

Is it not time to return to the viewpoint of the fathers of the republic as to the proper functions of government, and to realize that the sane and decent members of society possess certain inalienable rights of which they should not be deprived in order to confer special benefits or special protection upon those who do not deserve, or who have abused the privileges of citizenship?

DOMESTIC AND IMPORTED *VERATRUM* (HELLEBORE),  
*VERATRUM VIRIDE* AIT., *VERATRUM CALIFORNICUM* DURAND,  
AND *VERATRUM ALBUM* L.

I. BOTANICAL STUDIES.

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With the resumption of importation of European drugs difficulties are being experienced regarding their identification. A notable example is *Veratrum* (Hellebore).

The name Hellebore, while mainly applied in this country to drugs derived from *Veratrum* species, is also used for *Helleborus* species, especially in Europe and in connection with Black Hellebore. The *Helleborus* species, however, belong to an entirely different family (Ranunculaceae), while the *Veratrum*s belong to the Melanthaceae. Since, fortunately, the roots of these families are so different, instances of substitution of *Helleborus* for *Veratrum* species are probably not numerous. Some confusion has arisen, however, from the use of the name of White Hellebore for roots obtained from both *Veratrum album* and *Veratrum viride*. The former is not native and is usually obtained from Europe, and therefore sometimes referred to as "Imported White Hellebore;" the latter, being native, is at times referred to in the trade as "American" or "Domestic White Hellebore." While the United States Pharmacopoeia VIII recognized both *Veratrum album* L. and *Veratrum viride* Ait. as official, the last issue (IX rev.) only recognizes *Veratrum viride* Ait.

It is pointed out in the literature that the plants are very much alike and the roots and rhizomes obtained from either plant cannot be distinguished. The subject has received considerable attention in the past, not only from taxonomists, but also from histologists, chemists, and pharmacologists. The studies with regard to histological data have not led to definite results, either in proving the identity or distinct differences of *Veratrum album* and *Veratrum viride*. The question has therefore been taken up anew. Authentic samples, collected in the Appalachian mountains, as well as commercial samples, collected in import and interstate trade, were examined.<sup>1</sup> Since we were primarily called upon to establish, if possible, differentiations between these commercial products as they appear upon the market, we have given the histological characteristics, and some of the factors which may influence them, our special attention. We have also studied other characteristics considered of value for differentiation.

\*Joint contribution from the Pharmacognosy Laboratory and from the Insecticide and Fungicide Laboratory, Miscellaneous Division, Bureau of Chemistry.

<sup>1</sup> Some of the material used in this investigation was collected by R. C. Roark, formerly a member of the Insecticide and Fungicide Laboratory, Bureau of Chemistry.

