

Proceedings of the Iowa Academy of Science

Volume 5 | Annual Issue

Article 25

1897

Some Studies on the Seeds and Fruits of Berberidaceae

L. H. Pammel

J. R. Burnip

Hannah Thomas

Copyright ©1897 Iowa Academy of Science, Inc.

Follow this and additional works at: <https://scholarworks.uni.edu/pias>

Recommended Citation

Pammel, L. H.; Burnip, J. R.; and Thomas, Hannah (1897) "Some Studies on the Seeds and Fruits of Berberidaceae," *Proceedings of the Iowa Academy of Science*, 5(1), 209-228.

Available at: <https://scholarworks.uni.edu/pias/vol5/iss1/25>

This Research is brought to you for free and open access by the Iowa Academy of Science at UNI ScholarWorks. It has been accepted for inclusion in Proceedings of the Iowa Academy of Science by an authorized editor of UNI ScholarWorks. For more information, please contact scholarworks@uni.edu.

SOME STUDIES ON THE SEEDS AND FRUITS OF BERBERIDACEÆ.

BY L. H. PAMMEL, J. R. BURNIP AND HANNAH THOMAS.

Although several papers bearing on the anatomy of different organs of plants of this order have been published,¹ no one has studied the comparative anatomy of the seeds.

It gives us great pleasure to acknowledge the kindness shown us by Drs. B. L. Robinson, J. K. Small, Mr. G. H. Hicks, and Prof. C. S. Sargent for favors shown us in the way of obtaining material for study and the determination of some species; the free access to and use of the library of the Missouri Botanical garden, through the courtesy of the director, Dr. Trelease, and, finally, the faithful work in drawing the seeds and fruits and preparing the microscopic details for the engraver by Miss Charlotte M. King.

The literature on the anatomy of seeds is somewhat meager. Godfrin² (1880) has given us an account of *Berberis sinensis* and *B. aquifolium*. He states that the testa in this family are much alike. His figure and description of the osteosclerid layer does not agree as we have found it in the species studied.

He gives us a very good account and figure of the epidermal cells of *B. aquifolium*. He speaks of the epidermal cell-walls

¹ Decaisne, J. Memoire sur la famille des Lardizabalées précédé de remarques sur l'anatomie comparée de quelques tiges de végétaux dicotylédons. Arch. Mus. Hist. Nat. Paris. 1:143-213. pl. 10-13. Separate 1839.

Le Maout and Decaisne, J. Traité général de botanique descriptive et analytique Paris, 376. 1868.

Baillon, H. Remarques sur l'organisation des Berberidées. Adansonia 2:288—Histoire d pl. 3:43-76

Prantl, H. Berberidaceae in Engler and Prantl, Die natürlichen Pflanzenfamilien 3: 70-77.

Vesque, J. De l'anatomie des tissus. Nouvelles Arch. du Muséum II. 4:48-51.

Van Tieghem, Ph. E. Recherches sur la structure du pistil et sur l'anatomie comparée de la fleur. Mémoires savants étranger Acad. Paris, 21:1-261. Separate 35. pl. 2, f. 47-50. 1871.

² Etude histologique sur les téguments seminaux d. angiospermes. Bull. Soc. d. Sci. d. Nancy 5: 188-189, pl. 4, f. 9-10.

as being slightly lignified. The epidermal cell-walls in *B. amurensis* and *B. Thunbergii* studied by us are not lignified. Brandza³ (1891) also speaks of a lignification of the cell-walls of the epidermis in *B. sinensis*

His figure and description indicate that the osteosclerids are round. This layer, according to his researches on the development, forms a part of the outer integument. The pigment layer to the inner integument. He found tannin in the pigment layer in this species and *B. aquifolium*.

Brandza also studied the development of *Epimedium sulphureum*. Otto Paul⁴ (1882) describes the endosperm of *B. emarginata*, noting that the cell-walls may be differentiated into three parts, and that the contents consists of fat and protein.

W. Hirsch⁵ (1890) has given an excellent account of *B. vulgaris*, in which he notes that the cells of the lower part of the endosperm rapidly absorb water, swell, and finally collapse. These cells transfer nutrient material to the embryo during germination, and also gives it more space so that it can expand.

J. Holfert⁶ (1890) studied the seeds of the same species with special reference to the nutrient layer, but he also studied other parts of the testa. He distinguishes six layers as follows: (1) Epidermal cells strongly cuticularized; (2) a single row of parenchyma cells, the walls becoming mucilaginous; (3) nutrient layer; (4) osteosclerids correctly figured and described; (5) obliterated nutrient layer, or pigment layer; (6) several rowed nutrient layer with colorless cell-walls.

Marloth⁷ (1883) recognized four layers, the two inner consisting of cells with delicate walls. He also describes the epidermal cells, and the somewhat thick-walled parenchyma cells. *Berberis* is classed in his fourth group, in which the protective features occur in the testa, endosperm abundant, but cell-walls not thickened. John Lubbock⁸ figures and describes the seeds of several of our species. The seeds of *B.*

³Développement des teguments de la graine. *Revue generale de Bot.* 3: 76-78. pl. 5, f. 1-4.

⁴Vergleichende Untersuchungen über das Endosperm Inaug. Dis. Goettingen 27.

⁵Untersuchungen ueber die Frage welche Einrichtungen bestehen behufs Ueberführung d. in dem Speichergewebe d. Samen niedergelegten Reservestoffe in d. Embryo b. d. Kei Diss Inaug. Dis. Erlangen.

⁶Die Nährschicht d. Samenschalen. Inaug. Dis. Erlangen Flora. 4: 1890. Marburg 26. pl. f. 10-11.

⁷Ueber mechanische Schuetzmittel d. Samen gegen schädliche Einflüsse von aussen. *Engler Bot. Jahrb.* 4: 226-264.

⁸A Contribution to Our Knowledge of Seedlings. London. 1:108-114. f. 142-144.

aquifolium and *B. vulgaris* are figured in a general way. *B. erecta*, *B. concinna*, *B. sibirica*, as well as *Podophyllum emodi*, are described.

Brandza, who studied the development of *Berberis* and *Epimedium*, considers that the testa consists of two integuments. The epidermal layer, the outer nutrient layer and osteosclerids belong to the outer integument; the pigment layer and the collapsed parenchyma cells belong to the inner integument.

Some excellent details of development are given by Dr. Gray⁹ in his genera of North American plants.

In matters of synonymy and arrangement we have followed Gray and Robinson¹⁰ so far as it relates to American species.

