and was apparently stable. The mixture of ephedrine silver tartrate obtained was apparently a stable mixture. The dry powder had not changed in appearance upon standing for one month.

CONCLUSIONS

From the information obtained in this work the following conclusions may be drawn:

1. Ephedrine alkaloid in aqueous solution reduced silver salts to metallic silver. The ephedrine salts do not have the reducing property of the alkaloidal base.

2. Ephedrine or ephedrine sulfate appeared to be stable in solution with colloidal silver chloride. A colloidal solution of ephedrine silver nitrate was prepared which was apparently stable.

3. Ephedrine phosphate and silver phosphate, in strongly acid solution, were apparently stable. No chemical compound was produced. Ephedrine phosphate and silver phosphate were isolated and identified.

4. Silver compounds with ephedrine, such as ephedrine silver chloride and ephedrine silver nitrate, could not be prepared. Ephedrine hydrochloride was apparently converted into pseudoephedrine by the reaction of silver nitrate in alcoholic solution.

5. A mixture of ephedrine and silver tartrate was obtained that was apparently stable in aqueous solution. The compound was found by analysis to contain 10.5 per cent silver and to be a mixture of ephedrine nitrate and silver tartrate.

BIBLIOGRAPHY

(1) Nagai, N., *Pharm. Ztg.*, 32 (1887), 700.

(2) Lanwermeyer, C. F., JOUR. A. PH. A., 20 (1931), 891.

(3) Chen, K. K., and Kao, C. H., *Ibid.*, 15 (1926), 625.

(4) Waldbott, S., *Pharm. J.*, 128 (1932), 282, 283.

(5) Pilcher, J. D., *J. Am. Med. Assoc.*, 88 (1927), 720.

(6) Rebiere, G., *C. A.*, 20 (1926), 477.

(7) Burrows, G. J., and Parker, R. H., *J. Am. Chem. Soc.*, 55 (1933), 3621.

(8) Whitmore, W. F., and Lauro, M., *Ind. Eng. Chem.*, 22 (1930), 646.

(9) Guggenheim, M., U. S. Pat. 1,417,167 (May 23, 1922).

(10) Grutzner, B., *Arch. Pharm.*, 236 (1898), 370.

(11) Schwyzer, J., *Quart. J. Pharm. and Pharmacol.*, 2 (1929), 116.

The Histology of Salvia Officinalis*

By Elbert Voss† and Frank Fortunato

The need for a thorough and comprehensive investigation of the histology of *Salvia officinalis*, L., became apparent when it was deemed of such importance as to merit a place in the National Formulary, Sixth Edition. An investigation of the literature revealed that in most cases *Salvia* was mentioned in connection with other species of the same genus, only in broad general discussions of the characteristic features of the *Labiates*, of which family it is a member. The number of different species belonging to this family is so large that many of them, including *Salvia*, have not individually received the meticulous histological study they deserve.

The early literature contains only brief and incomplete descriptions of *Salvia officinalis* leaf and stem, but there are many references to adulterants. The recent work by Youngken and Vander Wyk (1) on a sample of *Salvia* obtained from the Harvard University Garden, Cambridge, Massachusetts, does not entirely agree with the findings made in the course of the present investigation. Hence, it is obvious that to facilitate the exclusion of adulterants and to aid in the identification of genuine *Salvia*, a study of additional material obtained from another geographical source is needed. An amplification of the histology of this drug is, therefore, sufficient justification for a work of this kind.

The present monograph on *Salvia* in the National Formulary (2) gives a brief description of the leaf powder. It admits the presence of not more than ten per cent of the

* Abstract of a thesis by Frank Fortunato presented in partial fulfilment of the requirements for the degree of Master of Science at the School of Pharmacy of Duquesne University, Pittsburgh, Pa.

† Professor of Botany and Pharmacognosy, Duquesne University, Pittsburgh, Pa.

stems. The monograph, under "test for purity," makes only one brief specification in regard to *Salvia* stems; namely, that powdered *Salvia* shall not contain an abundance of reticulate tracheæ and crystal-bearing cells, both of which are present in *Salvia* stems; but no other reference is made to the histology of the stem.

In the present investigation equal attention has been given to the stem and the leaf.

