

- (4) Whitson, A. R., Bulletin 68, Soil Series No. 49, *Wisconsin Geological and Natural History Survey*, State of Wisconsin, 258 (1927).
- (5) Treadwell and Hall, *Analytical Chemistry*, Vol. 2, 602 (1928).
- (6) A. O. A. C. Methods, 40 (1920).
- (7) Treadwell and Hall, *Analytical Chemistry*, 2, 86 (1928).
- (8) *Ibid.*, 78.
- (9) A. O. A. C. Methods, 41 (1920).
- (10) *Ibid.*, 41.
- (11) *Ibid.*, 39.
- (12) *Ibid.*, 45.
- (13) Treadwell and Hall, *Analytical Chemistry*, 2, 508 (1928).
- (14) A. O. A. C. Methods, 43 (1920).

A STUDY OF SEVERAL SPECIES OF THE GENUS MONARDA.*¹

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SECTION NO. 4—THE HISTOLOGY OF MONARDA MENTHÆFOLIA VAR. LEUCANTHA.

Since there have been questions arising as to the authenticity of classifying some groups of *Monardas* as independent species, the histology of the various *Monarda* species is becoming important. As a means of increasing the number of studies on *Monardas* now available the histology of *Monarda punctata* var. *leucantha*, Nash., is presented in the following paper.

Monarda punctata var. *leucantha* shows the characteristics of the Genus *Monarda* of the Labiatae (Lamiaceae) Family as follows:

Corolla two-lipped with lower lip three-lobed and middle lobe longer than lateral ones, two stamens, filaments elongate and anthers with divergent sacs, gynœcium with two carpels, a four-celled ovary, a fruit with four nutlets included in the calyx, leaf blades toothed, flowers in dense racemes, calyx elongated with five lobes. It is also assigned to subgenus *Cheilyctis* due to the fact that the flower clusters are mainly axillary, borne in spike-like interrupted panicles and the stamens do not exceed the curved upper corolla lip. This variety differs from *Monarda punctata*, Linn., externally inasmuch as the corolla is white with purple spots while *Monarda punctata* corolla is yellow with purple spots. See Plates 1, 2, 2A and 3.

The following microscopical studies were carried out upon specimens which had been fixed in formol-acetic acid fixative and double stained with safranin and methylene blue.

THE HISTOLOGY AND DEVELOPMENT OF THE FLOWER.

In the sectioning of the flower heads the various stages in the development of the flower were obtained in detail. The first flower part to become differentiated from embryonic tissue was the calyx. Next the corolla develops and in the course of this development the filament and rudimentary anthers appear. The differentiation of the gynœcium begins at approximately the same time. Up to this time the tissue present is meristematic with no apparent differentiation into cells with other functions.

From this point the embryonic flowers develop the differentiated tissues such as parenchyma, vessels in the veins, epidermis, trichomes and glandular hairs, pollen and meristematic

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tissue or regenerative tissue of the ovary. Histologically the flower cluster shows the usual typical flower structures in the flowers of the raceme and also in the bract.

The bract externally is composed of epidermal cells and numerous one- to three- or four-celled simple, multicellular, non-branching, non-glandular hairs and scattered sessile, multicellular, glandular hairs. These hairs are typical of all epidermal coverings of *Monarda punctata*, var. *leucantha* and so, for simplicity, they will hereafter be referred to as glandular and non-glandular hairs. Internally the principal tissue of the bract is mesophyll. No palisade is present. There are also scattered bundles composed of vessels and fibers.