BERBERIS CANADENSIS Pursh.¹¹

Fruit and Seed Characters.—Berry short-oval or sometimes globular, scarlet, two to three lines long, small, loose racemes, one to several seeded. Seeds oblong, shining, two lines long, obtusely three-sided, raphe on obtuse inner angle, chalaza at tip, micropyle and hilum adjacent, hilar pit with rounded, thickened border

Epidermis.—Cells elongated, slightly irregular on the margin, cuticle of uniform thickness, sharply demarcated from the remainder of the cell wall. The cuticularized layer is thicker and lighter in color, layer within uniform in thickness except where "cones" project into the lateral walls. The layer within cuticularized portion is brown in color, uniform in thickness. The walls are marked by conspicuous pore canals. The internal narrow zone is lighter in color than the outer part. This wall forms the separating line of adjoining cells and contains pore canals. The cells contain some coloring matter and protein substances, the latter being always reduced to a minimum, also an abundance of tannin.

Nutrient layer.—The cells are large and somewhat irregular, walls are brown, the cavity brown, containing a large amount of pigment and some protein matter. This layer may be separated into two parts. In the lower portion the cells are compressed and thick-walled. Tannin also occurs in this portion of the nutrient layer.

Osteosclerid.—Consists of one layer of cells, broad at the upper end, where the walls of adjoining cells usually unite;

⁹ The Genera of the Plants of the United States. 1:77-90. pl. 31-36

¹⁰ Synoptical Flora of North America. 1:66-72.

¹¹ Gray. The Genera of the Plants of the United States 1: 79. pl. 31, f. 10-12.

the cell cavity is very much reduced; has triangular intercellular spaces where the walls are united. Cells contain some brown pigment.

Pigment layer.—This layer belongs to the inner integument, and consists of narrow, thick-walled, elongated cells much darker in color than cells of nutrient and osteosclerid layers.

Parenchyma layer.—The cells of this layer are much compressed, and can only be made out on the addition of chloral hydrate. The cells are thin-walled and variable as to shape in different portions of the seed.

Endosperm.—The cells of endosperm are much alike, the first layer, aleurone, somewhat smaller, walls greatly thickened with longitudinal striæ; the cells contain no starch, but an abundance of protein and fat. A narrow zone of endosperm next to the embryo consists of thick-walled, elongated cells. The cell cavity in most cases being reduced to a narrow line.

Embryo.—The cells are quite uniform as to size, nearly isodiametric, cell walls thinner than in endosperm, densely packed with fat and protein grains. Procambial bundles in central part of the caulicle.

BERBERIS AMURENSIS Rupr.

Fruit and seed characters.—Berry light scarlet, in loose racemes, ellipsoidal, 4-5 lines long, usually two seeded. Seeds oblong-obovoid, light brown, obtusely two or more sided, convex on one side, and more or less flattened on the other; the raphe extending along one edge of the flattened side, chalaza at the apex. Seeds brown, three lines long, hilum and micropyle adjacent, the former a depressed cavity with a raised border.

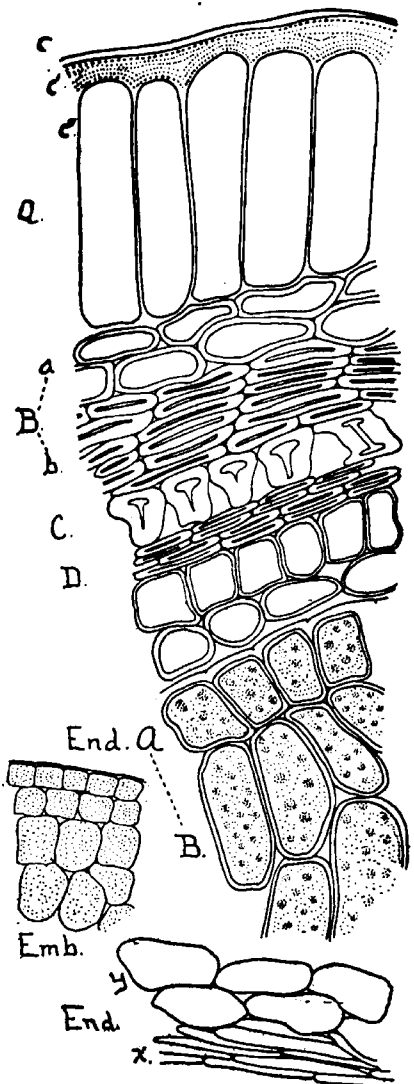


Fig. 14 *Berberis amurensis*, for description see explanation of plates.

Epidermis.—The palisade-like epidermal cells with thickened exterior walls, the latter much thinner; occasionally with thin cross-walls so that the epidermal layer consists of two layers. The cuticle of uniform thickness, the cuticularized layer strongly developed, lighter in color than cellulose layers. But all of the walls carry more or less pigment, with an abundance of tannin.

Nutrient layer.—This consists of two portions, the cells of upper part larger and thinner than lower. In ripe seed very much compressed, but can be made out readily by treating with chloral hydrate. Cells contain pigment, tannin, and protein grains, though the latter are not abundant.

Osteosclerid.—This consists of a single row of cells and does not differ essentially from that of *B. canadensis*. The cell-walls are much lighter in color than the pigment layer, and with a small cell cavity; in some cases the cells are not triangular in shape, but I-shaped, as in many leguminous seeds.

Pigment layer.—Cells elongated, thick walled, two or more rows. The walls, colored dark brown, when treated with ferric chloride show an abundance of tannin.

Endosperm.—The bulk of the endosperm consists of thick-walled cells which color blue with chloride of zinc, consisting of cellulose. The lower part of endosperm consists of smaller elongated cells. As stated by Hirsch, these cells collapse readily, and not only serve to convey nutrient material to the growing embryo, but to make room for its expansion. The aleurone layer does not differ essentially from most of the cells of endosperm, except that the cells are somewhat smaller. Cells contain fat and protein grains.

Embryo —The cells of first row with thick walls uniform in size, those below larger and irregular in shape. Cells contain fat and protein cell-walls and starch. Tannin absent.

BERBERIS VULGARIS L.¹²

Fruit and seed characters.—Baccate fruit, born in a loose raceme, scarlet, four to five lines long, two to three seeded; seeds light brown, ovate, two to three sided, two to two and one-half lines long; testa minutely roughened; hilum and micropyle in lower narrow end; the hilum forms a depressed round cavity with a raised border.

12 } Holfert, 26.
 } Hirsch, 19.