The material used for study was obtained from the United States Department of Agriculture, Bureau of Plant Industry, Washington, D. C.

HISTOLOGY OF THE LEAF

In cross sections of the leaf, regions common to the lamina and conducting areas of dorsiventral leaves are observed.

The cells of the upper epidermis of the lamina are quadrangular in outline, with thick, cutinized outer walls, and approximately every third or fourth cell gives rise to a trichome. The upper and lower epidermal cells of the midrib and veinal areas are smaller, with heavier and more wavy outer walls than those of the lamina. The cells of the lower epidermis are of very irregular sizes, being generally smaller and thinner-walled than those of the upper epidermis, with numerous larger ones giving rise to trichomes. Two rows of thick-walled hypodermal cells occur under the lower epidermis of the midrib. Passing from the upper epidermis toward the xylem of the midrib are four or five rows of collenchyma cells. The latter are followed by an area of relatively small parenchyma cells immediately above the xylem. From one to four rows of unmodified parenchyma cells occur at the sides of the fibrovascular bundle, and from three to five rows are found occupying the area between the phloem and the hypodermis of the lower surface.

The phloem area comprises almost half the fibrovascular bundle. The xylem area is composed of radially arranged and alternating rows of medullary rays and conducting cells. The latter are oval, round or polygonal in transverse outline, highly lignified and serve the function of support for the fibrovascular bundle. Medullary rays are one cell in width and usually alternate with single rows of conducting cells, but occasionally there may be from two to five rows of conducting cells filling the area between two medullary rays.

The lamina presents in general outline numerous undulations and thickened areas. The latter are due to a great increase in number of the spongy mesophyll parenchyma cells which project toward the upper epidermis. Both thickenings and undulations are accompanied by great variation in size and number of the mesophyll cells. Two rows of palisade cells, however, are most common. Occasionally there may be three rows at the crests of the undulations or near the margin, or occasionally one row at the crests of the thickened areas. In unmodified areas of the lamina there are usually four rows of spongy mesophyll cells.

HISTOLOGY OF THE PETIOLE

The petiole in cross section is triangular in general outline, with rounded angles and concave surfaces

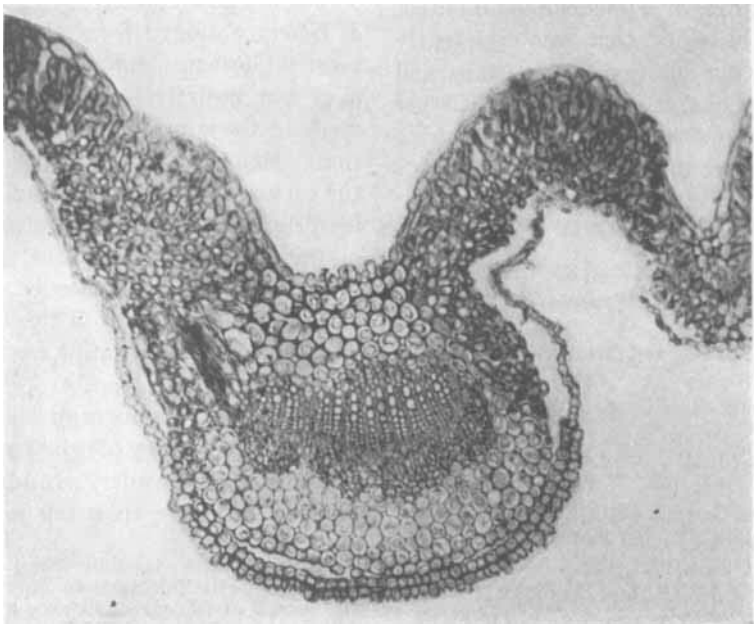

Fig. 1.—Photomicrograph. Transverse Section of Midrib. 100×.

