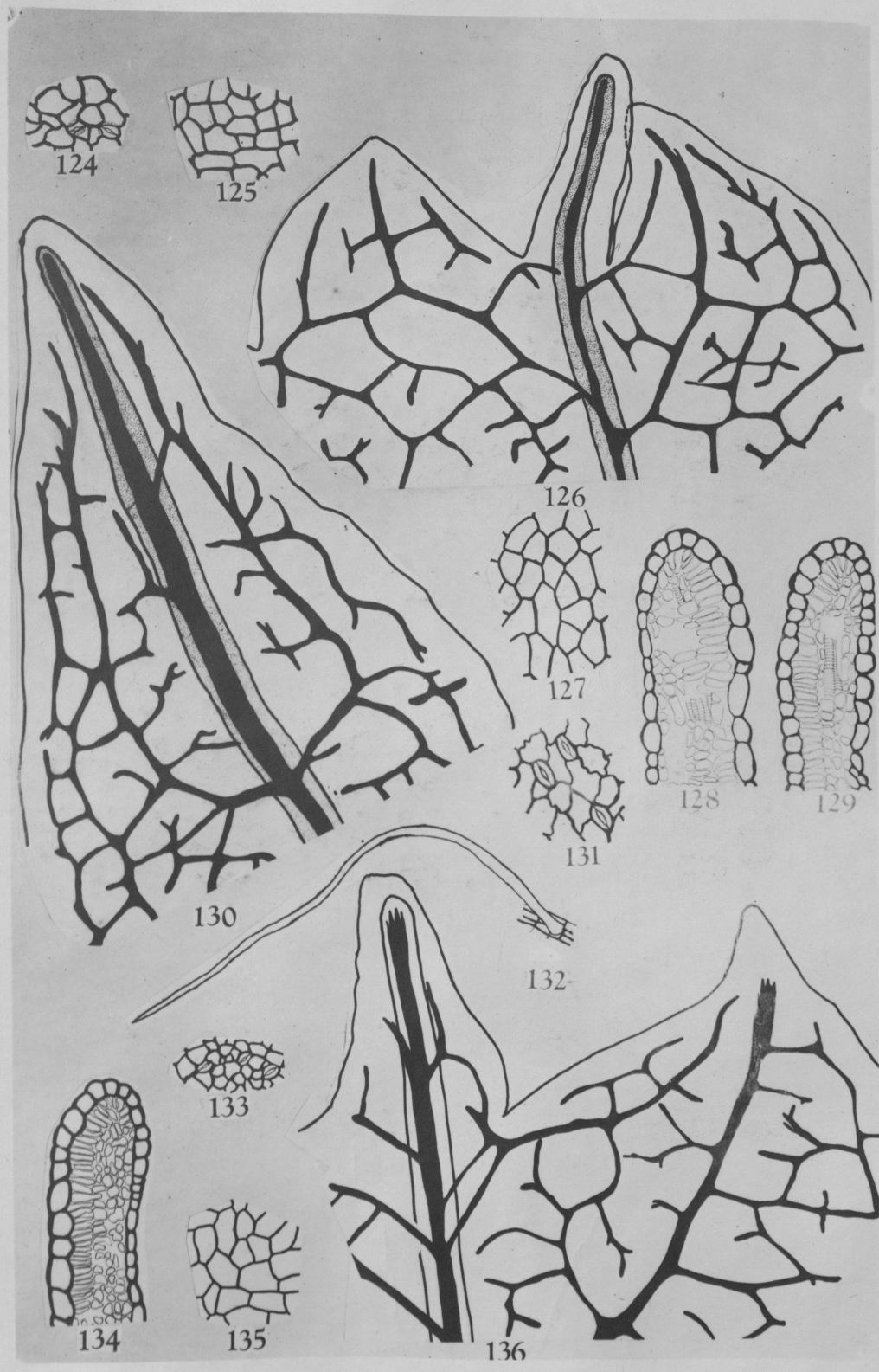
(x 92)

Fig. 125	R. omeiensis pteracantha, upper
Fig. 124	R. omeiensis pteracantha, lower
Fig. 127	R. spinosissima, upper
Fig. 131	R. spinosissima, lower
Fig. 135	R. omeiensis pteracantha, upper
Fig. 133	R. omeiensis pteracantha, lower