Epidermis—Palisade-like cells elongated, larger than in *B. canadensis*, occasionally divided. The cuticle of uniform thickness. The cuticularized layer somewhat undulating, lighter in color than cuticle, somewhat thicker than cellulose layers. The cuticle is darker in color than cuticularized portion. The internal layer of cell-wall is narrow and brown. Cells mostly empty except the pigment and a few protein grains.

Nutrient layer.—This is made up of two parts. The cells of the upper are somewhat irregular, comparatively thin-walled. Cells in lower part elongated, thicker-walled. Cell-walls contain a brown pigment. Vascular elements carried in this layer. These color rose on the addition of phloroglucin and hydrochloric acid.

Osteosclerid.—This consists of a single layer of thick-walled cells, with a large triangular intercellular space below, owing to the occurrence of a cell with a large diameter above and a narrower one below. Cell-walls nearly colorless.

Pigment layer.—Cells elongated, thick-walled, one to two rows of cells. Walls colored brown. Some pigment also contained in cell cavity.

Parenchyma layer—Just below the pigment layer occur thin-walled cells variable in size. This layer is very granular, and contains much more protein than occurs in nutrient layer. Holfert also classes this as a nutrient layer.

Endosperm.—The greater part of the seed is made up of endosperm. Cells of first row somewhat smaller. Walls uniformly thickened, differentiated into three parts. The bulk of the endosperm consists of cells larger than aleurone. The internal part of the endosperm with smaller elongated cells. Cells contain fat and protein grains.

Embryo—The cells of this layer do not differ essentially from those of *B. canadensis* and *H. amurensis*.

BERBERIS THUNBERGII DC.

Fruit and seed characters.—Fruit baccate, bright orange-scarlet, oval or elliptical, four to five lines long, one-seeded. Seeds terete, four lines long, nearly obovate; testa shining dark brown, terete in outline, minutely pitted; micropyle and hilum basal and adjacent, with a thickened margin.

Epidermis.—Cells large, somewhat longer than broad, variable as to size; internal walls thin, outer wall thickened; composed of four parts, the outer cuticle well developed; the cuti

cularized portion below is narrow, of even thickness; the intermediate layer is thicker and stratified, but not so much as in *B. nervosa*. The internal walls are much thicker than in *B. vulgaris*. Cells and walls carry a large amount of pigment. The cells contain some protein matter.

Nutrient layer.—First row of cells irregular, large, rather thick-walled. Cells below longer with walls of about the same thickness; this layer contains the vascular elements; on the addition of phloroglucin and hydrochloric acid the walls of these elements color rose purple. In addition to these layers another occurs, the cells of this are much smaller than in the preceding, not elongated radially, walls irregularly thickened and brown.

Osteosclerid.—Consists of a single layer of cells. Walls much thickened with a large triangular space. Cell-cavity very small. Cell-walls colored brown.

Pigment layer.—This consists of a narrow zone of one or two rows of cells, greatly elongated, with thick walls, deeply dark brown colored.

Parenchyma layer.—Occurs below the pigment layer, and is composed of three or four rows of cells. This layer is much compressed. In most cases cells contain granular protein grains.

Endosperm.—First row, the aleurone layer of smaller cells than remainder of endosperm, filled with protein grains and fat. In some cases a few tannin and pigment cells occur. It is very unusual for endosperm to contain pigment. The cell-walls of remainder of endosperm thick-walled. The walls color blue with iodine and sulphuric acid, and chlorodide of zinc. The internal part of endosperm consists of thick-walled elongated narrow cells.

Embryo.—First row of cells smaller. The exterior walls thickened. All these cells contain fat and protein grains but no starch. The walls consist of cellulose. Rudimentary bundles also occur in the caulicle, but lignification has not taken place

BERBERIS CERASINA *Schrader?*

Fruit and seed characters.—Baccate fruit, bluish-scarlet, globular, borne in a long and loose raceme; berry ten lines long, one or two-seeded. Seed brown, shining, five lines long, terete or one side flattened, the other convex; micropyle and hilum adjacent;

the hilum forming a prominent pit with raised border. Microscopically this seed does not differ essentially from *B. vulgaris*. The epidermal cells frequently with a cell-wall across the middle. Cell-walls slightly stratified.

Nutrient layer.—Cells as in *B. vulgaris*. The osteosclerid layer shows elongated, as well as triangular, intercellular spaces.

Parenchyma layer.—Consists of a granular narrow zone of small cells. The endosperm is divided into two parts; the inner, of elongated cells; the first row of cells of embryo smaller than those underneath.

BERBERIS AQUIFOLIUM Pursh.

Fruit and seed characters.—Fruit baccate, borne in rather short racemes, ovate or ellipsoid, smooth, deep purple or blue, with a glaucous bloom; usually four to six seeded; seed oblong-obovoid, obtusely three-sided, two lines long. Testa pale brown and somewhat shining; micropyle and hilum adjacent. The latter forms a depression with a thick dark margin. The raphe extending along the obtuse inner edge, chalaza at the apex.

Epidermis.—Cells very thick-walled, brown. Cuticle well developed, slightly irregular. The second layer of cell-wall not well developed, lighter in color than the third. This projects in the form of cones down between the thickened third layer of cell-wall. The third layer is very much thickened, with small radiating canals, as well as very evident stratification. The internal wall, or fourth layer, is very narrow. The cell cavity is very much reduced; it reaches its greatest length in the central portion of the cell. In some cases it has thinner walls on lateral sides. The great thickening of the cell-wall, evident stratification and small cell-cavity characterize this species and others studied of the sub-genus *Mahonia*.

Nutrient layer.—This consists of several rows of cells, those of the first layer elongated and much larger than the succeeding. Decidedly irregular. The cells in lower portion elongated, thinner-walled. Cells carry considerable pigment.

Osteosclerid.—This layer does not differ essentially from those previously described. It consists of a single row of cells with greatly thickened walls, and a small cell cavity, and the characteristic intercellular space.

Pigment layer—Several rows of much compressed, thick-walled, elongated cells of darker color than the nutrient layer.

Parenchyma layer.—Much compressed cells with granular contents of protein grains, somewhat variable in thickness.

Endosperm.—This constitutes the bulk of the seed; the first row of cells does not differ essentially from those beneath, except that they are somewhat smaller. In the lower portion of endosperm, the cells are smaller, elongated, and thinner-walled. The thick walls of the endosperm cells are differentiated into three parts, the inner being much more strongly developed. On the addition of sulphuric acid and iodine, the walls color blue. The cells do not contain starch, but protein grains and fat.

Embryo.—Does not differ from other species studied.