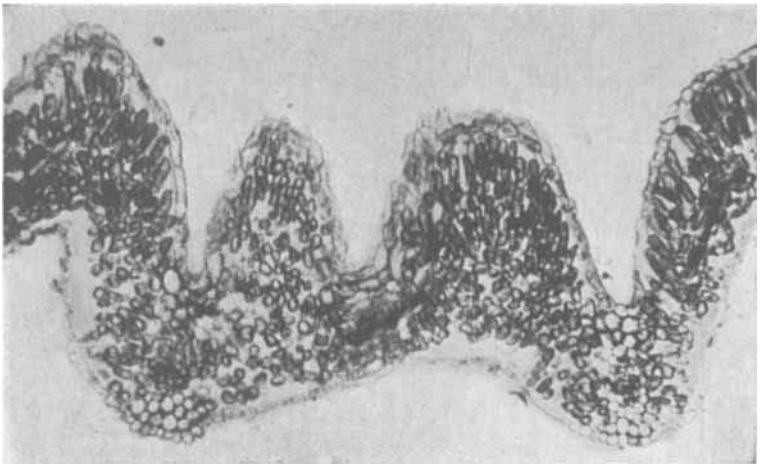

Fig. 2.—Photomicrograph. Transverse Section of Lamina. 100×.

between the angles. The epidermal cells are rectangular, with thick, cutinized and rounded outer walls, and numerous ones bear trichomes. Beneath the epidermis is found one to two layers of collenchyma cells, except in the angles where from four to six rows may occur. A large oval group of open collateral bundles at the center is surrounded by a broad cortex of thin-walled parenchyma cells. The smaller angles at the margins of the petiole each contain a small group of fibrovascular bundles similar to the large group in the center.

Trichomes.—Both glandular and non-glandular trichomes are numerous, with the non-glandular types present in greater number. The latter are uniseriate, from one to five cells in length, the individual cells distended or collapsed, and the end cell often attenuate and sometimes flexed. All trichomes are swollen at the base and usually seated on a short and broad pedestal. Three distinct forms of glandular trichomes occur: (*a*) one composed of a single-celled head with a thick cuticular wall supported by either a short and bulging stalk, or a straight, narrow, unicellular stalk; (*b*) a bicellular head supported by a bicellular stalk of varying length; (*c*) an eight-celled head with a very short, unicellular stalk.

Isolated Tissues of the Leaf.—The cells of the upper epidermis are devoid of stomata. They are polygonal in outline, with straight, heavy walls. Approximately every third cell bears a trichome, which is most commonly of the non-glandular type.

The lower epidermal cells are irregular or crescent-shaped in outline, with highly undulate margins. They contain numerous stomata which are surrounded by two epidermal cells lying transversely to the pore. There are proportionately fewer trichomes, with the glandular type relatively more numerous than on the upper epidermis.

The epidermal cells of the midrib and petiole are irregularly polygonal in outline with heavy straight walls. Trichomes, mostly non-glandular are present in great number, but no stomata are present.

The tracheal cells are greatly elongated, highly lignified and generally scalariform, occasionally spiral, in type.

Tracheids are highly lignified, usually spiral, but occasionally scalariform in type. The scalariform types are greatly elongated and very slender. The spiral types are of very irregular outline.

Parenchyma cells are elongated; some are very slender with thin unmodified walls, others distinctly rectangular with rather thick, pitted walls.

HISTOLOGY OF THE STEM

Transverse sections of the stem, passing from periphery toward the center, present an epidermis, cortex, wood and pith. Very young stems show distinct open collateral vascular bundles separated by wide pith rays. Older stems show progressively deeper and broader vascular bundles, which, in mature stems, form a continuous woody cylinder composed of narrow, tangentially elongated, open collateral bundles separated by medullary rays usually one cell in width, but occasionally two cells in width. Young stems are distinctly quadrangular in shape, the older ones tend to become round but retain a greater thickness of the cortex in the areas corresponding to the angles of younger stems. A slightly quadrangular shape is, therefore, retained in mature stems.

The epidermal cells in transverse sections are of two types. Those between the angles are quadrangular, slightly tangentially elongated, the outer walls are thickened, and occasional ones give rise to trichomes. The epidermal cells covering the thickened areas at the angles are relatively smaller than those between the angles. They are practically isodiametric in outline, with heavy outer walls. Numerous ones bear trichomes.

