

Scientific Section

Papers Presented at the Sixty-Second Annual Convention

THE PHARMACOGNOSY OF THE MEDICINAL RHAMNUS BARKS.

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(Continued from page 75.)

THE PLANT CHARACTERS.

All of the RHAMNUS plants that have been mentioned, are shrubs or small trees, though some are inclined to be procumbent. They have simple, mostly alternate, petioled leaves, usually thin, bright green and glossy, at least on the upper surface, and rather prominently veined. The flowers are small, axillary, usually in small clusters and greenish. The parts of the flower are in fours or fives, though the petals may be absent and the ovary is but one. The flowers are sometimes diœcious, and upon this character these RHAMNUS species seem to fall into two classes, possessing, also, other distinct botanical characteristics, which extend even to the bark and thus cause the bark-drugs derived from the plants to form two rather distinct classes.

In the first division are *Rhamnus catharticus*, *Rhamnus tinctorius* (*chlorophorus*) and *Rhamnus croceus*. These are characterized, for instance, by being rather small shrubs, thorny, with leaves not over 2 or 3 inches long, the flowers diœcious and the parts in fours, the bark thin, the cork purple or blackish in color, the bast bundles very prominent and loose on the inner surface of the dried bark and the bark free from stone cells.

The other group of these RHAMNI includes the species *purshiana*, *californica*, *caroliniana* and *wightii*. These plants are tree-like or large shrubs, non-thorny, with leaves more than 2 or 3 inches long, the flowers perfect and the parts in fives, the bark mostly rather thick, the cork red-brown in color, the inner surface of the dried bark nearly smooth and the bark containing many groups of stone cells.

It is to be noted that *Rhamnus frangula*, included in neither group, corresponds in its botanical features with the second group, but its bark characteristics are like those of group one.

Rhamnus catharticus.—A spreading shrub, 6 to 10 feet high, though rarely up to 20 feet high, the ends of the twigs usually forming into stout spines. Leaves are up to 2½ inches long, but mostly less than 2 inches, broadly ovate or elliptical, rather acute at apex and obtuse at base, finely serrate, smooth and of thin texture. The veins are prominent on under surface, the laterals, 3 or 4 pairs, inclined to branch from lower half of midrib. The flowers are diœcious, 3 or 4 in an axil, on peduncles, the calyx-tube with 4 small teeth, the 4 petals narrow and scale-like.

The fruit is globose, lobed by 4 delicate longitudinal grooves, with 3 or 4 seeds, each deeply grooved.

Rhamnus tinctorius (chlorophorus):—The following is Decaisne's description: Twigs, cylindrical, ash gray, terminating in spines and scattered short hairs; leaves 3 to 5 cm. long, 2 to 3 cm. wide, alternate-opposite, short petiolate, ovate, acuminate, base cuneate, denticulate, glabrous above, pubescent beneath, nerves of leaf depressed on upper surface, prominent on lower surface; stipules linear, stiff hair-like, membranous; flowers (male) in twos or fours in the axils; calyx tube infundibuliform, cut into lanceolate, reflex, barely pubescent pieces; petals obovate, membranaceous; stamens not quite equal in height; ovary abortive; style divided, obtuse; berries small nuts obovoid or rounded, slightly furrowed below, shiny.

Rhamnus croceus:—Is shrubby, low and branching with spiny twigs and yellow wood. Leaves $\frac{1}{2}$ inch long, roundish-obovate, toothed, coriaceous, evergreen, nearly glabrous, when dry bright yellow-brown beneath. Flowers on short pedicels, 2 to 6 in the axils, dioecious, apetalous, sepal teeth and stamens four, ovary one, 2-celled; fruit yellowish, greenish and, when ripe, red, small obovate, usually, by abortion, 1-seeded; seed with a longitudinal furrow on one side.

Rhamnus purshiana:—Usually tree-like, averaging 15 to 20 feet high, but sometimes attaining a height of 40 feet with a trunk 18 inches in diameter. Leaves up to 7 inches long, broadly elliptic, apex obtuse, finely serrate, very thin, somewhat pubescent beneath and with prominent, evenly-spaced straight lateral veins. The flowers are in axillary clusters, the parts in fives. The fruit is 3-lobed and 3-seeded.

Rhamnus californica:—Shrubby, sometimes procumbent, again tree-like. It averages 15 feet high, though attaining a maximum of 30 feet. Leaves up to 3 or 4 inches long, oblong or obovate, obtuse apex, entire or finely serrate, rather thick, glabrous above, usually pubescent beneath. The flowers and fruit are like those of *Rhamnus purshiana*, though the fruit is usually 2-seeded.

Rhamnus caroliniana:—A shrub or small tree, with broadly elliptic leaves, 2 to 6 inches long, 1 to $2\frac{1}{2}$ inches wide, acute obscurely serrate, smooth, slightly pubescent on the veins beneath. Flowers in axillary, peduncled umbels or occasionally solitary, the parts in fives. Fruit is globular, smooth, sweet, 3-seeded.

Rhamnus wightii:—A shrub or small tree 9 to 12 feet high. The leaves are 3 to 5 inches long, 1 to 2 inches wide, elliptical or ovate, sharply acute, finely serrate,

(Detail of cut on succeeding page.)

RHAMNUS PURSHIANA BARK.

Fig. 1.—Transverse section from just below terminal bud. A—outer bark, B—middle bark, C—inner bark. 1—epidermis with curved trichomes; 2—phellogenetic layer (cork does not develop until the middle of first summer); 3—outer parenchyma developing into collenchyma; 4—inner parenchyma containing schizogenic mucilage sacs; 5—lining cells compressed and with living contents; 7—intercellular space filled with mucilage; 8—rosette aggregate of calcium oxalate (these are abundant in the parenchyma of the middle bark); 9—outer layer of angular, elongated cells, the developing primary bast; 10—primary phloem; 11—medullary ray of the bark; 12—developing cambium. (X 600, reduced $\frac{1}{2}$.)

Fig. 2.—Longitudinal radial section from just below the terminal bud. Letters and numbers as under Fig. 1. The pores in the walls of the parenchyma cells and the lining cells of the mucilage sacs are very evident. (X 600, reduced $\frac{1}{2}$.)

Figs. 3 and 3a.—Two mucilage sacs from the pith just below terminal bud. The lining cells are but slightly compressed, have no pores evident in the wall and contain living contents. (X 600, reduced $\frac{1}{2}$.)

Fig. 4.—Transverse section of outer bark from a 4-year-old stem. 1—epidermis with a thick cuticle; 2—cork with brownish wall; 8—phellogen; 4—parenchyma of middle bark. (X 600, reduced $\frac{1}{2}$.)