BERBERIS REPENS *Lindl.*

Baccate fruit in a comparatively short raceme, blue with a glaucous bloom, four to five lines long, five or more seeded. Seeds dark brown, ovate, elliptical or quadrangular, curved at base, two lines long, two or more sided, obtuse or somewhat angular; dorsal side convex. Testa minutely roughened, prominent raphe on one side, chalaza at the tip. Micropyle and hilum adjacent, hilar pit small with a well marked border.

Epidermis.—This species does not differ from the preceding. The cuticle is well developed. The remainder of cell-wall enormously thickened; the third layer of wall shows prominent stratification; the cell-cavity is much reduced, the walls colored brown.

Nutrient layer.—This layer seems to be suppressed in some places. The cells are not so regular as in other species. In some cases they are more elongated, in others are the characteristic triangular intercellular spaces; the cell-cavity in this species is larger than in other species of the sub-genus. The epidermal cells are much longer, and as regards stratification, it has reached its highest development in this species. It would not be difficult to separate this species from the other members of this sub-genus by the characters here presented.

Pigment layer.—Cells narrow, elongated, thick-walled, brown. An abundance of tannin.

Parenchyma layer.—A much compressed layer. Cells carrying a large amount of granular matter, consisting mostly of protein grains.

Endosperm.—This does not differ from preceding species, as to shape, size and contents of cells.

Embryo.—Agrees with *B. aquifolium*.

B. NERVOSA *Pursh.*

Fruit and seed characters.—Baccate fruit, borne in a long raceme, blue with glaucous bloom, globular three to four lines long, one to two seeded. Seeds brown, oblong, curved at base, two lines long, two-sided or terete; raphe extends along the edge of the narrow side, prominent. Testa shining, slightly pitted, chalaza at tip of seed, hilum and micropyle adjacent. The hilar pit smaller than in *B. Thunbergii*.

Epidermis.—The cuticle well developed, forming a continuous zone on the outer surface, followed by a straw-colored stratified layer, which reaches its greatest thickness where the walls separate, giving this portion a concave appearance. The third layer is also strongly stratified, darker in color and decidedly uneven, presenting the appearance of a series of cone-shaped depressions, around which the lines curve. A narrow connection occurs between this and the middle portion of cells, where the wall is thicker than below. This again connects with a thickening in lower part of wall. The internal part of wall is lighter in color and strongly stratified; walls are greatly thickened, with a small cell-cavity. The cells are lighter in color than in nutrient and pigment layers.

Nutrient layer.—Structure same as in last species. Cell-walls much darker in color in lower part of parenchyma.

Parenchyma layer.—This layer is much compressed, and consists of thin-walled cells. In some places poorly defined. Cells contain protein grains.

Endosperm.—First layer of cells smaller, with thickened outer walls, cells below larger except a narrow zone next to the embryo; the latter are elongated, thick walled, and contain but a small amount of granular matter. The cells of endosperm contain no starch, but an abundance of fat and protein grains. Cell-walls made up of cellulose.

Embryo.—First row of cells regular, somewhat longer than broad, with thickened outer walls, much smaller than those below, filled with protein grains and fat, but no starch.

CAULOPHYLLUM THALICTROIDES *Michx.*

Fruit and seed characters.—Dr. Gray¹³ long ago called attention to the disappearance of the thin pericarp soon after fertilization owing to the pressure of the growing seed. The ovary contains two stalked ovules. Seeds at maturity three lines long, stalked, globular, blue, covered with a glaucous bloom, four lines in diameter. The bony inner part of the testa dark brown, hard, with a conspicuous white horny endosperm.

Epidermis.—Cells somewhat longer than broad, thick-walled, brown. The cuticle even, cuticularized layer thicker than internal layer. Cell cavity much reduced.

Nutrient layer.—Variable in thickness. This is followed by thick-walled parenchyma cells; containing more pigment than the parenchyma cells. The osteosclerid layer absent.

Nucellar layer—This is very much reduced and compressed. The cells contain a large amount of protein in the shape of small grains.

Endosperm.—The bulk of the seed consists of endosperm. The cells are very thick-walled, and on the addition of water, swell. The cells of internal part of endosperm are elongated, smaller and thicker walled.

JEFFERSONIA BINATA *Barton.*

Fruit stipitate, coriaceous, obovate, dehiscent by a slit at the top, with a persistent short style, seven lines long. Seeds numerous, slightly curved, oblong arillate laterally, three lines long. Testa brown, shining, longitudinally wrinkled. Hilum in a depressed cavity on outer side the persistent straw-colored arillus.

Epidermis.—The cells are rather short, exterior wall greatly thickened, the cuticle covering the surface evenly, darker in color than the cuticularized layer. The internal wall narrower and arched above. Cell cavity considerably reduced.

Nutrient layer.—This is more strongly developed than in *Caulophyllum* or *Diphylleia*, consists usually of about six rows of cells. The first layer of cells does not differ materially from those below. The walls show peculiar thickenings in the angles; resembling the mechanical element collenchyma found in different plants. Walls colored brown.

¹³ *The Genera of the Plants of the United States.* 81. pl. 32.

Osteosclerid.—The cells of this are thick-walled and have the shape of an I, like the cells of the second layer in the testa of leguminous seeds. The narrow parts meet below, allowing an intercellular space between the projecting arms. These cells are much smaller than those of *Berberis*.

Pigment layer.—This consists of short, thick-walled cells radially elongated, carrying more pigment than the cells of the parenchyma layer.

Parenchyma layer.—Not strongly developed and varies in thickness in different parts of the seed. The cells are elongated, but somewhat irregular; contain protein grains.

Endosperm.—This makes up the bulk of the seed, is a pure, white, hard substance. Cell-walls greatly thickened, differentiated into three well-defined portions. The cells contain fat and protein grains, but no starch. The first layer of cells of endosperm does not differ materially from the remainder. There is, however, a slight difference in the cells of the endosperm next to the embryo; these are smaller and radially elongated.

DIPHYLLEIA CYMOSA *Michx.*

Fruit and seed characters.—Baccate fruit blue, four to six lines long, by four to five lines oblong or globose, usually two-seeded. Seeds oblong, curved at the base, usually two-sided. Testa reddish, wrinkled. Hilum with a white scar, in a somewhat depressed cavity, and a conspicuous tubercle towards the dorsal side.

Epidermis.—The epidermal cells are rather short, in some cases elongated, and in others isodiametric. The cuticle well developed, and as in *Berberis* the wall is differentiated into three parts. The portion below the cuticle is thicker and lighter in color. The middle portion of the wall is irregularly thickened, producing cone-like projections between the lateral walls. The internal wall is somewhat brownish and strongly stratified.