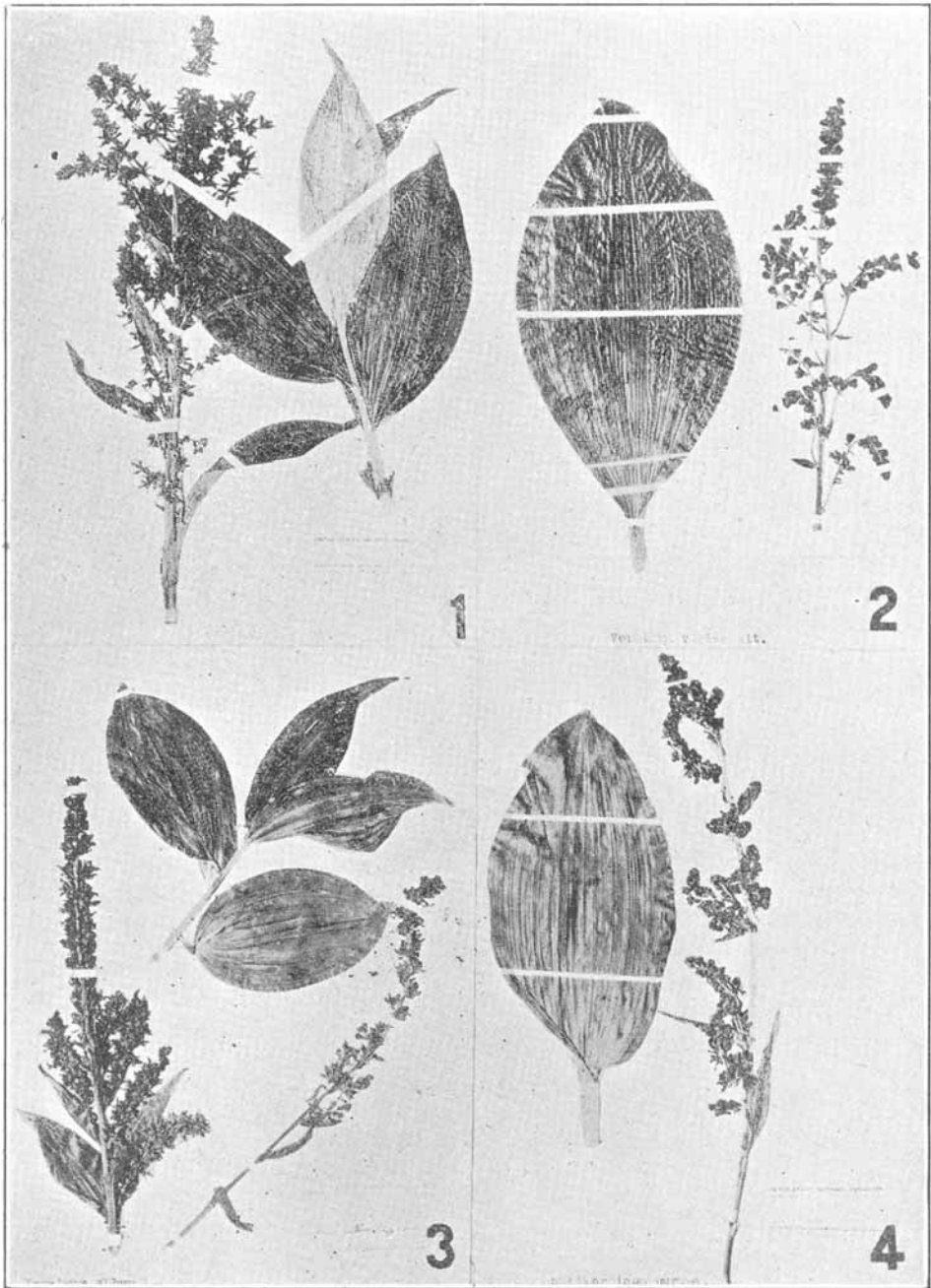


Plate I.—Illustrates habit of *Veratrum viride* (1 and 2), *Veratrum album* (3), and *Veratrum californicum* (4).  $\times 1/5$ .

Some attention was given to *Veratrum californicum* Durand, a form which has been described as *Veratrum album* Watson. This plant appears to grow rather abundantly in the western part of the United States. A statement is also included with regard to *Veratrum nigrum* L., a European form which has been considered a possible substitute in Europe for *Veratrum album*.

#### TAXONOMY.

The three forms, *Veratrum viride* Aiton, *Veratrum californicum* Durand, and *Veratrum album* L., pending further investigation, might be considered as species, though their relationship is indeed very close. This view of close relationship is generally recognized. A brief discussion of views concerning the taxonomy of these forms may be of interest.

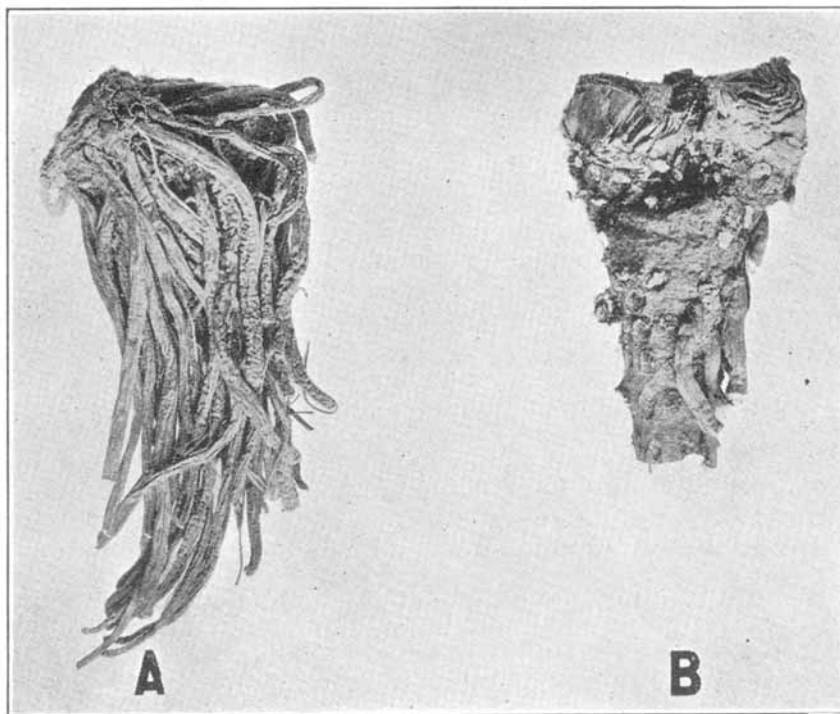


Fig. 1.—*Veratrum album*. A—Rhizome with roots; B—Rhizome with crown of leaf scales, roots removed. Approximately natural size.

There are botanists and others (4, 5, 8,) who consider the domestic form *Veratrum viride* Aiton as *Veratrum album* L., Moeller (6) still considers *Veratrum viride* Aiton as a variety of *Veratrum album* L. According to Bentley and Trimen (1) the form described as *Veratrum album*, var. Regel, is synonymous with *Veratrum viride* Aiton. Watson (9) includes among others *Veratrum parviflorum* Bong and *Veratrum escholtzii* Gray under the species *Veratrum viride* Ait.

*Veratrum album* L., the imported form, according to Flückiger (2), and Bentley and Trimen (1), is identical with *Veratrum viridiflorum* Kunth and *Veratrum lobelianum* Bernh., representing a variety of *Veratrum album*. In Index Kewensis

(3) *Veratrum escholtzii* Gray, *Veratrum lobelianum* Bernh., *Veratrum polygamum* Gilib., are also considered synonymous with *Veratrum album* L.

According to Bentley and Trimen, *Veratrum californicum* Durand is a plant identical with *Veratrum album* L. Flückiger considers it a transitional form between *Veratrum viride* Ait., and *Veratrum album* L. Watson regards it as a distinct species and points out that the plant he described as *Veratrum album* Wat., was *Veratrum californicum* Durand.