Fig. 5.—Transverse section of inner bark from a 4-year-old stem. 1—secondary bast with crystal fibers; 2—medullary ray; 3—phloem; 4—cambium. (X 600, reduced $\frac{1}{2}$.)

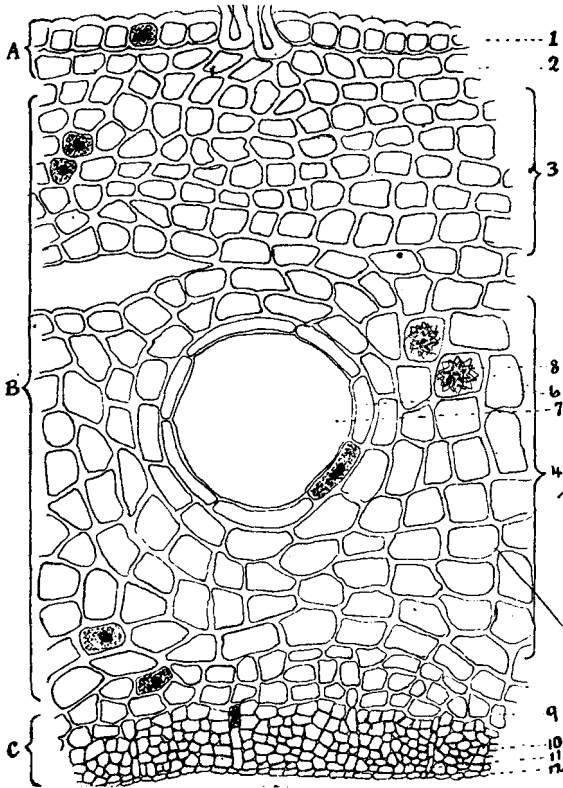


Fig. 1

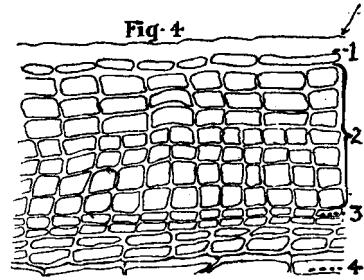


Fig. 4

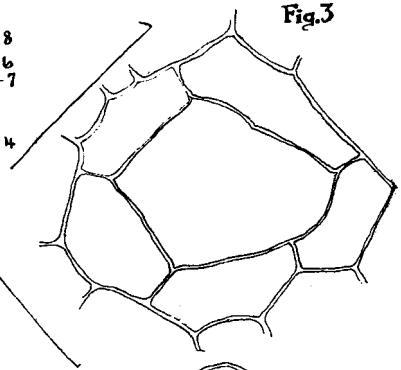


Fig. 3

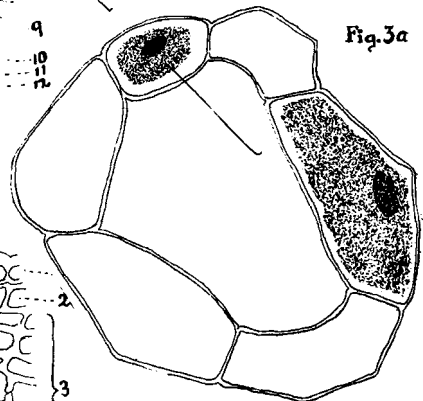


Fig. 3a

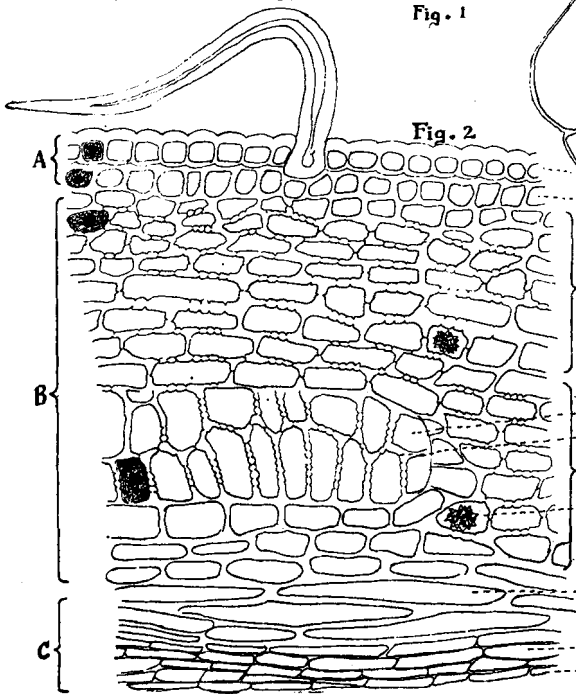


Fig. 2

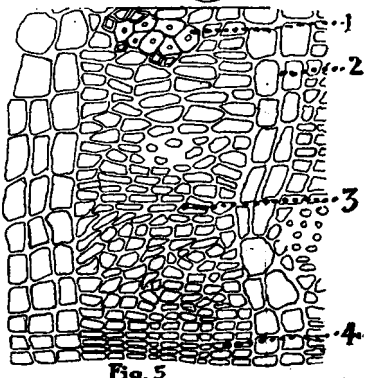


Fig. 5

smooth. Flowers are greenish-white, in axillary clusters, calyx 5-toothed petals 5, stamens 5, stigmas 3. Fruit ovoid, 3-seeded.

Rhamnus frangula.—A spreading³³ shrub, non-thorny, 6 to 15 feet or at the extreme 20 feet high. Leaves 1 to ⁴⁸ inches long, broadly oval or ovate, obtuse, entire, smooth above, somewhat pubescent below. The veins are prominent on the lower surface, the laterals numerous, straight and coming off at regular intervals along the midrib. Flowers, from May to September are perfect, small, whitish, 2 or 3 in each axil, the parts in fives. Fruit green, then red and when fully ripe blackish, is globular, the size of a large currant, smooth, though with 2 or sometimes 3 slight longitudinal grooves and usually 2-seeded.

EXTERNAL APPEARANCE OF THE DRUG.

It is to be noted that the bark from any tree or shrub usually presents wide differences in appearance, according to the age of the stem from which it is taken. This fact holds true of the bark-drugs derived from the RHAMNI under consideration and, though in the collection of the bark for the commercial drug, some effort is made to keep the article fairly uniform in appearance yet an admixture of bark from older and younger stems is common.