TRICHOMES

(x 92)

Fig. 132	R. omeiensis pteracantha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MIDRIB CROSS SECTION

(x 98)

Fig. 137 R. hugonis

Fig. 138 R. rugosa

Fig. 139 R. setigera

Fig. 140 R. wichuraiana

Fig. 141 R. dumetorum

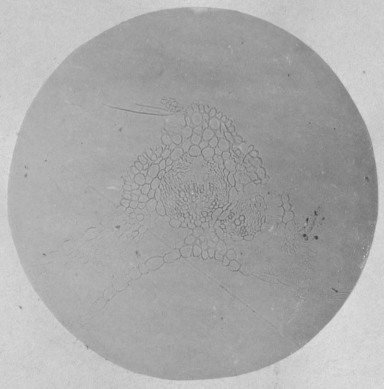

Fig. 137

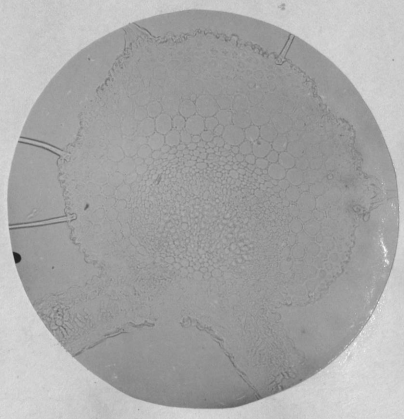

Fig. 138

Fig. 139

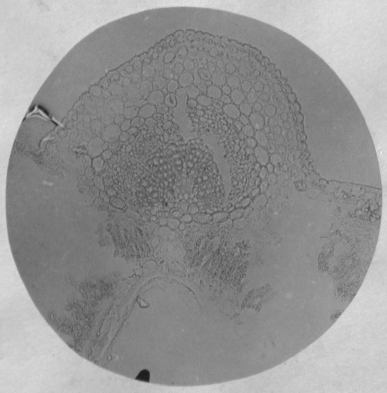

Fig. 140

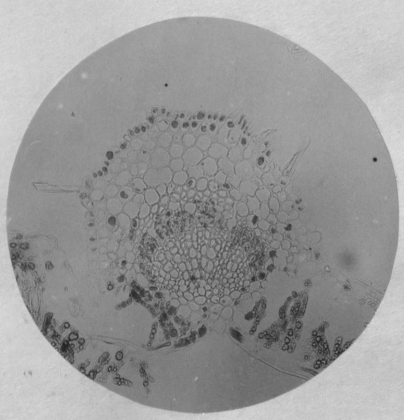

Fig. 141

MIDRIB CROSS SECTION

(x 98)

Fig. 142	R. dumatorum
Fig. 143	R. koreana
Fig. 144	R. sericea
Fig. 145	R. micrantha
Fig. 146	R. californica