#### BOTANICAL CHARACTERISTICS.

(a) *Plants*.—The subject of the plant characteristics of the different species *Veratrum album*, *Veratrum viride*, and *Veratrum californicum* has been given limited attention. Only herbarium specimens and descriptions in literature were studied. A table of data referring to ecological as well as morphological characteristics of the plants is given below. Plate I illustrates the general habit of the plants.

TABLE I.—DESCRIPTION OF PLANTS.\*

|         | <i>Veratrum viride</i> Ait.   | <i>Veratrum album</i> L.   | <i>Veratrum californicum</i> Durand.  |
|---------|---|--|---|
| Habitat | In swamps and wet woods.  | Moist meadows in mountainous districts.  | Wet meadows and springs in mountainous regions.   |
| Rhizome | Erect, with numerous fibrous fleshy roots. 3 to 5 cm. long to about 2 cm. thick.  | Similar to <i>viride</i> with roots less fleshy. 5 to 7 cm. long to about 2.5 cm. thick.                     | Similar to <i>viride</i> with apparently larger rhizomes and larger coarse fibrous roots. |
| Stem    | Stout; 60 to 240 cm. tall, pubescent.   | Stout; 120 cm. tall, pubescent.  | Very stout; 90 to 180 cm. tall, pubescent.  |
| Leaves  | Acute; lower broadly elliptic, sheathing, 15 to 30 cm. long by 7 to 15 cm. wide; pubescent; the upper ones successively narrower; those of the inflorescence small, oblong, lanceolate. | Similar to <i>viride</i> , but smaller, with upper leaves less acuminate.                                    | Similar to <i>viride</i> .  |
| Panicle | 20 to 40 cm. long, densely many-flowered; lower branches spreading or somewhat drooping.  | 30 to 40 cm. long, flowers numerous, shorter pedicels than in <i>viride</i> ; lower branches not drooping.   | 30 to 40 cm. long; similar to <i>viride</i> , with ascending branches.                    |
| Flowers | Yellowish green. Perianth segments oblong or oblanceolate, 2 to 2.5 cm. broad.  | Pale greenish yellow. Perianth segments ovate, sub-acute or obtuse, somewhat broader than in <i>viride</i> . | Greenish or cream. Perianth segments oblong obovate or oblanceolate; 0.8 to 2.0 cm. long. |
| Fruit   | Ovary glabrous; capsule 3-celled; 2 to 2.5 cm. long, 0.8 to 1.1 cm. thick; many-seeded.   | Capsule 3-celled; many-seeded. 2.25 cm. long, 1.1 cm. thick.   | Ovary glabrous; capsule oblong, ovate acute, 2.5 cm. to 3.3 cm. long; many-seeded.        |

\*Based on data in literature and also observations of limited number of Herbarium specimens.

As may be seen from data on the table, the form of the leaves, and especially the structure of the inflorescence, may be considered rather characteristic. Bastin (11), Schrenk (16), Denniston (12), Flückiger (2), have considered both *Veratrum viride* and *album* in their studies. Holm (13), studied *Veratrum viride*, and Meyer (15) and Koch (14) only *Veratrum album*. Bastin (11), Schrenk (16), Denniston (12), and Flückiger (2), as well as the textbooks dealing with the subject, agree that the rhizomes cannot be differentiated, either by external or internal morphology. Schrenk (16) is the only one who discovered a structural difference in the cell walls of the endodermis of the roots, results which we, in general, have been able to confirm. Bastin (11) points out that the rhizome of *Veratrum album*, in contrast to that of *Veratrum viride*, has the roots mostly trimmed away. Bentley and Trimen (1) point out that both kinds of *Veratrum album* may be found in commerce with and without roots (fibers.) The samples which we have observed have been whole, with attached roots and basal leaf scales. Denniston (12) describes the rhizome of *Veratrum viride* as being generally split longitudinally. Holm (13) found it in commerce as small fragments. We have usually found *Veratrum viride* to consist of rhizomes split longitudinally, with roots and basal leaf scales attached. Fig. 1 is introduced to illustrate the average appearance of rhizomes with and without roots. Fig. 2, A and B, show the gross structure of rhizome in longitudinal and cross-sections.