These RHAMNUS barks fall into the same groups as were noted under the botanical description of the plants. Thus the barks from *Rhamnus catharticus*, *Rhamnus tinctorius* (*chlorophorus*), *Rhamnus croceus* and *Rhamnus frangula* fall into one division, characterized particularly by the relative thinness of the bark, the fibrous fracture and tough, stringy bast bundles and the absence of stone cells from the middle bark. In the other group comprising the barks of *Rhamnus purshiana*, *Rhamnus californica*, *Rhamnus caroliniana* and *Rhamnus wightii* the barks are thicker, slightly fibrous in fracture with little external evidence of bast bundles and possess many stone cells.

All of these barks have some features in common. Thus, they all occur in quills and curved pieces, the thinner barks from the young stems being more inclined to quill and the thicker bark remaining in more or less curved pieces. On all of these barks, lenticels occur after the stem is one or two years old, but these may be more or less obliterated by the increased growth of cork or be covered by lichens which are present to a more or less extent. The color of the inner surface of the barks darkens with age. When freshly gathered, this color is usually a cream or very light-brown, but upon drying and aging may change to a dark seal-brown or almost black. The odor is slight, the taste rather mildly bitter, acrid and astringent.

Rhamnus frangula Bark:—(The description is made from various lots of the commercial drug purchased from drug dealers.)

In single or double quills, very seldom in curved pieces, up to .5 M. in length and 3 cm. in diameter, often crushed and flattened. The bark is seldom more than 1 mm. thick, though it may reach 2 mm. in thickness. The outer surface is a dark greenish- or brownish-purple, sometimes almost black, modified by grayish lenticels and lichens. The lenticels, usually abundant, regularly arranged and conspicuous, are transversely elongated up to 5 mm. and of a light gray or grayish-brown color. The lichens are whitish, fairly abundant, but rather inconspicuous. Some longitudinal wrinkles may be present. On bark from the older

stem. There may be considerable roughness, fissured brownish cork. The inner surface is marked by fine striations and occasionally loosened bast and varies in color from a light cinnamon to a dark sepia-brown. It fractures easily, rather abruptly and unevenly and shows projecting fibers, fine and short in young bark, sometimes longer and coarser in older bark but in this feature frangula bark differs markedly from the other members of this group. Odor, slight, taste mildly bitter, astringent and acrid.

Rhamnus catharticus Bark:—(From samples received from Professor William Mansfield of New York, the Missouri Botanical Gardens of St. Louis, and from shrubs in the South Parks of Chicago and in the author's gardens in Oak Park.)

In quills and curved pieces up to .5 M. in length and 2 cm. in width, the bark up to 2 mm. in thickness. The outer surface is black, sometimes with a brownish tinge and with occasional grayish lichens. The lenticels are rather few, small, rounded or somewhat elongated transversely, irregularly scattered and very dark-brown or almost black in color. On pieces from older stems the cork is transversely cracked and inclined to peel transversely in thin flakes. The inner surface is marked by fine striations and by many loosened bast strands so that it often appears very hairy. The color is of various shades of brown, the bast bundles nearly white. Odor is slightly aromatic, the taste bitter and acrid. It fractures easily and evenly except for the projecting bast bundles which may form a fine white "brush" an inch in length.

Rhamnus chlorophorus (tinctorius) Bark:—(From a specimen exhibited in a collection of rare drugs at the World's Columbian Exposition in 1893.)

Long, narrow, curved strips, often with some wood attached, the bark seldom more than 2 mm. in thickness. The external color is more inclined to purple than red, but modified by grayish lichens, red-brown transverse lenticels, rough, blackish cork, etc. The inner surface is like that of *Rhamnus catharticus* bark but more exaggerated. The base color of the inner surface is very dark brown, with the numerous light yellow bast strands easily breaking away and projecting as long threads. Upon fracturing, the inner bark becomes lamellated and the bast strands easily separate from the other tissues. The odor and taste correspond to those of the other *Rhamnus* barks.

Rhamnus croceus Bark:—(From specimens in the College Museum and received from Mr. Theodore Payne of Los Angeles, Calif.)

In thin quills and curved pieces, up to 3 or 4 mm. thick. Outer surface grayish to dark-brown with a marked red tinge where the outer layers are scraped away. The lichens are abundant, whitish and grayish and some bear brownish apothecia. Lenticels are inconspicuous. The inner surface is dark-brown with more or less light-yellow longitudinal lines or loose projecting bast strands. The fracture is short and even in the outer layers but exposing numerous short projecting bast bundles in the inner layer. The inner bark flakes off rather easily, exposing layer after layer of these tough interlacing strands of bast. The odor is slight but distinctly aromatic and the taste slightly bitter and rather pungent.

Rhamnus carniolica Bark:—(From a specimen received from Professor Henry Kraemer, Philadelphia.)

In quills or curved strips, the bark 1 to 3 mm. thick. The outer surface is dark

red-brown modified by many grayish lichens and numerous, rather obscure, irregular, light-brown lenticels, 1 to 2 mm. long. Some longitudinal wrinkles may be seen. The inner surface is grayish to dark-brown and striate. The fracture is short-fibrous, the fibers projecting .5 to 1 cm. from the inner bark. Odor slight; taste bitter and astringent.

Rhamnus purshiana Bark:—Commercial Cascara bark is seldom in quills, usually in pieces more or less curved or nearly flat, 5 to 10 cm. long and proportionately quite broad. The bark is seldom less than 1 mm. thick, usually 2 or 3 mm., but up to even 8 mm. thick. The basic color of the outer surface is red-brown but it is often so completely covered with dense whitish lichens that small pieces may be entirely white or grayish. Lenticels are present, transversely elongated and light brown, but, where the lichens are abundant, are inconspicuous. The lichens often show black or brownish apothecia. Adhering mosses are occasionally found and on the thicker pieces roughly fissured cork is present. The inner surface is finely striate and varies from a light yellow-brown to a dark- or purplish-brown. The fracture is quite abrupt, fairly even, though fine projecting fibers can be seen on the fractured surface. It has only a slight odor but a distinctly bitter, acrid and disagreeable taste.

Rhamnus californica Bark:—(Samples from Dr. Albert Schneider of San Francisco, and Mr. Theodore Payne of Los Angeles, California.)

In quills, curved and flat pieces, the bark rather thinner than Cascara bark. The natural color of the outer surface is a dull grayish red-brown exhibiting rather numerous but small and inconspicuous light-brown lenticels. Most of the bark is covered with grayish lichens, evenly distributed. These are often roughened and dull, rather than silvery as on cascara. The black apothecia are numerous. The inner portion of the cork is a bright reddish-brown. The inner surface of the bark varies from a light to a dark brown and is smooth or finely striate. The fracture, odor and taste are as those of Cascara bark.