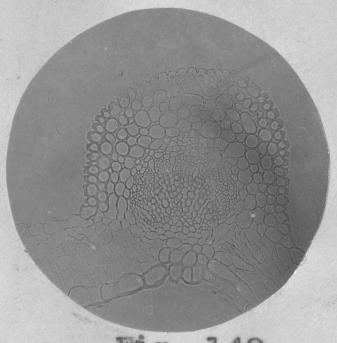

Fig. 142

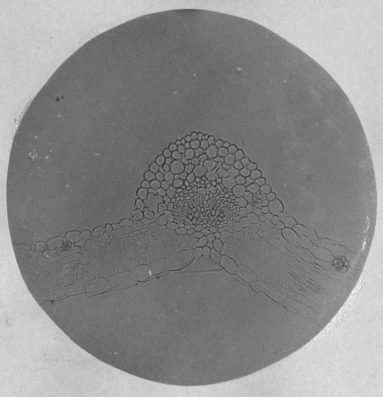

Fig. 143

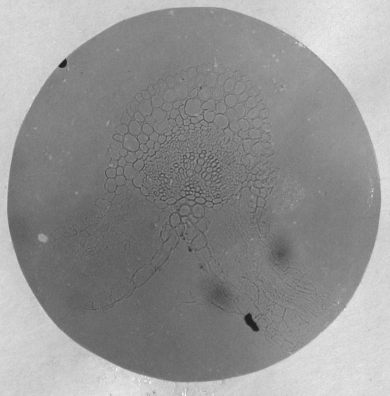

Fig. 144

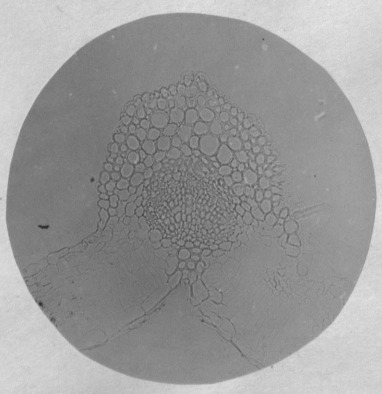

Fig. 145

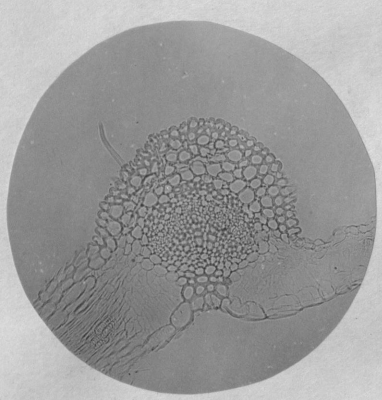

Fig. 146

MIDRIB CROSS SECTION

(x 98)

Fig. 147 R. watsoniana

Fig. 148 R. ecae

Fig. 149 R. omeiensis pteracantha

Fig. 150 R. omeiensis

Fig. 151 R. spinosissima

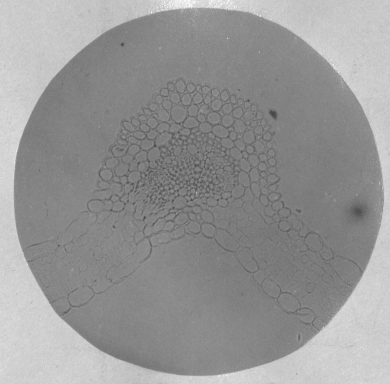

Fig. 147

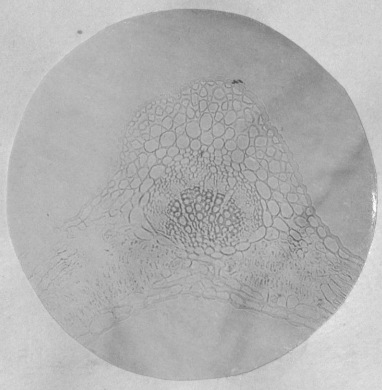

Fig. 148

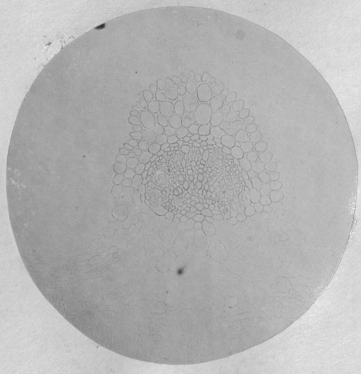

Fig. 149

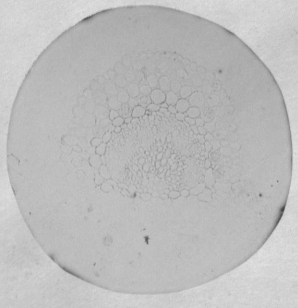

Fig. 150

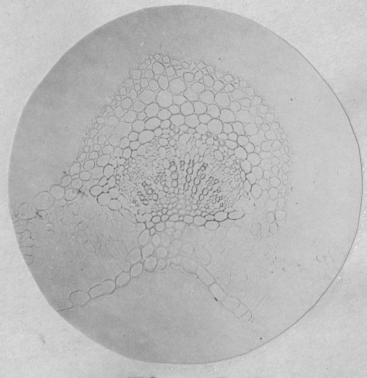

Fig. 151

PETIOLE CROSS SECTION

(x 58)