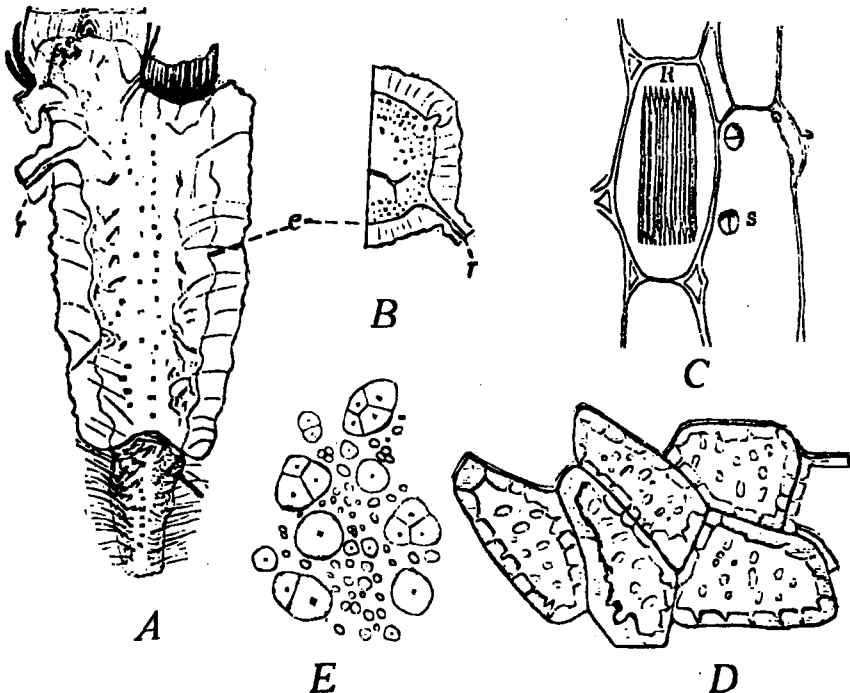


Fig. 2.—*Veratrum album*. A—Rhizome, longitudinal section; B—Rhizome, cross-section; C—Root. Tangential section, calcium oxalate raphides, approximately  $\times 150$ ; D—Rhizome. Endodermal cells approximately  $\times 200$ ; E—Starch. A, B, C, D, after Meyer; E, after Bastin.

The principal histological characteristics, based upon our own findings and a critical study of statements in the literature, are tabulated below. Plate II is introduced to show general microscopical structures of the roots and should facilitate orientation of cells and cell structures, referred to in the table and text.

TABLE II.—HISTOLOGICAL CHARACTERS OF THE RHIZOME.\*

| Transverse Section.   |  |  |
|---|--|--|
| <i>Veratrum viride</i> Ait.   | <i>Veratrum album</i> L.<br>Cortex.  | <i>Veratrum californicum</i> Durand.   |
| 1. Metadermis: Transformed cells; walls uniformly brown, thick, no suberin reaction.  | 1. Metadermis: Transformed cells; walls uniformly brown, thick, no suberin reaction.   | 1. Metadermis: Cell walls uniformly brown, thick, no suberin reaction.   |
| 2. Parenchyma: Circular, almost isodiametric in cross-section; roughly pitted; starch grains single, 2 to 3 compound.   | 2. Parenchyma: Almost isodiametric in cross-section; starch grains single, 2 to 3 compound.  | 2. Parenchyma: Almost isodiametric in cross-section; very little starch observed.  |
| 3. Raphide bundles: Not numerous; length about 0.054 mm. to 0.1 mm., averaging about 0.07 to 0.08 mm.   | 3. Raphide bundles: Not numerous; length about 0.038 to 0.070 mm., averaging about 0.05 to 0.06 mm.  | 3. Raphide bundles: Not numerous; length about 0.075 to 0.18 mm., averaging about 0.096 to 0.140 mm.   |
| 4. Fascicular bundles occasional.   | 4. Fascicular bundles occasional.  | 4. Fascicular bundles occasional.  |
| Central Cylinder.   |  |  |
| 1. Endodermis: Located between cortex and central cylinder; wavy or one-layered except locally. Cells thickened on inner tangential and radial walls; lumen more or less 1/2 width of cell; walls somewhat lignified. | 1. Endodermis: Located between cortex and central cylinder; wavy or one-layered except locally. Thickening on inner tangential and radial walls more pronounced than in <i>V. viride</i> ; lumen more or less 1/3 width of cell; walls somewhat lignified. | 1. Endodermis: Located between cortex and central cylinder; wavy or one-layered except locally. Thickening on inner tangential and radial walls more pronounced than in <i>V. viride</i> and <i>V. album</i> . |
| 2. Stele: Pericambium cells, radial groups of vascular cells alternating with groups of sieve tissue enclosing more or less sclerenchymatized parenchyma.   | 2. Stele: Pericambium cells, radial groups of vascular cells alternating with groups of sieve tissue enclosing more or less sclerenchymatized parenchyma.  | 2. Stele: Pericambium cells, radial groups of vascular cells, alternating with groups of sieve tissue enclosing more or less sclerenchymatized parenchyma.   |

\*Leaf scales commonly attached to the rhizome show crystals usually longer than those present in rhizomes and roots.

TABLE III.—HISTOLOGICAL CHARACTERS OF ROOT.