Rhamnus wrightii Bark:—(Specimens from O. A. Farwell, Detroit.)

In single quills or curved pieces of varying thickness, color and markings, according to the age of the stem from which it is collected. From young stems the bark is seldom more than 1 mm. thick, of a brown color, more or less covered with grayish lichens, or reddish brown where the outer layer is scraped off so as to

(Detail of cut on succeeding page.)

RHAMNUS PURSHIANA BARK.

Fig. 6.—Mature mucilage sac from a transverse section 15 mm. below terminal bud. The lining cells (1) elongated tangentially and compressed radially (to the mucilage sac), with walls slightly lignified, with pores and of about the same thickness as the surrounding parenchyma cell-walls (2). (X 600, reduced ½.)

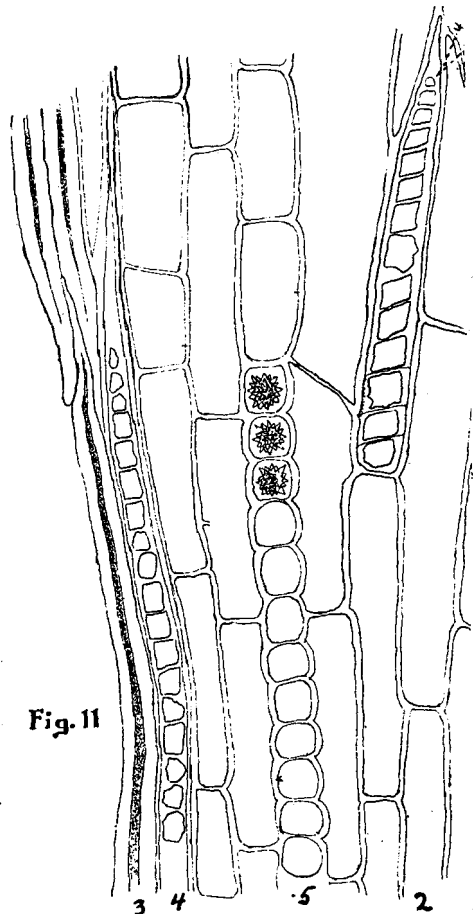
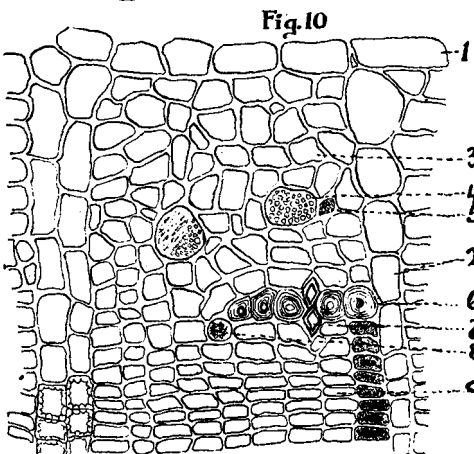
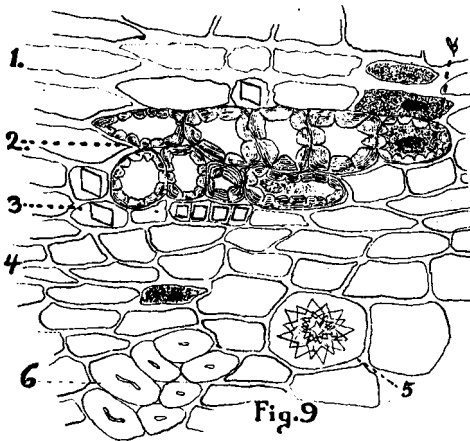
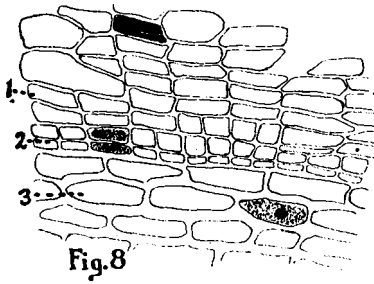
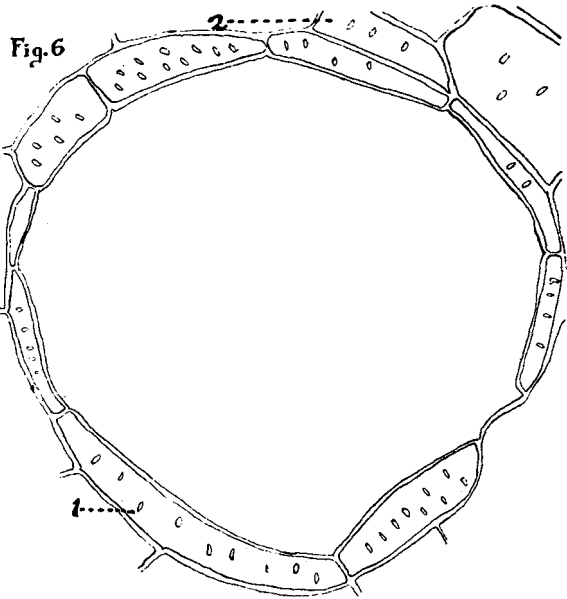
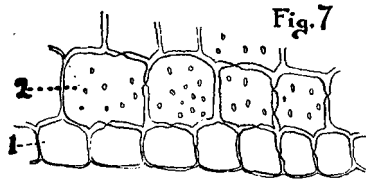
Fig. 7.—As in Fig. 6, except that the drawing is from a longitudinal section and is of a portion of one side of a wide mucilage sac. (X 600, reduced ½.)

Fig. 8.—Transverse section 30 cm. below terminal bud. 1—mature cork cells; 2—phellogen; 3—collenchyma. (X 600, reduced ½.)

Fig. 9.—Transverse section 30 cm. below terminal bud. 1—collenchyma; 2—group of stone cells with very distinct pores and stratifications developing from parenchyma of the middle bark; 3—prismatic crystals, single or in group, formed in connection with the group of developing stone-cells; 4—parenchyma cells of the middle bark; 5—large rosette aggregate of calcium oxalate crystals; 6—small group of unlignified primary bast. (X 600, reduced ½.)

Fig. 10.—Transverse section 30 cm. below terminal bud. 1—parenchyma of middle bark; 2—medullary ray; 3—phloem; 4—sieve tube showing sieve plate; 5—companion cell; 6—small group of secondary bast; 7—two crystal fibers in connection with the secondary bast; 8—small rosette aggregate of calcium oxalate crystals; 9—cambium. (X 600, reduced ½.)