Tangentially arranged groups of pericyclic fibers, located about one-third the distance from the cambium to the epidermis, divide the cortex into an inner and an outer region. Individual groups of these fibers vary from one to four cells in width, and from

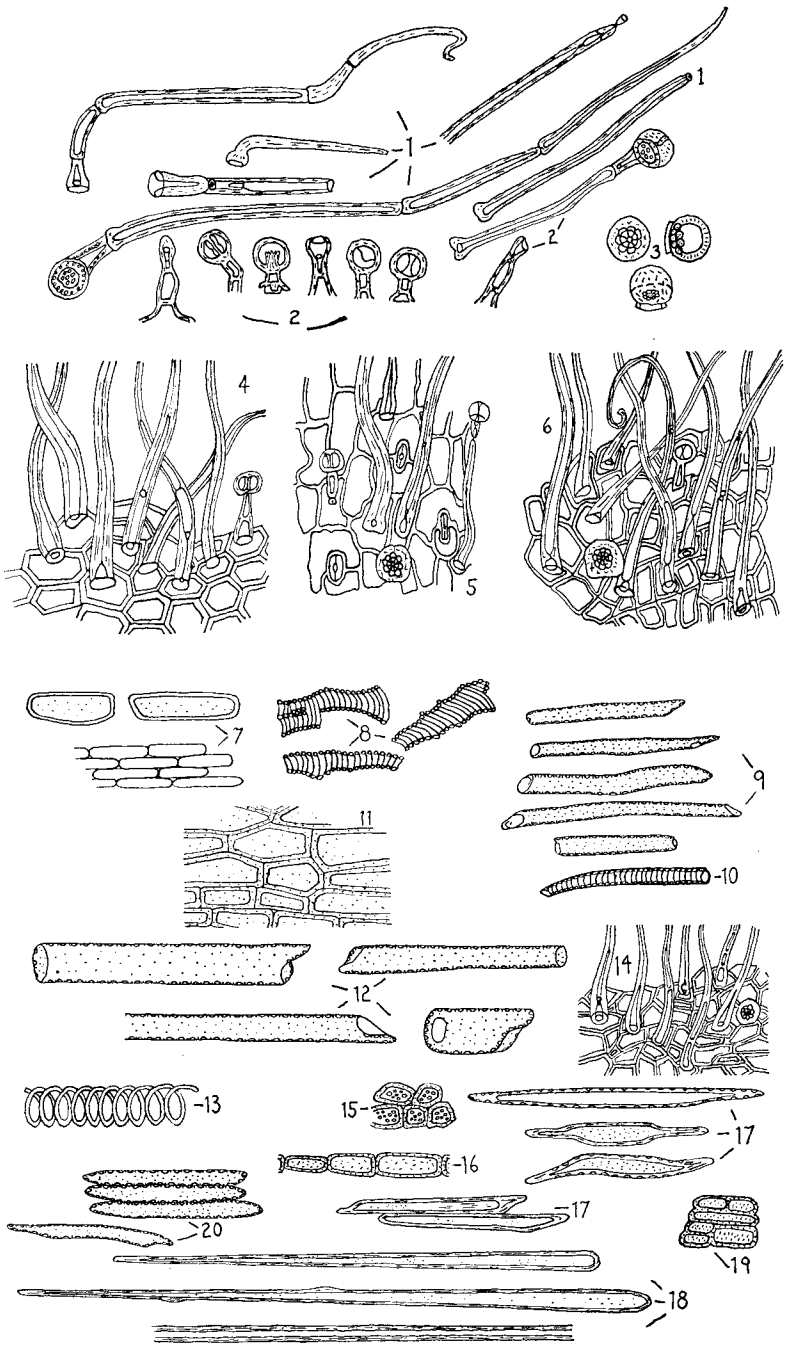

Fig. 3.—Isolated Tissues of Salvia officinalis.
(1) Non-glandular trichomes. (2 and 3) Glandular trichomes. (4) Upper epidermis of the lamina. (5) Lower epidermis of the lamina. (6) Epidermis of the petiole. (7 and 11) Parenchyma cells of the leaf. (8) Spiral and Scalariform tracheids of the leaf. (9) Scalariform trachael cells of the leaf. (10) Spiral tracheal cell of the stem. (12) Scalariform and reticulate tracheal cells of the stem. (13) Spiral tracheal cell of the stem. (14) Stem epidermis. (15) Crystal-bearing parenchyma cells of the stem. (16) Medullary ray cells of the stem. (17) Wood fibers of the stem. (18) Bast fibers of the stem. (19) Parenchyma cells of the stem. (20) Tracheids of the stem.

approximately three to fifteen cells, averaging approximately ten cells, per group. The larger groups are situated below the angles of the stem and smaller groups between the angles. In younger stems many of these fibers are unlignified, but in older stems all are heavily lignified. The cells of the outer cortex are tangentially elongated, thin-walled and irregular in outline. This area averages approximately seven rows of cells in width between the angles of the stem. Large groups of collenchyma displace the cells of the outer cortex at the angles of the stem, and account for the increase in thickness in these areas.