| <i>Veratrum viride</i> Att.  | <i>Veratrum album</i> L.<br>Cortex.  | <i>Veratrum californicum</i> Durand.  |
|--|--|---|
| <p>1. Epidermis: Cells more or less quadratic; outer tangential wall curved, walls lignified. <i>Longitudinal section, about 0.05 to 0.105 mm. in length, averaging about 0.060 to 0.080 mm.</i></p> <p>2. Hypodermis:<br/>(a) Outer endodermis: Long and short cells similar to epidermis, cellulose, sometimes compressed.<br/>(b) Collenchyma: Often 2 to 3 rows, sometimes interrupted near aerenchyma.</p> <p>3. Aerenchyma: Air spaces surrounded by disorganized parenchyma cells; more pronounced than in <i>V. album</i>.</p> <p>4. Parenchyma: Cells more or less circular, larger below epidermis, smaller towards central cylinder; contain starch, spherical or ellipsoidal, single, 2 to 3 compound, about 0.005 to 0.018 mm. in diameter. Crystal cells vary in length, <i>raphides about 0.045 to 0.120 mm. in length and averaging about 0.060 to 0.080 mm.</i></p> | <p>1. Epidermis; Cells more or less quadratic; outer tangential wall curved, walls lignified. <i>Longitudinal section, about 0.07 to 0.15 mm. in length and averaging about 0.09 to 0.12 mm.</i></p> <p>2. Hypodermis:<br/>(a) Outer endodermis: Long and short cells, similar to epidermis, cellulose, sometimes compressed.<br/>(b) Collenchyma: Often 2 to 3 rows, sometimes interrupted near aerenchyma.</p> <p>3. Aerenchyma: Air spaces surrounded by disorganized parenchyma cells; not so pronounced as in <i>V. viride</i>.</p> <p>4. Parenchyma: Cells more or less circular, larger below epidermis, smaller towards central cylinders; contain starch, spherical or ellipsoidal, single, 2 to 3 compound, about 0.005 to 0.018 mm. in diameter. Crystal cells vary in length, <i>raphides about 0.04 to 0.70 mm. length and averaging about 0.05 to 0.06 mm.</i></p> | <p>1. Epidermis: Cells more or less quadratic; outer tangential wall curved, walls lignified. <i>Longitudinal section, about 0.06 to 0.19 mm. in length, averaging about 0.09 to 0.14 mm.</i></p> <p>2. Hypodermis:<br/>(a) Outer endodermis: Long and short cells, similar to epidermis, cellulose, sometimes compressed.<br/>(b) Collenchyma: Often 2 to 3 rows, sometimes interrupted near aerenchyma.</p> <p>3. Aerenchyma: Air spaces surrounded by disorganized parenchyma cells; pronounced.</p> <p>4. Parenchyma: Cells more or less circular, larger below epidermis, smaller towards central cylinder. (Starch found to be very small in amount and disorganized in material examined.)</p> |
| <i>Central Cylinder.</i>   |  |   |
| <p>1. Endodermis: Located between cortex and central cylinder; cells with inner tangential and radial walls thickened, slightly lignified, <i>U-shaped lumen diagnostic (longitudinal section lumen more or less 1/2 width of cell; about 0.09 to 0.215 mm. in length and averaging about 0.15 to 0.20 mm.).</i></p>   | <p>1. Endodermis: Located between cortex and central cylinder; cells with inner tangential and radial walls considerably thickened, apparently lignified, <i>V-shaped lumen diagnostic (longitudinal section, lumen more or less 1/3 width of cell; about 0.06 to 0.30 mm. in length and averaging about 0.150 to 0.200 mm.).</i></p>  | <p>1. Endodermis: Located between cortex and central cylinder; cells with inner tangential and radial wall, considerably thickened; shape of lumen intermediate between U and V, rather elongated (longitudinal section, lumen more or less 1/4 width of cell; about 0.070 to 0.250 mm. in length and averaging about 0.10 to 0.170 mm.).</p>   |

TABLE III.—HISTOLOGICAL CHARACTERS OF ROOT (*Concluded*).

| <i>Veratrum viride</i> Ait.   | <i>Veratrum album</i> L.  | <i>Veratrum californicum</i> Durand.  |
|---|---|---|
| 2. Stele: Contains fascicular bundles; raphide bundles not so numerous in parenchyma of cylinder. | 2. Stele: Contains fascicular bundles; raphide bundles not so numerous in parenchyma of cylinder. | 2. Stele: Contains fascicular bundles; raphide bundles not so numerous in parenchyma of cylinder. |

*Rhizome*.—It may be seen from Table III that so far as the differentiation of the rhizomes is concerned, the length of the calcium oxalate raphides\* located in special cells (Fig. 2, C) can be used. In addition, we find that the thickening of the inner tangential and radial walls of the endodermal cells may also be used. These cells differ markedly in the degree of the thickness of the walls, *Veratrum viride* showing the least, and *Veratrum californicum* the most pronounced thickening. Fig. 2, D, illustrates in a suggestive way the general outline of these cells.

*Roots*.—These thickenings are even more pronounced in the roots, and enable one to differentiate the species in the powder. Illustrations showing the characteristic thickenings of the roots are given for transverse as well as longitudinal sections (Plate III). The calcium oxalate raphides appear to be more numerous in the roots and may readily be found in longitudinal sections and in the powder. An additional means for differentiation is found in the epidermal cells of the root, especially in longitudinal sections. Here again, the epidermal cells of *Veratrum viride* are shorter than those of *Veratrum album*. *Veratrum californicum*, on the other hand, has longer epidermal cells than either of the species already mentioned. Starch grains, in confirmation of Bastin's (10) and Denniston's (12) findings (see Fig. 2, E), showed no striking differences in *Veratrum viride* and *album*.