Fig. 11.—Longitudinal section 30 cm. below terminal bud cut radially through phloem. 2—phloem parenchyma; 3—immature secondary bast; 4—immature crystal fibers; 5—row of rosette aggregates separated by septa (the whole row formed from one cambium cell). (X 600, reduced ½.)



expose the middle layer. Older bark is 2 or 3 mm. in thickness with grayish or whitish lichens and numerous corky lenticels. Bark from old stems is thicker and more or less rugged from numerous, deep, transverse or irregular cracks in the cork and of a dark brown color. The inner surface is dark brown, the color deepening with exposure in air to almost black. The fracture of the outer portion is short but of the inner layer fibrous and tough. It has a slightly aromatic odor and a somewhat astringent, bitter taste.

HISTOLOGY OF THE DRUGS.

The RHAMNUS barks present, histologically, many common features. They each exhibit an outer bark of cork tissue, a middle bark of parenchyma tissue bearing chlorophyll and an inner bark containing in addition to the phloem strands and medullary rays, strands of bast.

The chief histological distinction between these barks lies in the presence or absence of stone cells in the middle bark, and this distinction forms the same groups that have already been twice mentioned; viz: one group embracing the bark from the species *catharticus*, *tinctorius* (*chlorophorus*), *croceus* and *frangula* in which stone cells are absent and the group including the barks from the species *purshiana*, *californica*, *caroliniana* and *wightii* in which stone cells are present.

Rhamnus purshiana bark has been selected for the type-study and its structure is described in detail. The descriptions of the other barks bring out especially the points of distinction from Cascara bark.

Rhamnus purshiana Bark:—The fresh material used for these sections is from shrubs supplied by the U. S. Dept. of Agriculture and grown in Oak Park, Ill., and from specimens sent from the Missouri Botanical Gardens at St. Louis, Mo.

In a transverse section, cut from just beneath the terminal bud, from a stem collected in late fall, the bark measures about 0.4 mm. in thickness on each side of the stem, which was about 2 mm. in diameter. It is easily differentiated into an outer, middle and inner bark.

The outer bark (Figs. 1 and 2) consists of a row of epidermal cells, 15 to 20 microns in diameter, nearly cubical (square in both transverse and longitudinal sections), with thin inner and side walls and an outer wall thickened to 5 microns and cutinized. The lumen is filled with dark-brown contents. The epidermis bears many curved, pointed, unicellular trichomes up to 20 microns in thickness and 2 mm. long. Their walls are cutinized and form about two-thirds the diameter at the base of the trichome. The trichomes are even more abundant on the scales of the bud.

The middle bark (Figs. 1 and 2) consists of an outer layer of parenchyma cells somewhat elongated tangentially, with cytoplasm and nucleus and somewhat thickened, pored, cellulose walls. Then follows typical rounded parenchyma cells surrounding numerous tubular mucilage-sacs, the largest of which are 0.2 mm. across. The lumen of these sacs is bordered by thin-walled cells elongated tangentially (to the sac) and compressed radially (Fig. 1). These cells are, in fact, nearly cylindrical, for their diameter longitudinally (Fig. 2) is usually no greater than the radial diameter. These mucilage-sacs are apparently of schizogenic origin.

A study of the pith, where these secretion-sacs are also abundant, affords still further support of the view that these sacs are of schizogenic origin. Thus, as shown in Fig. 3, there are five cells, broad and thin-walled, with living contents surrounding an intercellular space containing mucilage. Fig. 3a represents a more mature secretion sac and shows the lining cells somewhat compressed but yet with living contents and thin, non-porous cellulose walls. Fig. 6 indicates a mature secretion-vessel from the pith in transverse section. It is 180 microns across, bordered by cylindrical cells elongated tangentially (to the vessel) to a maximum length of 135 microns, a width radially of 10 to 20 microns and a depth (as seen in Fig. 7), nearly the same. These cells possess simple, oval pores connecting one cell with another and with the adjoining pith parenchyma. In Fig. 7, a view of one side of one of these secretion-sacs in the pith cut longitudinally 10 mm. below the terminal bud, the secretion-cells show the wall facing the lumen of the vessel to be very thin and without pores, but the walls adjacent to the pith parenchyma to be thicker and to possess pores. The walls of both secretion- and parenchyma-cells are slightly lignified. The maximum length of these secretion-sacs is 0.7 mm., but in all observed, the ends were not bordered with secretion-cells, indicating possibly that the vessels were curved and longer than above stated. The mucilage stains with methylene blue, as does that of *Althaea* and *Ulmus* and in sections cut and kept in a small amount of water the fluid becomes quite sticky and stringy. The mucilage-sacs, both in the bark and pith, are present in abundance only for a short distance from the terminal bud. They are abundant in the bark, however, for a distance of several mm. about each lateral bud. Evidently the mucilage is stored for the use of the buds in their early spring development.

A few rosette aggregates of calcium oxalate (Figs. 1 and 9), 15 to 45 microns in diameter are found in the middle bark as also in the pith in this section.

The inner bark (Figs. 1 and 2) contains an almost continuous outer layer of cells, rounded, and from 5 to 10 microns wide, in transverse sections, but already elongated and with overlapping, pointed ends in longitudinal section. Their walls are of cellulose, somewhat thickened and they contain cytoplasm and nucleus. This is the developing primary bast. The inner layer of the inner bark is the primary phloem consisting of very small thin-walled cells with living contents. Sieve-tubes cannot be differentiated. The cambium is beginning to form. The wood circle, while very narrow, yet contains many xylem masses rather evenly spaced with two or three or several rows of parenchyma between them. Each mass contains from 1 to 10 very small spiral tracheal tubes.

In a transverse section cut from the stem, 2 mm. below the terminal bud, it was observed that the outer wall of the epidermis was much thickened, up to 10 microns thick; that the mucilage-sacs of the middle bark were somewhat larger, the lining cells being more compressed radially and elongated tangentially; that the primary bast cells had somewhat thickened their walls and were becoming angular in shape; that the cambium was well formed, had added several tracheal tubes to each xylem mass and had increased the amount of phloem. Large rosette aggregates were very abundant in middle bark and pith. The formation of crystals in the secondary phloem was also noted. Medullary rays between the xylem masses and extending into the phloem were easily differentiated.

In sections cut from the same stem, 15 mm. below the terminal bud, it was noted that the outer wall of the epidermis had further thickened and was now fully 15 microns wide. The mucilage-sacs were few. The outer parenchyma of the middle bark had very much thickened its cell walls with cellulose, in fact resembled collenchyma. Primary bast had further thickened its walls which still remain cellulose. The cambium had developed much xylem, the wood circle being now 2.5 mm. in thickness. The medullary rays were distinct, filled with starch, the grains being 4 to 6 microns wide.