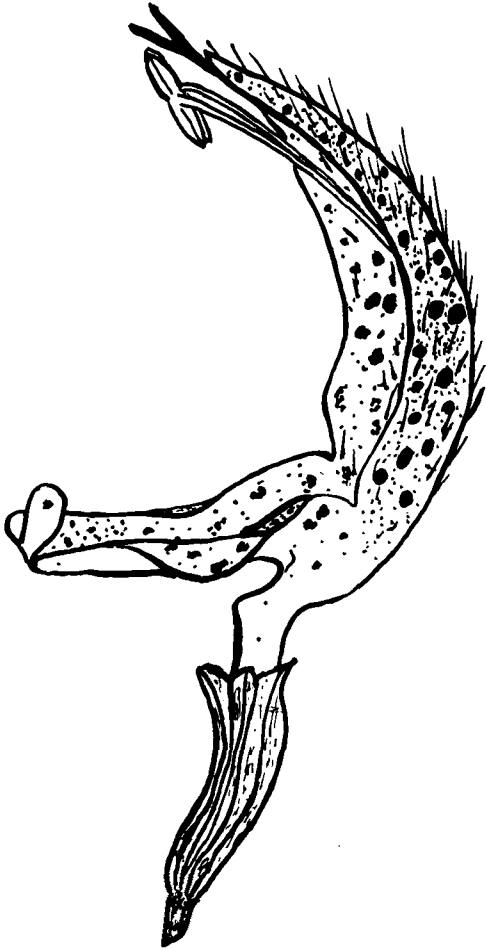


Plate No. 1.—Pen Drawing of the Flower of *Monarda punctata* var. *leucantha*, Nash. ($\times 5$).

The following parts of the flower are present:

- (a) The calyx
- (b) The corolla
- (c) The stamens
- (d) The pistil.

The calyx is composed of a simple epidermis on the internal surface while the external surface has glandular and non-glandular hairs in addition. Internally the tissues are parenchyma,

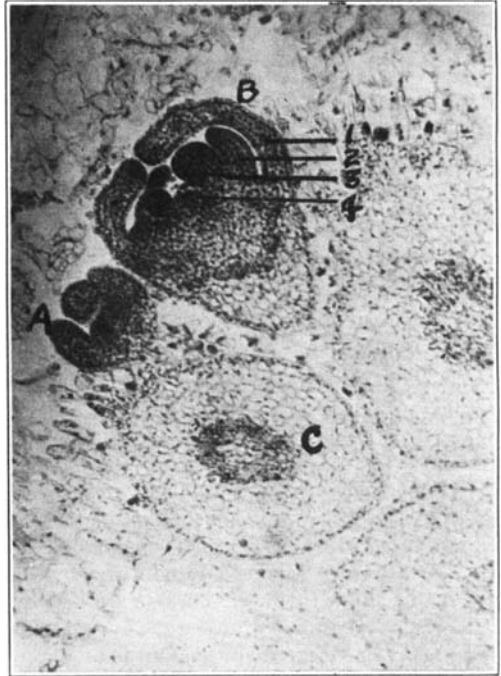


Plate No. 2.—Longitudinal Sections of Rudimentary Flower Buds ($\times 140$). A—Bud showing differentiation of the calyx. B—Bud showing more advanced differentiation into the following: 1—the calyx; 2—the corolla; 3—the anthers; and 4—the pistil. C—The cross section of the receptacle of a florette.

mesophyll and fibrovascular bundles. In all the specimens examined there were thirteen fibrovascular bundles present which coincided with the ribs of the calyx.

The corolla (Plates Nos. 3 and 4) is composed of epidermis, mesophyll, parenchyma and scattered vascular bundles. The inner wall of the corolla tube is composed of characteristically wavy-walled epidermis. There are also non-glandular hairs present in mature corollas.

The stamens, of which there are two, are composed of a two-lobed anther and a filament which is adnate to the corolla near its base. The anther is composed of two distinct lobes (Plate 3) which are united to the filament at their point of attachment and which are filled with pollen.

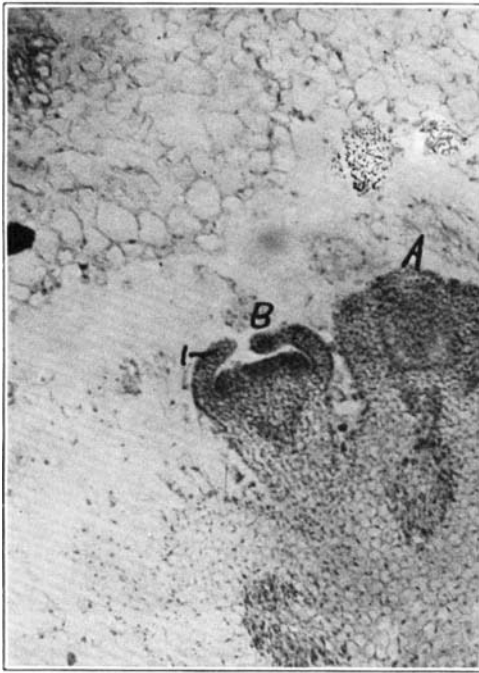


Plate No. 2A.—Longitudinal Sections of Rudimentary Flower Buds ($\times 140$). A—A very rudimentary flower bud showing very little differentiation of tissues. Calyx not yet formed although it is beginning to differentiate. B—Differentiation has begun with the formation of the calyx. 1—is the calyx.