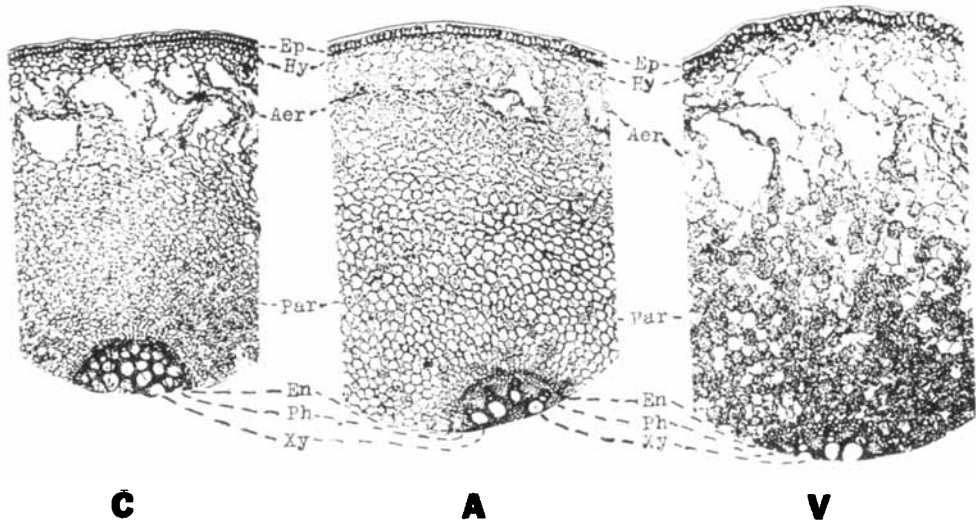


Plate II.—Cross-sections of roots; epidermis (Ep), hypodermis (Hy), aerenchyma (Aer), parenchyma (Par), endodermis (En), phloem (Ph), and xylem (Xy). V—*Veratrum viride* × 50; A—*Veratrum album* × 50; C—*Veratrum californicum* × 25.

\*The identification has been verified by microchemical and optical methods.



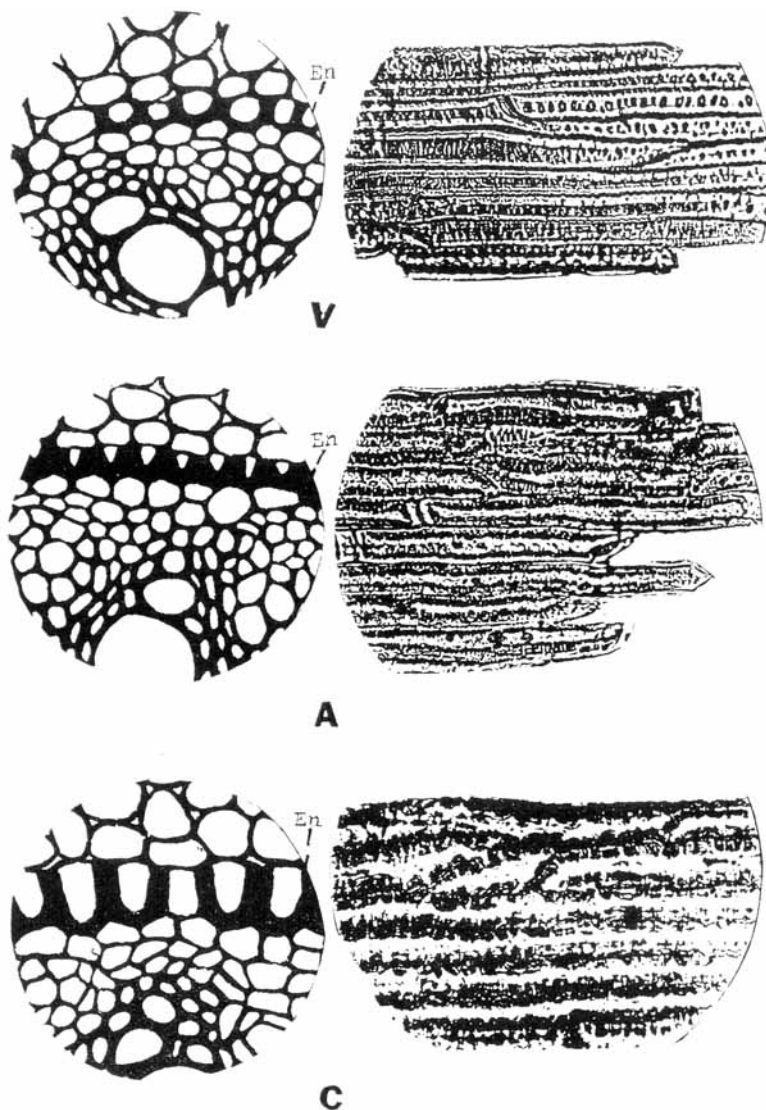


Plate III.—Root endodermis (En), cross and longitudinal section.  $\times 400$ .  
 V—*Veratrum viride*; A—*Veratrum album*; C—*Veratrum californicum*.

*Basal leaf scales.*—Short leaf scales (Fig. 1, B) may or may not be present, forming a crown to the rhizomes of *Veratrum album* and *Veratrum viride*. They contain calcium oxalate raphides, which are considerably longer than those in either the roots or rhizomes. The occasional presence of the scales in the powdered drug may render the use of the raphides less reliable as a means for differentiation.

Material of *Veratrum viride*,\* collected from dry and moist locations, showed variations in the character of the lumen of the endodermal cells. Plants growing in moist situations showed the lumen typical for the endodermal cells of *Veratrum*

\*These plants were found growing on Spruce Knob, W. Va.

*viride*, while those of plants growing in unusually dry locations showed a lumen approaching the V-shape characteristic of *Veratrum album*. The length of the crystals in the material was found to be essentially the same. The result of the sulphuric acid reaction was too variable to be entirely satisfactory.

*Veratrum nigrum* is differentiated by its relatively smaller cylinder in the root; it also shows relatively much less parenchyma in the rhizome (15).