At 20 cm. from the terminal bud the first development of cork was noted, otherwise the stem showed little change except a large growth of wood. At about 25 cm. from the bud the first lignified secondary bast was seen and at 30 cm. the formation of stone cells from parenchyma cells of the middle bark had begun.

A description of sections of the stem at 30 cm. from the terminal bud is as follows:—

Total diameter of stem 7 mm., of which the bark is 0.6 mm. on each side.

The outer bark (Fig. 8) consists of six rows of cork cells from 15 to 30 microns tangentially, 10 to 15 microns radially and the same longitudinally. In transverse and longitudinal sections they are 4-sided and arranged in radial rows. The walls are thin, suberized and brownish in color. Some of the cells appear to be filled with a homogenous brown mass.

Middle bark (Fig. 9). The outer collenchyma has undergone no change. Its cells are from 15 to 45 microns tangentially, 10 to 15 microns radially and 30 to 60 microns longitudinally. Their walls of cellulose are from 3 to 8 microns in thickness; the contents are cytoplasm and nucleus and dark brown in color. The inner layer of the middle bark consists of parenchyma 15 to 30 microns tangentially and longitudinally, 10 to 15 microns radially, the cellulose walls 3 or 4 microns in thickness with elongated oval or angular pores. The contents are similar to those of the collenchyma. Mucilage-sacs, except near lateral buds, are practically absent.

The stone cells develop from the parenchyma of the middle bark apparently by a thickening and lignification of the walls. No characteristics in any of the parenchyma cells could be found to indicate they would become stone cells until the first sign of lignification occurred. In Fig. 9, *b* indicates a cell with walls no thicker than the adjoining parenchyma cells, but it shows pores more plainly and it has begun to lignify. Usually but one or two parenchyma cells at a spot show

(Detail of cut on succeeding page.)

RHAMNUS PURSHIANA BARK.

Fig. 12.—Longitudinal section of phloem showing development of a row of calcium oxalate rosettes separated by delicate septa. (X 600, reduced $\frac{1}{2}$.)

Fig. 15.—Tangential section through phloem of bark 1.5 mm. thick from a 5-year-old stem. 1—phloem parenchyma; 2—one fiber of a bast bundle; 3—crystal fibers with prismatic crystals separated by septa; 4—medullary ray. (X 600, reduced $\frac{1}{2}$.)

Fig. 16.—Transverse section from bark 5 mm. thick. A group of bast fibers associated with stone cells and crystal cells. 1—bast fiber; 2—stone cell; 3—crystal cell; 4—parenchyma cell of phloem. (X 600, reduced $\frac{1}{2}$.)

Fig. 17.—Stone cells from the powder.

Fig. 18.—Cork in surface view from the powder.

Fig. 19.—Phloem parenchyma containing starch from the powder.

Fig. 20.—Phloem parenchyma with sieve tube and a radial view of a medullary ray (from the powder).

Fig. 21.—Phloem parenchyma with medullary rays in tangential view (from the powder).

Fig. 22.—The end of a mass of bast. 1—bast fibers; 2—crystal fibers; 3—crystal fiber inside view.

Figs. 17 to 22, inclusive, are X 600, reduced $\frac{1}{2}$.

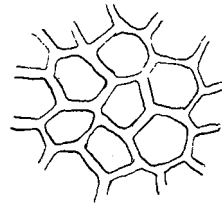
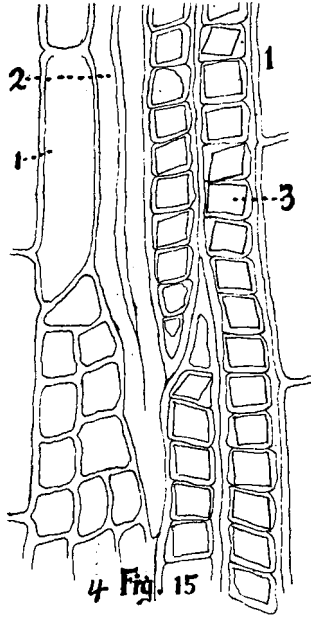
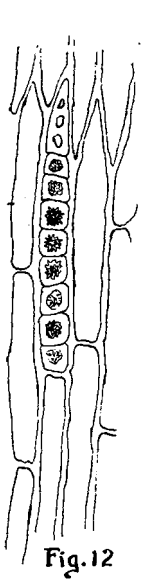


Fig. 18

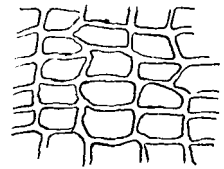


Fig. 19

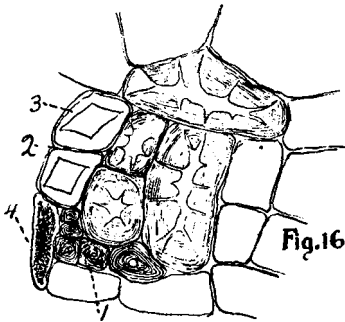


Fig. 16

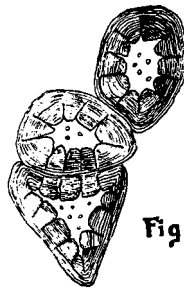


Fig. 17

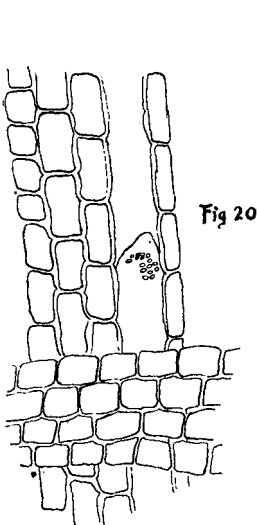
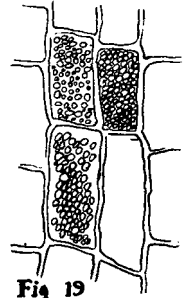


Fig. 20

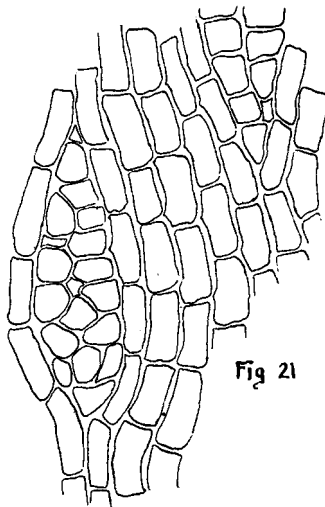


Fig. 21

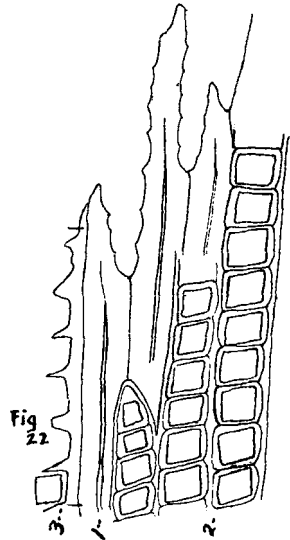


Fig. 22

these first signs of change but neighboring cells follow until they form a group of stone cells varying in size but usually not larger than 4 cells radially, 20 cells tangentially and 10 cells longitudinally. The first section showing stone cells contained but the one small group, but the number of groups rapidly increased from this point on.