Fig. 152 R. hugonis

Fig. 153 R. rugosa

Fig. 154 R. setigera

Fig. 155 R. wichuraiana

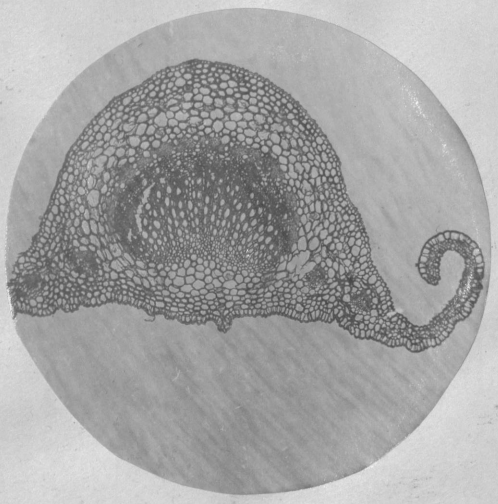

Fig. 152

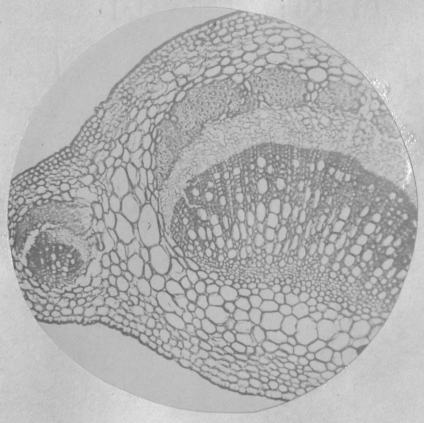

Fig. 154

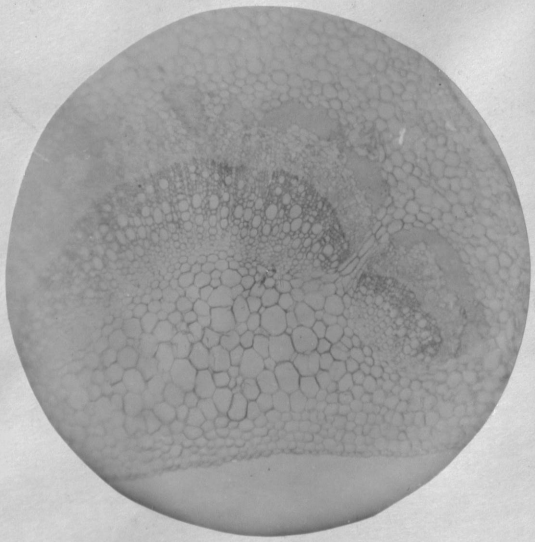

Fig. 153

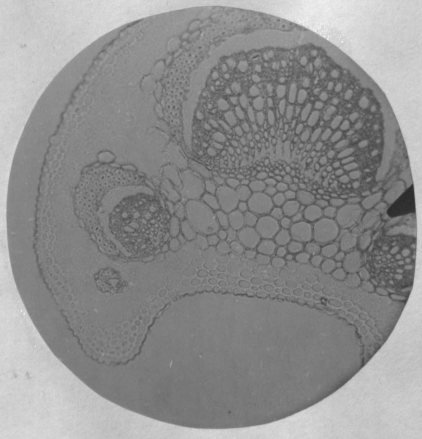

Fig. 155

PETIOLE CROSS SECTION

(x 58)