The woody cylinder is composed of xylem areas made up of vessels, tracheids and wood fibers, with parenchyma cells near the pith. The xylem areas are separated by medullary rays which are usually one cell, or occasionally two cells, in width. Medullary rays are more numerous below the angles of the stem, being rather infrequently found in areas midway between the angles. The latter areas also contain a relatively greater proportion of tracheids and wood fibers, with fewer vessels. All tissues of the xylem areas have generally a radial arrangement which is least apparent in areas about the larger vessels.

By far the most conspicuous elements of the xylem areas are the vessels which are polygonal in outline, with highly lignified walls, averaging approximately 0.025 mm. in diameter. They occur singly or in radially arranged groups of from two to six cells per group, and may be bordered by the medullary rays or by other xylem elements.

Tracheids occur interspersed among the smaller groups of vessels. They are relatively more numerous in the less vascular areas between the angles of the stem.

The most typical cells of the pith region are thin-walled, very large in diameter and isodiametric in outline. Numerous pith cells in the marginal areas are filled with a yellowish crystalline substance.

In radial sections the epidermal cells are slightly elongated and quadrangular in outline. The thin-walled parenchyma cells of the outer cortex are quadrangular and longitudinally elongated, while the more delicate cells of the inner cortex are of irregular outlines. Bast fibers are observed in some sections between the inner and outer cortex. Spiral and reticulate vessels with compactly arranged groups of tracheids and wood fibers between them, are apparent in radial sections, while medullary rays are very seldom seen. The first three or four outer rows of cells of the pith have fairly heavy walls, are elongated and polygonal in outline and occasional ones contain the yellowish crystalline substance observed in other sections. Passing toward the center of the stem the pith cells are less elongated and more isodiametric in outline.

In tangential sections the medullary rays vary from four to an indefinite number of cells in height and may even extend across the entire section, thus making it impossible to determine the actual number of cells present in some groups. Sections near the pith show numerous elongated parenchyma cells interspersed among vessels, tracheids and wood fibers.

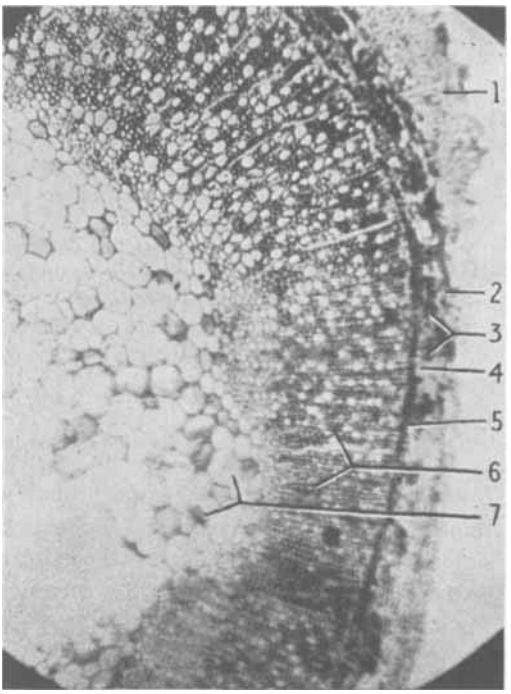

Fig. 4.—Photomicrograph. Transverse Section of Stem.

(1) Collenchyma. (2) Outer cortex. (3) Bast fibers. (4) Inner cortex. (5) Cambium. (6) Woody cylinder. (7) Pith.

Isolated Tissues of the Stem.—The stem epidermal cells like those of the petiole, are irregularly polygonal in outline, with heavy walls, and bear numerous non-glandular and occasional glandular trichomes. The trichomes are similar to those of the leaf.