There are formed at this time in some of the parenchyma cells adjoining the stone cell group, small prismatic crystals of calcium oxalate, seldom exceeding 15 microns in greatest diameter and usually not more than 8 or 10 microns. One or more of the crystals may occur in a cell. If more than one occur, they are separated by a delicate septum or septa of cellulose. The slight enlargement of the parenchyma cells, when forming into stone cells, tends to compress the surrounding parenchyma and causes the stone cells to be angular or irregular in shape. Usually their greatest diameter is tangentially and seldom exceeds 60 microns. They mostly are from 30 to 45 microns, some as small as 15 microns in diameter. The walls are thickened sometimes almost to the extinguishment of the lumen (Fig. 14), again the lumen may occupy one-third the total diameter (Figs. 16 and 17). Pores are prominent and stratifications may be distinguished.

Inner bark (Fig. 10). This is still very narrow, hardly more than 100 microns wide. The primary bast (Fig. 9), in small scattered bundles, the fibers with thick cellulose walls, may be seen at the outer edge of the inner bark. The phloem presents nothing new.

The secondary bast, first observed about 5 cm. higher up in the stem, is now seen to be present in small bundles of 2 to 24 fibers, 30 bundles in a single row being present in this transverse section. The bast fibers seldom exceed 15 microns in diameter, nor more than 0.8 mm. in length. They are circular or somewhat angular in transverse section and in longitudinal view fiber-like with slenderly tapering ends (Fig. 11). The lumen is seldom more than one-fifth the total diameter. The walls are partially lignified, the cell contents nearly gone.

Crystal fibers are found adjacent to the bast bundles (Fig. 11). One bundle of bast in transverse section containing 13 bast fibers had adjacent to it 13 crystal fibers, another bundle of 8 bast fibers had 8 crystal fibers about it, another of 6 bast fibers had 4 crystal fibers, another of 8 bast fibers had 2 crystal fibers, one of 16 bast fibers had 9 crystal fibers about it and one of 16 bast fibers had 16 crystal fibers. It could not be established that the number of crystal fibers corresponds with the number of bast fibers in the bundle, though according to my observations the crystal fibers never exceed in number the bast fibers. While sometimes there is but one tangential row of bast fibers in a bundle, they often are arranged in 2 or 3 or even 4 rows. The crystal fibers, though sometimes 15 to 20 microns in width, are usually less than that. They average almost the same width as do the bast fibers. While it is usually difficult to obtain their length, yet in two or three instances they were clearly shown to exceed 300 microns in length and they probably closely approximate the bast fibers in length. They are inclined to be angular in transverse section, usually 4-sided, and fiber-shape longitudinally, with pointed ends, though often not so pointed as the bast fibers. The walls are thin, about the same as the surrounding phloem cells, 1 to 2 microns thick. The

crystals they contain are mostly prisms of calcium oxalate arranged in a single row occupying nearly the width and length of the lumen. They are largest and best-formed at the middle of the fiber and become smaller and more irregular toward the ends, where they are very small. In some fibers rosettes are associated with the prismatic crystals. The number of crystals in a fiber is often 30 or 40. The crystals are rhombohedrons, each of the six faces being nearly equal in size and shape, the acute angles being of about 60 degrees. Their diameter seldom exceeds 15 microns, the smallest being about 5 microns. In the more mature fibers the crystals are separated by septa of cellulose. These septa form with the development of the fiber and the formation of the crystals, but are difficult to distinguish until after the fiber matures. Then the wall adjacent to the bast and the side walls, as also the septa, become lignified. The outer wall was never found to be lignified, but in older bark or in the powdered drug was often broken away, leaving the lignified septa projecting from the inner thickened lignified wall (Fig. 22).

The phloem also contains longitudinal rows of rosette aggregates of calcium oxalate (Fig. 11), though these usually are not adjacent to the bundles of bast. These crystals are apparently produced in the elongated cells of the cambium, 3 or 4 to 20 or 30 crystals in a cell, but from the time crystals begin to form delicate septa begin to show between them (Fig. 12). With the enlargement of the cell and of the crystals and the increased thickness of the septa, the whole takes on the appearance of a row of rounded parenchyma cells each containing a rosette aggregate (Fig. 11). Crystals of any kind were not observed in the medullary rays, but their cells are filled with starch.

The cambium of 4 or 5 rows is well defined. The average width of the cambium cells radially was 8 microns, tangentially 15 microns, longitudinally 60 microns. The medullary-ray cambium (Fig. 10) consists of nearly cubical cells, though they are sometimes elongated tangentially.

Sections of the bark from a 5-year-old stem were 1.5 mm. in thickness (Fig. 14).

Outer bark—10 to 12 rows of small brown unlignified cork-cells; total radial width 80 microns.

Middle bark—unchanged except for numerous masses of stone cells, usually elongated tangentially, the largest mass being 630 microns, about 20 cells, in this direction. The radial or longitudinal dimension of these stone cell groups seldom exceeds 200 microns, though in one instance a group measured 400 microns. They seldom exceed 8 or 10 cells in these directions. The cell lumen is usually very small, and while pores and stratifications are visible they are not well defined. The walls are strongly lignified.

Inner bark—this is now 1 mm. thick. Occasional groups of unlignified primary bast may still be seen, but many large stone cell-groups have been developed in the outer portion of the inner bark. These groups lie between the medullary rays along with the small groups of first-formed secondary bast. The medullary rays, 1-, 2- or 3-cells wide, are distinctly seen extending back to the cambium. They are from 100 to 300 or 400 microns apart. There were 46 rays in 7 mm. of bark. Between the rays 5 tangential rows of small bundles of secondary bast with crystal fibers were found. In tangential section the bast is in long interweaving strands, 6 to 12 or 14 cells wide, bordering the medullary rays,

the strands separating so as to snugly enclose the ray. The medullary rays are elliptical, ranging in height from 100 microns (8 cells) to 1.5 mm. (100 cells), and in width at their widest part from 30 microns (2 cells) to 90 microns (4 cells). In the majority of cases they are 3 cells wide throughout most of their length, but narrowing to 2 cells, then to 1 cell toward their upper and lower edges.