*Determinations Made on Commercial Samples of Veratrum* (Hellebore).—The data thus far reported in this investigation are the result of work done on material especially collected for the project. It seemed desirable also to secure more comprehensive data regarding commercial samples of hellebore. A large number of samples, both of the powdered and crude material, were therefore collected from a number of dealers in botanicals and determinations made as to the identity of the product, irrespective of the label upon it. The results of these determinations have been recorded in Table IV.

#### MICROCHEMICAL TESTS.

A number of investigators have given the color reactions obtained with different reagents some attention. Denniston (12) points out that *Veratrum album* and *Veratrum viride* might be differentiated by the color reactions which concentrated sulphuric acid produces with these drugs. Concentrated hydrochloric acid and other reagents have been recommended. We have tried both cold and warm hydrochloric acid without any distinctive results. Different concentrations of sulphuric acid were also applied, the most satisfactory results being obtained with concentrated sulphuric acid when added either to the powder or the sections. In the case of *Veratrum viride* the reaction obtained consisted of a distinct yellowish tint observed immediately after applying the sulphuric acid to the powder or the sections. It appears that the chemical substance producing the yellowish tint immediately diffuses in the acid. For this reason, a powder or section treated with the concentrated sulphuric acid must be directly observed, otherwise the yellow tint will be affected by the red coloration which soon appears. In the case of *Veratrum album* the color change appears more limited to the vegetable material and the characteristic orange or red tint observed occurs immediately after the acid has been applied. Direct observation is essential also in this case. No yellow tint was observable. In either case, the color changes, to red and finally to dark reddish brown, were more or less influenced by the charring of the plant material. The application of the sulphuric acid test to a large number of samples indicated that there were instances where the color differences were not so clearly defined in the two species. The color reaction will usually be found valuable as a confirmatory test but not entirely satisfactory in itself. The same test was applied to *Veratrum californicum*, with the result that the color reaction is not markedly different from *album*, indicating rather an intermediate tint between that given by *Veratrum viride* and *Veratrum album*. The color obtained with concentrated sulphuric acid in sections indicated that the alkaloids are mainly located in the parenchymatic and collenchymatic tissue below the epidermis. The findings of Rundquist (20) seem thus confirmed, while those of Borscow (19), who found the alkaloid mainly located in the cell walls of the epidermis and endodermis, could not be verified.

TABLE IV.—EXAMINATION OF VERATRUMS (HELLEBORE).

| Ph. No. | Label.                   | Identification.        |                 | Common name.    | Condition. | Color with Luesen of endo-<br>Cob. H <sub>2</sub> SO <sub>4</sub> ,<br>dermal cells.<br><i>Veratrum Album.</i> | V-shape | Crystals in microsc. |         |  | Origin of sample. |     |
|---------|--------------------------|------------------------|-----------------|-----------------|------------|--|---------|----------------------|---------|--|-------------------|-----|
|         |                          | Scientific name.       | White Hellebore |                 |            |  |         | Powdered Red         | V-shape | Min. Av. Max.                            |                   |     |
|         |                          |                        |                 |                 |            |  |         |                      |         | Min.                                     |                   | Av. |
| 3124    | White Hellebore          | <i>Veratrum album</i>  | White Hellebore | Powdered Red    |            | V-shape  | 44      | 61                   | 76      | Commercial, imported                     |                   |     |
| 3128    | "                        | "                      | "               | "               | "          | "  | 44      | 60                   | 76      | "  |                   |     |
| 3130    | Japanese White Hellebore | "                      | "               | "               | "          | "  | 49      | 62                   | 76      | "  |                   |     |
| 3123    | White Hellebore          | "                      | "               | "               | "          | "  | 40      | 60                   | 85      | "  |                   |     |
| 3129    | American Hellebore       | "                      | "               | "               | "          | "  | 44      | 59                   | 87      | " domestic                               |                   |     |
| 3134    | White Hellebore          | "                      | "               | "               | "          | "  | 40      | 60                   | 87      | " imported                               |                   |     |
| 3159    | "                        | "                      | "               | "               | "          | "  | 49      | 59                   | 87      | Commercial                               |                   |     |
| 3185    | "                        | "                      | "               | "               | "          | "  | 40      | 60                   | 87      | Commercial, imported                     |                   |     |
| 3160    | Hellebore                | "                      | "               | Whole           | "          | "  | 38      | 63                   | 88      | Commercial                               |                   |     |
| 3131    | Japanese White Hellebore | "                      | "               | "               | "          | " Suggesting more U-shape  | 50      | 70                   | 100     | Commercial, imported                     |                   |     |
| 3164    | White Hellebore          | "                      | "               | "               | "          | V-shape  | 40      | 60                   | 100     | "  |                   |     |
| 3167    | "                        | "                      | "               | Powdered        | "          | "  | 55      | 80                   | 109     | "  |                   |     |
| 3136    | "                        | "                      | "               | "               | "          | "  | 55      | 74                   | 120     | "  |                   |     |
| 3139    | White Hellebore          | <i>Veratrum viride</i> | Green Hellebore | Powdered Yellow | "          | U-shape  | 60      | 81                   | 109     | Commercial, domestic                     |                   |     |
| 3140    | American White Hellebore | "                      | "               | "               | "          | "  | 55      | 78                   | 112     | "  |                   |     |
| 3113    | "                        | "                      | "               | Whole           | "          | Approaching V-shape  | 57      | 82                   | 114     | Collected on dry mountain, West Virginia |                   |     |
| 3117    | <i>Veratrum viride</i>   | "                      | Hellebore       | "               | "          | "  | 57      | 88                   | 114     | Slightly moist plateau in North Carolina |                   |     |
| 3132    | "                        | "                      | Green Hellebore | "               | "          | U-shape  | 57      | 81                   | 114     | Commercial, domestic; low, dry ground    |                   |     |
| 3108    | "                        | "                      | "               | "               | "          | "  | 60      | 80                   | 115     | Commercial, domestic                     |                   |     |
| 3122    | American Hellebore       | "                      | "               | "               | "          | "  | 60      | 88                   | 120     | "  |                   |     |
| 3135    | White Hellebore          | "                      | "               | Powdered        | "          | "  | 55      | 86                   | 120     | Commercial                               |                   |     |
| 3141    | <i>Veratrum viride</i>   | "                      | "               | "               | "          | "  | 80      | 100                  | 120     | Commercial, domestic                     |                   |     |
| 3166    | American Hellebore       | "                      | "               | "               | "          | "  | 55      | 82                   | 120     | "  |                   |     |
| 3163    | "                        | "                      | "               | Whole           | "          | "  | 44      | 80                   | 131     | "  |                   |     |
| 3121    | White Hellebore          | "                      | "               | Powdered        | "          | "  | 62      | 91                   | 135     | "  |                   |     |