Fig. 156 R. dumetorum

Fig. 157 R. dumatorum

Fig. 158 R. koreana

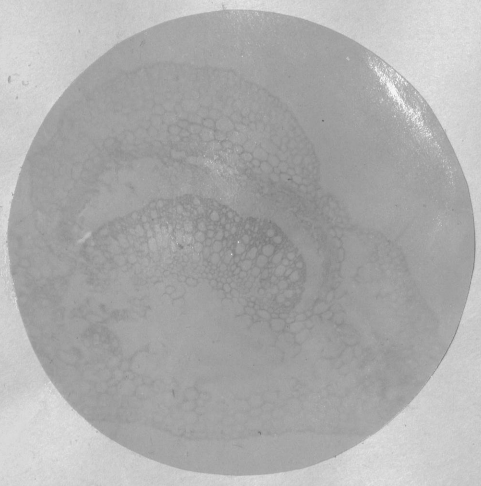

Fig. 156

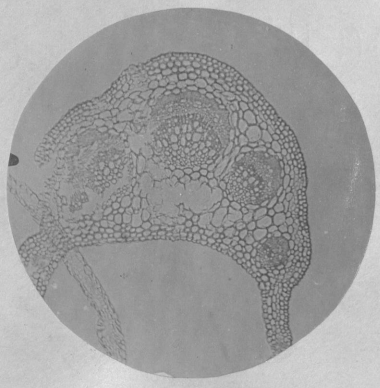

Fig. 158

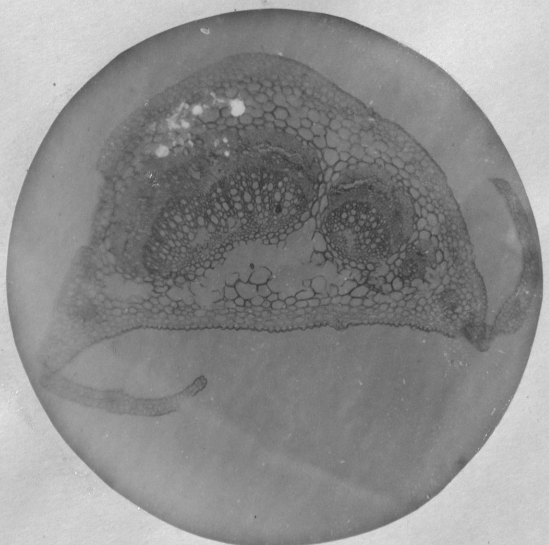

Fig. 157

PETIOLE CROSS SECTION

(x 58)

Fig. 159	R. sericea
Fig. 160	R. micrantha
Fig. 161	R. californica
Fig. 162	R. watsoniana

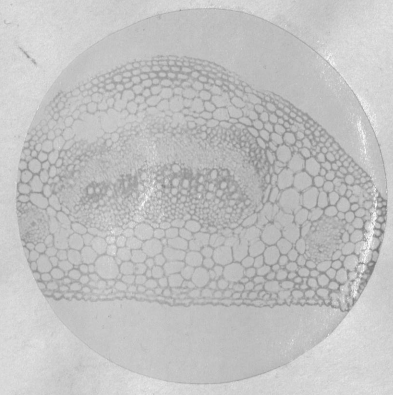

Fig. 159

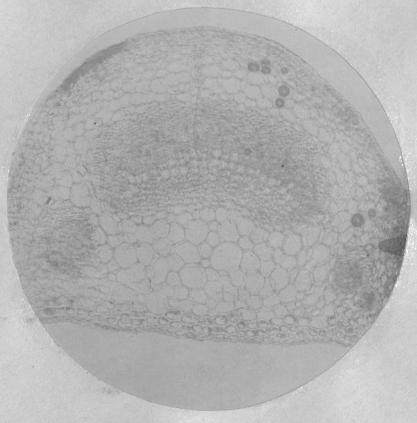

Fig. 161

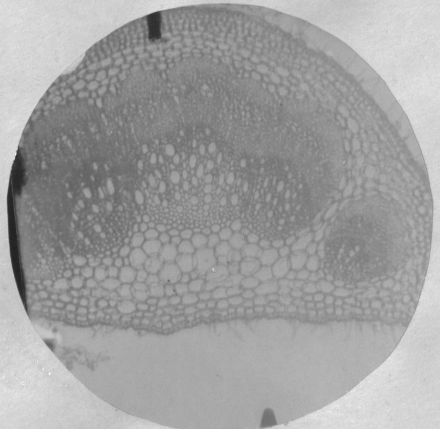

Fig. 160

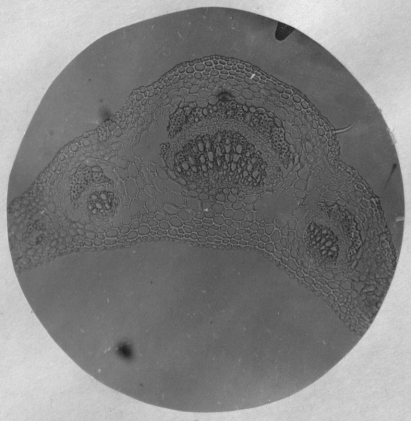

Fig. 162

PETIOLE CROSS SECTION

(x 58)