Nutrient layer.—The cells of this layer are thinner-walled, considerably elongated; the layer is variable in thickness, consisting of three or four rows of cells.

Osteosclerid.—This layer so characteristic in the *Berberis*, does not appear in this genus.

Pigment layer.—This is but slightly differentiated.

Endosperm.—Well developed. differentiated into two parts. The first row of cells, aleurone, next to the testa, does not

differ materially from the remainder, except that the cells are somewhat smaller. The cell-walls of endosperm are thick-walled, usually somewhat longer than broad, first row of cells uniform. Cell walls colorless, consist of cellulose. Cell contains fat and protein grains.

PODOPHYLLUM PELTATUM L.¹⁴

Fruit large, ovate; a fleshy berry. Seed white, enveloped by a pulpy arillus, which on drying becomes membranaceous. Some writers do not admit that this is a true arillus. Seeds elongated, three by one and three-fourths lines long, white. The upper end of the seed larger than the lower, somewhat irregular.

Epidermis.—Cells much larger than in *Jeffersonia*, light colored, cuticle somewhat irregular, darker in color than cellulose layer. The inner layer arched. Cell cavity large.

Nutrient layer.—This consists of two layers of large cells, longer than broad, with thin walls. Cells contain protein grains.

Osteosclerid.—Apparently absent.

Pigment layer.—Does not differ essentially from *Jeffersonia*,

Endosperm.—Bulk of seed is made up of white endosperm. The cells of first layer, aleurone, are smaller than the remainder except that portion of the endosperm next to the embryo. The walls are thickened, white. Cells contain fat and protein grains. Cell walls made up of cellulose.

Embryo.—First row of cells smaller, and form a continuous row. The cells contain fat and protein grains, but no starch. Cell-walls made up of cellulose.

KEY BASED ON ANATOMICAL CHARACTERS.

- A. Epidermal cells greatly elongated.
 - 1. Cell cavity of epidermal cells large.
 - a. Stratification of epidermal cell-walls evident.
B. Thunbergii, *B. amurensis*.
 - b. Stratification of epidermal cell-walls not evident.
B. canadensis, *B. vulgaris*, *B. cerasifna*.
 - 2. Cell-cavity much reduced with very evident stratification.
B. repens, *B. aquifolium*, *B. nervosa*.
- B. Epidermal cells not greatly elongated.
 - 1. Epidermal cells brownish or black.
Small, not much longer than broad, brown,

Jeffersonia.

¹⁴ Gray. The Genera of the Plants of the United States. pl. 35-36.

Longer than broad, blackish,

Caulophyllum.

Isodiametric, internal layer of exterior wall stratified, reddish,

Diphylleia.

2. Epidermal cells light colored, large.

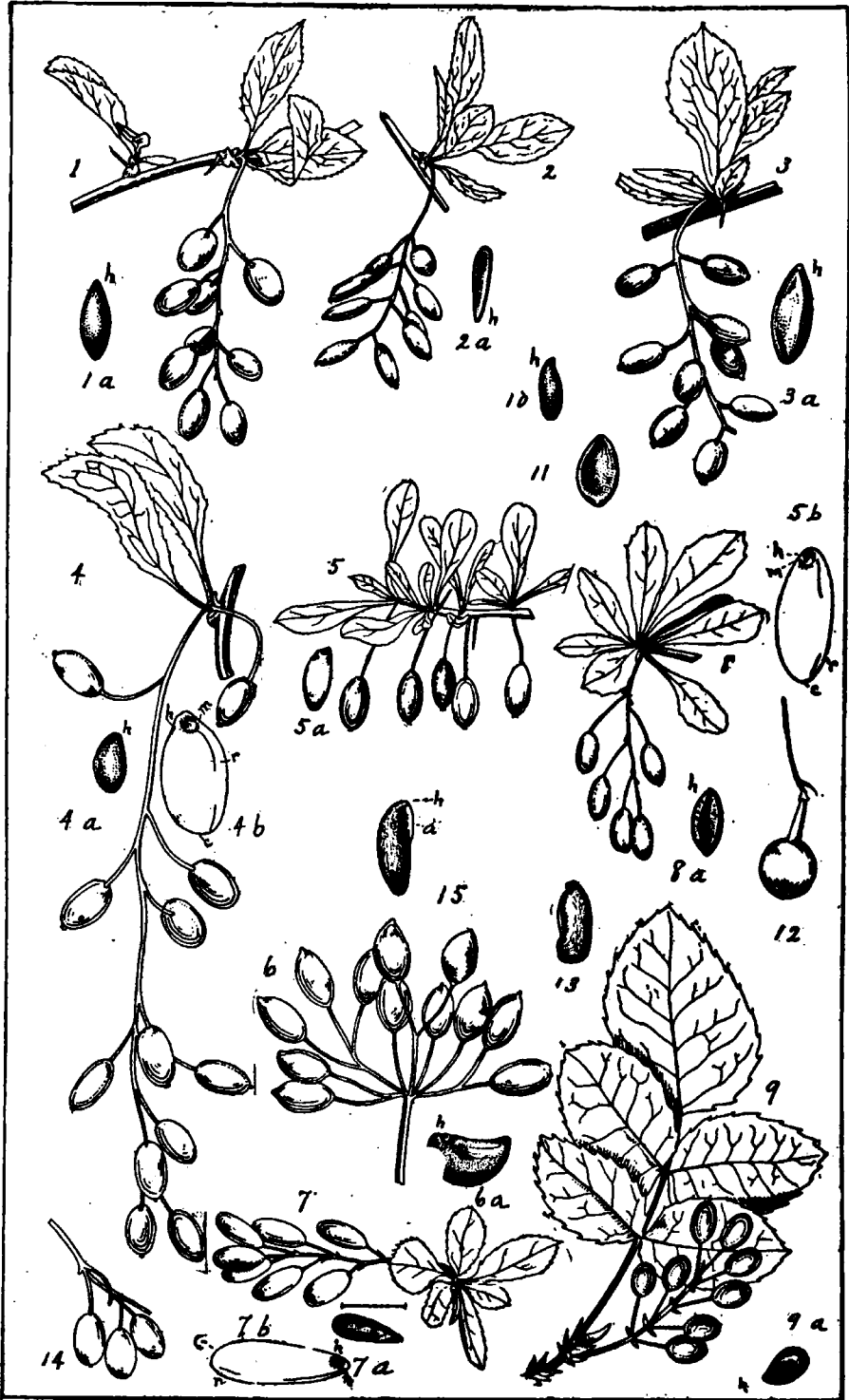
Podophyllum.