The tracheal cells are both spiral and reticulate, varying from 0.100 mm. to 0.200 mm. in length and 0.015 mm. to 0.030 mm. in width. One end is usually round, the other diagonally extended. The side walls are heavily lignified and in reticulate types the markings frequently have a distinct scalariform arrangement. The spiral tracheal cells are comparable to the reticulate ones in size.

Tracheids are spiral or reticulate, and heavily lignified like the tracheal cells. They occur singly or in large groups when isolation has not been thorough. They are relatively much smaller than the vessels in transverse and longitudinal dimensions. They are greatly elongated in general outline with the ends either round or extended to an obtuse point.

The bast fibers approach or exceed the length of the longest non-glandular trichomes. Their side walls are heavy, and, in general, regularly thickened. A distinct cavity is usually present throughout the

length of the fiber. The ends are either round or acutely pointed.

Wood fibers vary in length, from one to three times the length of the tracheids. They are characteristically heavy-walled and highly lignified, the side walls are usually parallel with a broad cavity in the center. The ends may be round, but are usually extended to an acute or an obtuse point, and the latter may be straight or bent.

Pith cells bearing yellowish crystalline substance are conspicuous. Other pith cells may be unmodified, or possess irregular pit-like markings.

Medullary rays are distinguishable from the cells of the pith only by their longitudinal arrangement when seen in groups of two or more.

SUMMARY AND CONCLUSIONS

A comprehensive study has been made of the histology of *Salvia* stem and leaf using a single sample obtained from the United States Department of Agriculture, Bureau of Plant Industry.

Our findings do not agree completely with those reported in the recent study made by Youngken and Vander Wyk on material from another source. The differences are significant enough to suggest that more than one variety of *Salvia officinalis* may now be in use as the official drug.

The present investigation reveals the following important histological characteristics of *Salvia*. These have not been emphasized in previous publications:

1. The occasional presence, in transverse sections of the stem, of medullary rays two cells in width.

2. Concentrically arranged groups of *bast* fibers dividing the cortex of the stem into inner and outer regions.

3. The relative abundance of medullary rays and conducting elements in xylem areas beneath the angles of the stem as compared to their occurrence between the angles.

4. Tangential sections of the stem revealing groups of medullary rays varying from four to an indefinite number of cells in height.

5. While no additional types of trichomes were noted on either stem or leaf, the absence of stalkless glandular trichomes with eight-celled heads is emphasized. The latter invariably possess short and broad, one-celled stalks. Glandular trichomes with one-celled heads have unicellular stalks. Those with two-celled heads show two-celled stalks, the latter varying greatly in length.

6. Leaves in cross section occasionally contain three rows of palisade cells at the crests of undulations or near the margin. Numerous thickened areas in the lamina are due to a great increase in the number of spongy mesophyll cells. These cells tend to displace, partially or entirely, the palisade mesophyll, and, together with the undulations of the lamina, give the latter an exceedingly irregular outline.

The above references to the variations in trichome and leaf structure should appear in the National Formulary monograph of *Salvia* leaf powder.

REFERENCES

(1) Youngken, H. W., and Vander Wyk, R., "The Pharmacognosy of *Salvia officinalis*," *Bull. N. F. Committee*, VII (December, 1938) 3, 79–81.

(2) "The National Formulary, 1936 Edition," Mack Printing Co., Easton, Pa., pages 323–324.

A Study of Athyrium Filix-Foemina

By Malcolm S. Trupp and Forrest J. Goodrich†*

INTRODUCTION

Many ferns are found growing natively in the State of Washington and several of them have been carefully investigated as to their chemical components. *Athyrium filix-fœmina* (Lady Fern) is a plant of unusual beauty and has attracted considerable attention. It is reported in the literature (1) as having anthelmintic principles in its roots, rhizomes and stipes. The purpose of the investigation was to determine whether or not it possessed anthelmintic principles similar to the official Aspidium and to ascertain the presence of significant components.

Athyrium filix-fœmina is a large non-evergreen fern found in the moist woods and near streams. The fronds are often more than a meter in length, pinnately two-three com-

* Instructor in Pharmacy, Saint Louis College of Pharmacy.

† Professor of Pharmacognosy, University of Washington.