\*Values given are based upon at least 25 measurements. Sizes may differ in other samples due to variation in composition (leaf scales), etc. See text.

*Use as an Insecticide.*—Veratrum has been used in the past as a poison against animals and certain insects, and its insecticidal value appears established. Recently experiments have been carried out, using hellebore, in attempts to kill fly larvae in manure piles (17, 18). The results have been positive, showing a distinct insecticidal value in this material applied in powdered form or extract. The investigational work has been done probably in the main on *Veratrum viride*, and the results do not, therefore, permit of a definite conclusion as to the comparative value of either *Veratrum album* or *Veratrum viride*.

*Commercial Data Regarding Veratrum.*—With regard to the extent of importation, no definite data appear available. Recently new shipments in considerable amount have entered this country from Europe. These shipments proved to be *Veratrum album*. To our knowledge, no *Veratrum viride* is exported. Definite information with regard to the extent to which the domestic hellebore enters commerce is not available to us. In the following table are given the market prices of the crude powdered drugs during the period from 1914 to 1920:

TABLE V.—PRICE FLUCTUATIONS OF DOMESTIC AND IMPORTED VERATRUM.

| Year.     | Quotation per pound.*                   |                  |  |                  |
|-----------|---|------------------|--|------------------|
|           | Imported white.<br>( <i>V. album</i> .) |                  | Domestic green.<br>( <i>V. viride</i> .) |                  |
|           | Whole sample.                           | Powdered sample. | Whole sample.                            | Powdered sample. |
| 1914-1916 | 9-10 cents                              | 10-13 cents      | .....                                    | .....            |
| 1916      | .....                                   | 20-25 cents      | .....                                    | .....            |
| 1917      | 40-45 cents                             | .....            | .....                                    | .....            |
| 1918      | .....                                   | 26-28 cents      | 22 cents                                 | 24 cents         |
| 1920      | 20 cents                                | 22 cents         | 20 cents                                 | 22 cents         |
| 1921      | .....                                   | 19-20 cents      | 20 cents                                 | 19-20 cents      |

\*Drug and Chemical Markets. *Oil, Paint and Drug Reporter*.

An examination of this table would seem to indicate that the price is apparently influenced by the supply of and the demand for the crude botanical and not so much by the specific demand for either the white or green Veratrum.

## SUMMARY.

1. Means are pointed out for the differentiation of the rhizomes and roots of domestic Veratrum (*Veratrum viride*) and imported Veratrum (*Veratrum album*). These results are interesting in view of the belief generally expressed in textbooks and recent articles that differentiation is not possible.

2. Means are also pointed out for the differentiation of *Veratrum californicum*, another native form, hitherto not studied histologically.

3. The main differentiating characteristics found in the rhizome and roots of *Veratrum album*, *Veratrum viride* and *Veratrum californicum* were those of the endodermal cells forming in the case of the rhizome and root a sheath, the cells of which show different thickenings of the inner tangential and radial walls. Also, the calcium oxalate raphide bundles occurring in both rhizome and root were found to be more or less characteristic, differing in length in the different species. Calcium oxalate raphides occurring in the leaf scales attached to the rhizomes of *Veratrum viride* and *Veratrum album* were found to be distinctly longer than those in the rhizomes and roots of these species. The epidermal cells of

the roots showed sizes which were also different, being smallest in the case of *Veratrum viride*, larger in *album*, and still larger in *californicum*.

It has been evident during the course of this investigation that these characteristics vary to a considerable degree, even showing a tendency to overlap in single instances, thus demonstrating the close relationship of the forms under consideration. The analyst, in doubtful cases, should be aware of this fact and not confine himself to one single character nor to one specimen in arriving at a conclusion.

4. The present market quotations indicate that *Veratrum album* and *Veratrum viride* are considered of equal value.

5. No data, however, as to the relative value of *Veratrum viride* and *Veratrum album*, definitely identified as such, appear to be available. The means we have pointed out for their histological differentiation should permit of comparative studies of the plants as found in the market and as a result of such studies establish their relative values as therapeutic agents and as insecticides.

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