KEY BASED ON FRUIT CHARACTERS.

- A. Fruit a berry, 1, 2, 3.
1. Scarlet, acid except *B. Thunbergii*.
Short oval or globular. *B. canadensis*.
Ellipsoidal, eight to ten lines long. *B. amurensis*.
Ellipsoidal, eight to ten lines long. *B. vulgaris*.
Globular, bluish scarlet. *B. cerasina*.
Oval or elliptical, bright scarlet *B. Thunbergii*.
 2. Blue, or bluish-black with glaucous bloom.
 - a. Short.
Ovate or elliptical, eight to ten lines long.
B. aquifolium.
Eight to ten lines long.
B. repens.
 - b. Long.
Fruit globular, few seeded.
B. nervosa.
Fruit globular, in a corymbiform cyme.
Diphylleia cymosa.
 3. Fruit a large, fleshy berry, borne singly.
Podophyllum peltatum.
- B. Fruit a pod.
Jeffersonia binata.
- C. Pericarp deciduous.
Caulophyllum thalictroides.

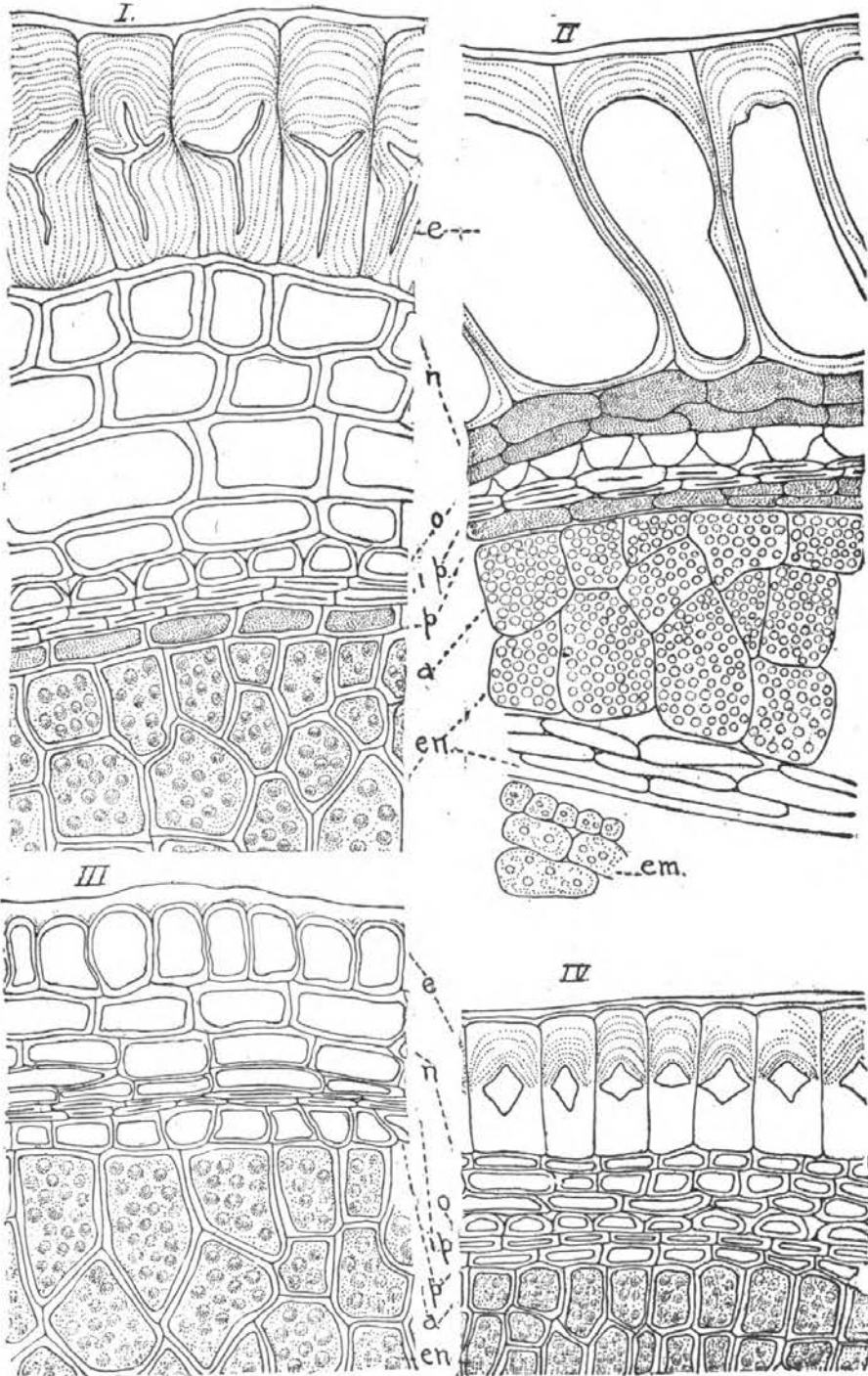
KEY BASED ON SEED CHARACTERS.