The phloem contains a few sieve tubes in which the transverse sieve plates could not well be differentiated, accompanied by companion cells and many parenchyma cells. The parenchyma cells are rounded or angular in transverse section, oval in longitudinal section, contain living contents and serve for starch storage. Calcium oxalate crystals, except the prismatic ones in the crystal fibers, are not so abundant in the inner bark as in the middle bark. Occasional rows of rosettes and isolated rosettes and prisms are seen. One isolated prism was noted, measuring 35 microns across, though seldom do crystals of the inner bark exceed 20 microns. The primary crystals of the middle bark, however, attain a diameter of 30 and even 45 microns.

The examination of specimens from the commercial drug gave no new features except a thickening of the inner bark. The thickest piece of bark examined was 8 mm. across. In this specimen the outer bark did not exceed 0.150 mm. and contained 26 rows of suberized cork cells. The middle bark was 1 mm. in width and in 10 sq. mm. contained 34 groups of stone cells, arranged in 4 irregular rows. The inner bark was 7 mm. thick and contained 10 tangential rows of bast bundles. It was noted also that many small groups of stone cells were found associated with the bast in the inner bark (see Fig. 16). Starch was quite plentiful in the medullary ray cells and phloem parenchyma. Rosette aggregates and prisms isolated or in longitudinal rows were fairly abundant and the bast bundles and crystal fibers differed not from previous description.

An unusual specimen was met with, in which the secondary bast was practically absent. The specimen was 5 mm. thick, the middle bark contained stone cell groups and a few such groups were found in the inner bark, but with the exception of a few very small bundles in the outer portion of the inner bark, no bast was found.

It might be said that, on the average, stone cells constitute more than half of the lignified tissue of the drug *Rhamnus Purshiana*.

The Powder.—The most conspicuous element of the powder is the masses of bast with the associated crystal fibers. These bast masses in commercial powder (No. 60) are often more than 1 mm. in length and usually 2, 3 or 4 cells wide. The individual bast and crystal fibers are distinguished from one another with difficulty in these masses and only occasionally are the completely separated fibers found in the powder. However, the long rows of prismatic crystals show very distinctly, even after the use of the hydrochloric acid in connection with the phloroglucin test. It is to be noted that when a crystal fiber is observed along an edge of the mass of bast, in profile view as it were, the septum walls which are gradually thickened and lignified toward the thickened lignified wall adjacent to the bast are plainly seen. The outer wall is often missing, being pulled off apparently with the adjacent parenchyma cells (Fig. 22). These bast masses are usually free from any adhering parenchyma.

Almost equally numerous are the masses of strongly lignified stone cells, usually dense and of about 100 to 300 microns in each direction. Some smaller groups and some nearly isolated stone cells are found. The crystals associated with the stone cell groups are not nearly so much in evidence as those on the bast masses. In the larger groups the individual stone cells are difficult to distinguish, but in the smaller (Fig. 17), it is seen that in size, shape and markings they correspond to the description already given.

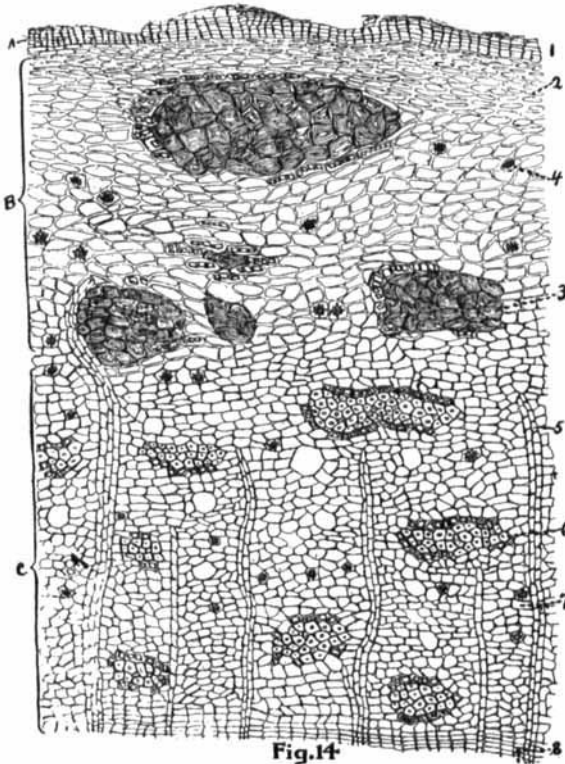


Fig. 14.
RHAMNUS PURSHIANA BARK.

Fig. 14.—Transverse section of bark 1.5 mm. thick from a 5-year-old stem. A—outer bark, B—middle bark, C—inner bark. 1—6 to 12 rows of cork cells; 2—collenchyma; 3—group of mature stone cells with accompanying prismatic crystals; 4—parenchyma with occasional rosettes; 5—medullary ray; 6—secondary bast with crystal fibers; 7—phloem consisting mostly of parenchyma with an occasional rosette or isolated prism of calcium oxalate; 8—cambium. (X 150, reduced $\frac{1}{2}$.)

Fragmented, usually 3 cells wide and 8, 10 or more cells long. The cells are irregular or rounded in shape.

Scattered throughout the mount are numerous free prismatic crystals and rosette aggregates. But seldom does the diameter of the rosettes exceed 20 microns or of the prismatic crystals 15 microns.

The parenchyma cells of the medullary rays and phloem are more or less filled with single spherical starch grains seldom exceeding 4 microns in diameter and without distinctive markings (Fig. 19).

Fragments of cork, yellowish or brownish in color, are present. They seldom show the very regular arrangement of the cells in radial rows, but present a surface view (Fig. 18), or are irregular masses.

The bulk of the powder consists of masses of parenchyma tissue. The rather thick-walled collenchyma-like cells of the outer middle bark are occasionally seen, pieces of middle-bark parenchyma with rosettes are quite common, and pieces of phloem parenchyma with fragments of medullary rays in either radial or tangential view are abundant. In these phloem masses the cells of the medullary ray in radial view (Fig. 20) average 20 by 25 microns, while their walls are usually thin and unpitted, though sometimes thicker and pitted. In tangential view (Fig. 31), the rays are ellip-

(To be continued.)