Fig. 163 R. ecae

Fig. 164 R. omeiensis pteracantha

Fig. 165 R. omeiensis

Fig. 166 R. spinosissima

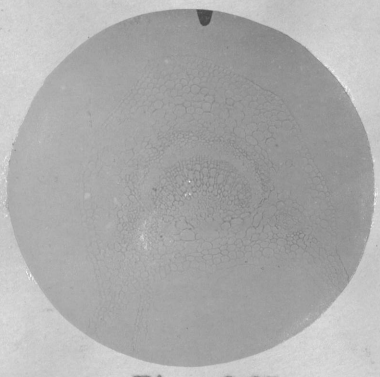

Fig. 163

Fig.165

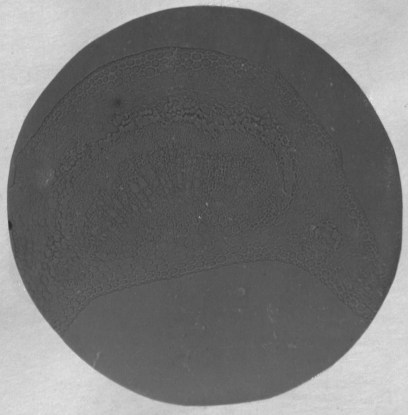

Fig.164

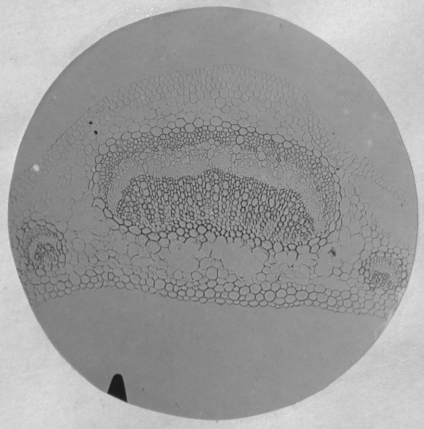

Fig. 166

CONCLUSION.

It has been possible in preceding pages to show outstanding histological as well as gross morphological differences; furthermore, I have been able, with the fifteen species of Rosa, to classify them according to histological features of the stem and also the leaves. In some instances I feel that the petiole and midrib alone would serve as criteria for classification of these species.

In conclusion I should like to bring out the anatomical characters common to all the species and those characters that are peculiar to a single species or group of species. Those features common to all the species of Rosa I have studied in this research are : (1) Absence of endodermis and lack of segregation of a pericycle; (2) Moderately thick-walled collenchyma cells in the stem, with the inner border usually undulated; (3) Cork of epidermal origin (except in micrantha); (4) Tendency of vascular system in petiole to be in several separate bundles; (5) Stomata restricted to lower leaf surface; (6) Presence of stipules. Those features peculiar to certain species are: (1) Presence of collenchyma at the leaf margin of hugonis, setigera, and micrantha;

(2) Collenchyma wanting in midribs of watsoniana; (3) Bast fibers occurring in midrib of rugosa, dumetorum, dumatorum, koreana, micrantha, californica, watsoniana, and spinosissima, absent in all the others; (4) Pith cells of two distinct sizes in hugonis, dumatorum, sericea, ecae, omeiensis pteracantha and spinosissima.

The plants of the genus Rosa are shrubs with upright, climbing or trailing stems. The stems may have almost a solid cylinder of bast fibers several cells wide radially; or it may have relatively few bast fibers.

The leaves of this genus are compound or simple, and stipulate usually; however, few species have simple leaves and no stipules. The fifteen species considered here have odd-pinnate and stipulate leaves. In some species of Rosa the stipules are adnate at the base of the leaf; while, in others the stipules extend one-half the length of the petiole. In those species considered here the stipules usually extend more than half the length of the petiole. Not only is there a wide range in size of leaflets, but also in their internal structures. For instance, I find that few of the species have leaflets with collenchyma at the margin (hugonis, setigera, micrantha), the others being without this feature. Also bast fibers occur in the midribs of some species and not in

others, and there is a great variation in the pattern of the venation and the spacing of its ultimate divisions; for instance, Rosa hugonis has approximately 28 vein endings per square millimeter, while californica has 1 to 2 vein endings. The palisade cells occur in 1 or 2 layers in these species and the number of palisade cells ranges from 7, 200 per square millimeter of leaf surface in watsoniana to 23,750 in koreana.

With wide ranges in histological features such as these before us, it becomes evident that, while variations in gross morphological characters have been taking place in the history of the genus, the cells and tissues composing the different members have also felt the forces compelling variations and have responded in ways so definite as to make these finer structures of taxonomic value no less than the larger superficial characters which the systematists have been accustomed to employ.

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