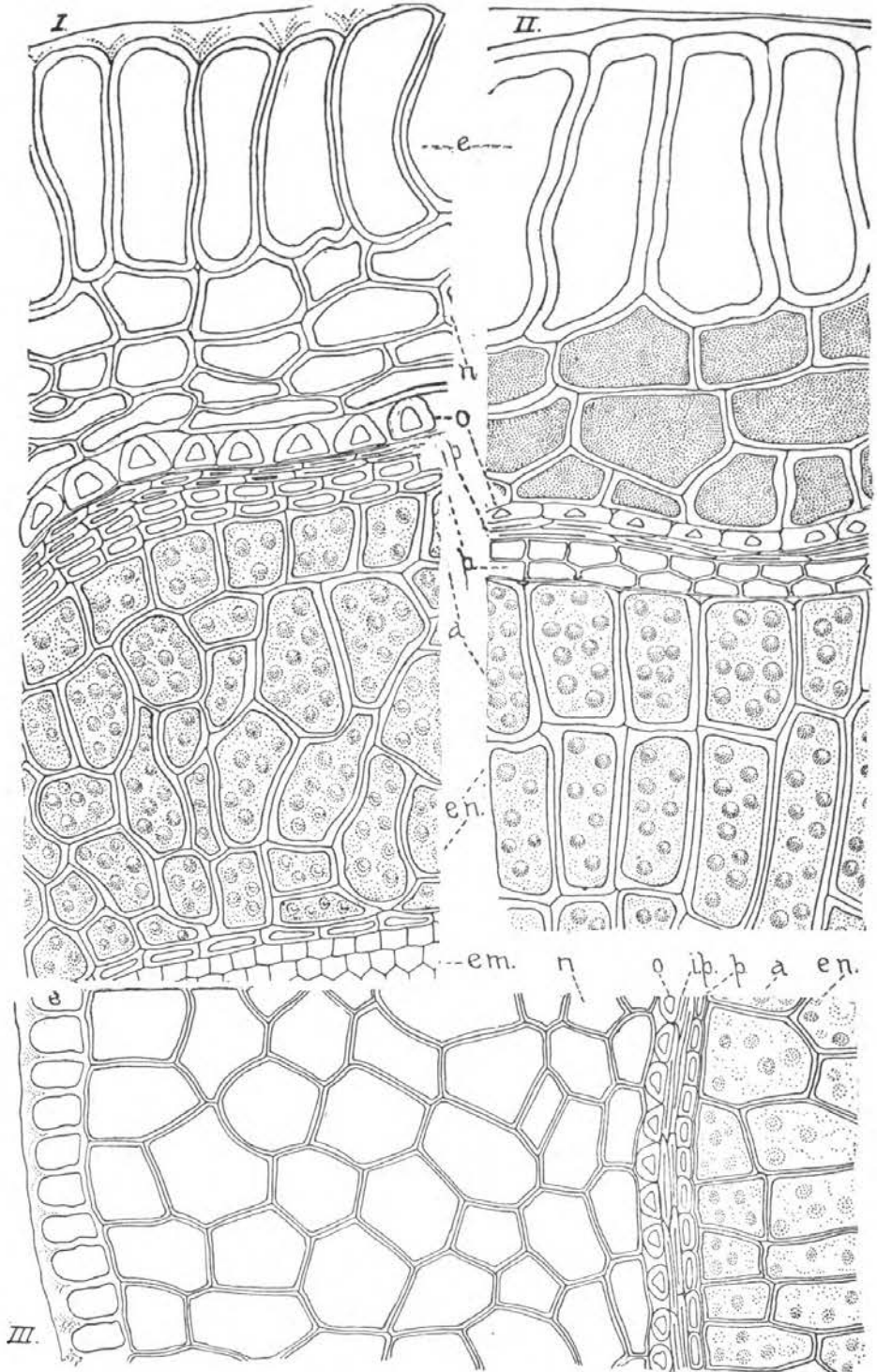
- A. Seeds arillate.
1. Whole seed enveloped by a pulpy arillus.
Podophyllum peltatum.
 2. Small lateral aril at base.
Jeffersonia binata.
- B. Seeds not arillata, 1, 2.
1. Seeds globose, blue, berry-like.
Caulophyllum thalictroides.
 - a. Hilum of same color as seed.
 - (1) Seeds usually terete, large, obovate.
B. Thunbergii.
Seeds usually terete or convex dorsally.
B. cerasina.



IOWA ACADEMY OF SCIENCES.

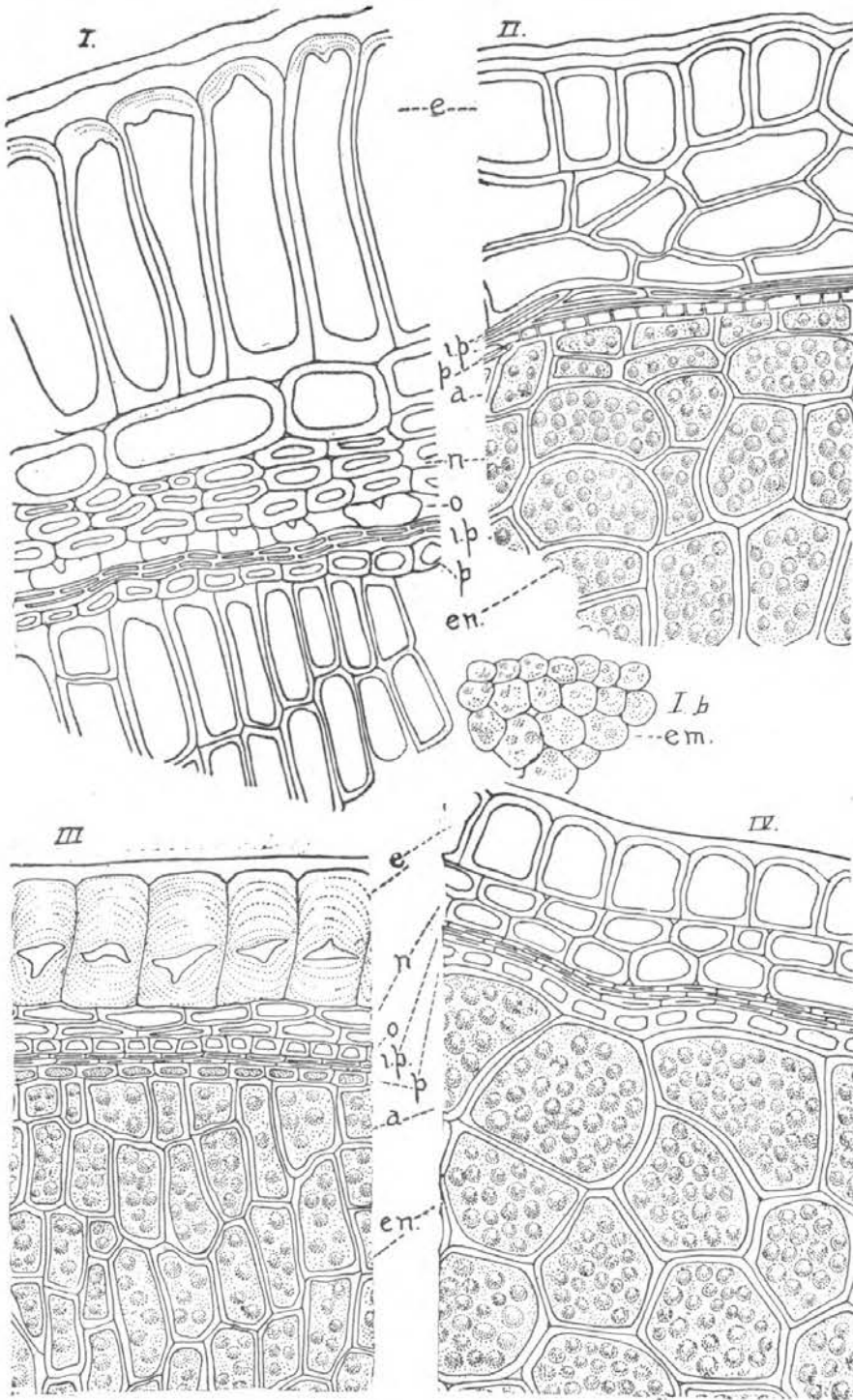
PLATE XIII.





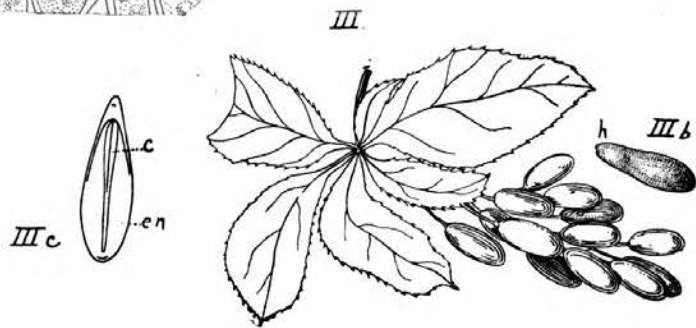
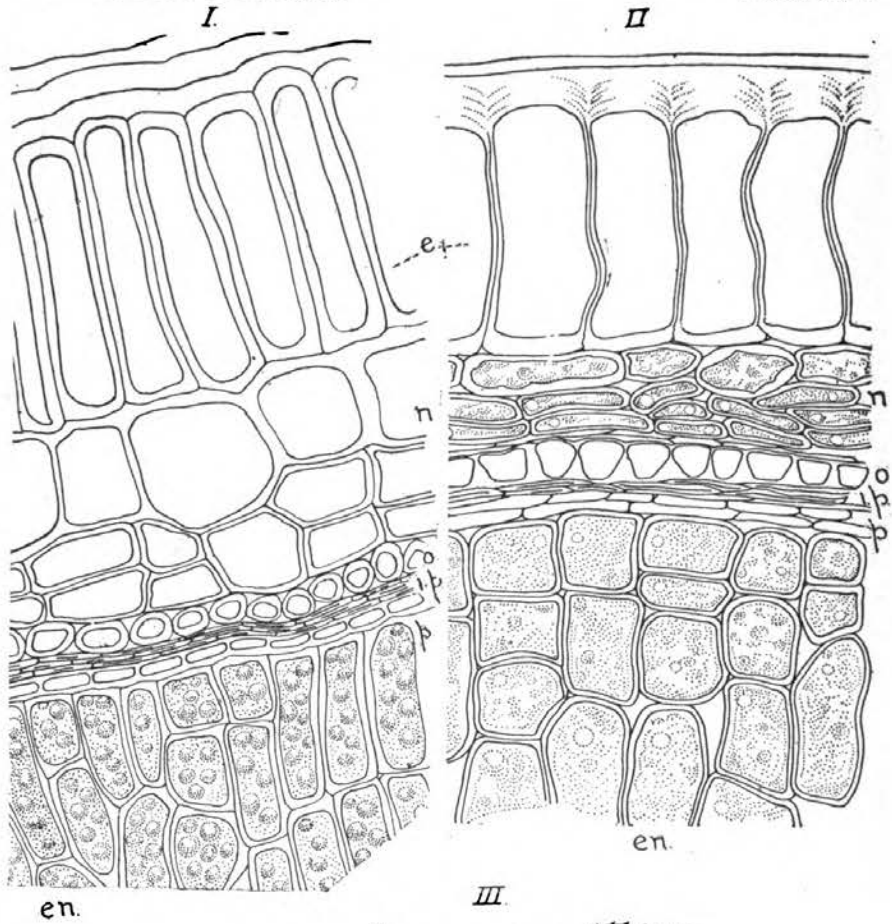
IOWA ACADEMY OF SCIENCES.

PLATE XV.



IOWA ACADEMY OF SCIENCES.

PLATE XVI.



(2) Seeds not terete.

Shining, oblong, four lines long.

B. canadensis.

Light brown, oblong, three lines long.

B. amurensis

Light brown, ovate, four to five lines long.

B. vulgaris.

Light brown, obovoid, ten lines long.

B. aquifolium.

Dark brown, oblong, curved, four to five lines long, small.

B. repens.

Brown oblong, curved at base, four lines long, large.

B. nervosa.

b. Seeds reddish, hilum white.

Diphylleia cymosa.

EXPLANATION OF PLATES.

Abbreviations used for different parts of seed: *e*, epidermal cell; *n*, nutrient layer; *o*, osteosclerid layer; *p*, pigment layer; *a*, aleurone layer; *en*, endosperm; *tp*, inner integument; *em*, embryo,

PLATE XII Fig. 1. *Berberis laxiflora* *B. canadensis*; *1a*, seed; *h*, hilum. Fig. 2. *B. esculenta*, (Hort.). Fig. 3. Form of *B. cerasina*. Fig. 4. *B. cerasina*. Fig. 5. *B. thunbergii*; *5a*, seed; *5b*, seed; *h*, hilum; *r*, raphe; *c*, cotyledons. Fig. 6. *Diphylleia cymosa*. Fig. 7. *B. vulgaris*; *7a*, seed; *7b*, seed; *r*, raphe; *m*, micropyle; *h*, hilum. Fig. 8. *B. amurensis*. Fig. 9. *B. aquifolia*. Fig. 10. *B. repens*. Fig. 11. *B. nervosa*. Fig. 12. *Caulophyllum thalictroides*. Fig. 13. *Podophyllum peltatum*. Fig. 14. *B. canadensis*. Fig. 15. *Jeffersonia binata*; *a*, arel; *h*, hilum.

PLATE XIII. Fig. I. *Berberis nervosa*. Fig. II. Form of *B. cerasina*. Fig. III. *Podophyllum peltatum*. Fig. IV. *B. repens*.

PLATE XIV. Fig. I. *B. canadensis*. Fig. II. *B. thunbergii*. Fig. III. *Jeffersonia binata*.

PLATE XV. Fig. I. *B. vulgaris*. Fig. II. *Diphylleia cymosa*. Fig. III. *B. aquifolium*. Fig. IV. *Caulophyllum*.

PLATE XVI. Fig. I. Form of *Berberis vulgaris*. Fig. II. *B. amurensis*. Fig. III. Fruit *B. vulgaris*; *III b*, seed; *h*, hilum; *III c*, cross section of seed; *e*, embryo; *en*, endosperm.