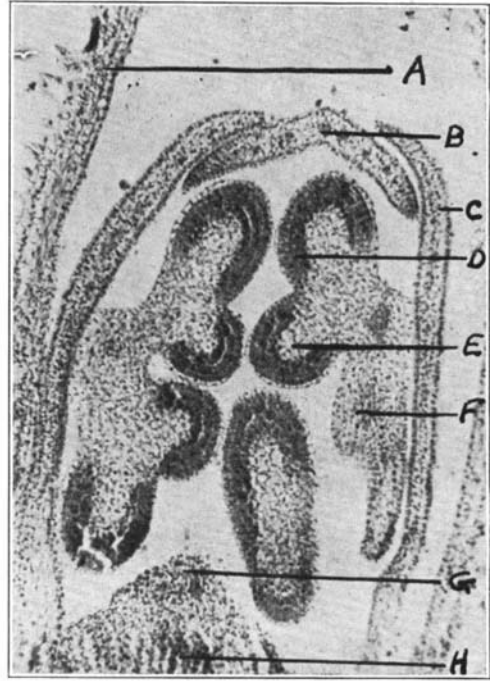


Plate No. 3.—Longitudinal Section of a Flower Bud ($\times 140$). The bud has advanced from the rudimentary stage and is now approaching the stage at which it will flower. It shows the following: A—the calyx; B—the lip of the corolla; C—the corolla proper; D—the pollen developing in the anther, nucleus present; E—a lobe of the anther; F—the filament; G—the pistil; and H—the ovary.

The filaments are composed principally of parenchyma tissue and epidermis and a central cylinder of vascular tissue which traverses the length of the structure.

The pistil is composed of two carpels as indicated by the forking of the style (Plate 1) and by the median line which was found in numerous sections of the ovary in the progress of this study. Each carpel gives rise to two lobes which in turn develop into the four nutlets that compose the fruit of the plant. See Plate No. 4. Histologically the pistil is composed of parenchyma, ducts and meristematic tissue. The latter is found in the lobes of the ovary.

HISTOLOGY OF THE LEAF.

The petiole of the leaf of *Monarda punctata* var. *leucantha* is composed of a large double central fibrovascular bundle which is divided into a left and right half by a row of parenchyma cells. These bundles are composed of xylem strands surrounded by two to three rows of phloem.

The bundles themselves are surrounded by large thin-walled epidermis of the petiole. Laterally as the petiole approaches the leaf blade the petiole may also be composed of leaf blade tissues, *i. e.*, palisade and mesophyll. The epidermis is composed of typical epidermal cells and glandular and non-glandular hairs.

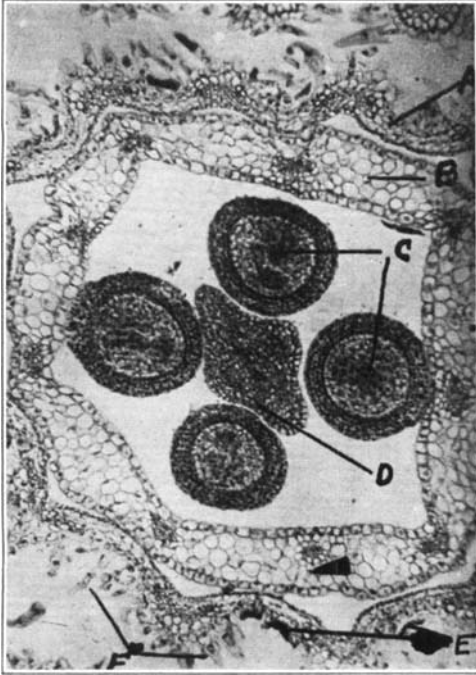


Plate No. 4.—Cross Section of the Flower ($\times 140$). This section was taken at the level of the top of the lobes of the ovary. The following structures are seen. A—the calyx; B—the corolla; C—the lobes of the ovary; D—the pistil; E—very young glandular hairs showing the individual cells with nuclei; and F—very young epidermal hairs with nucleated cells.

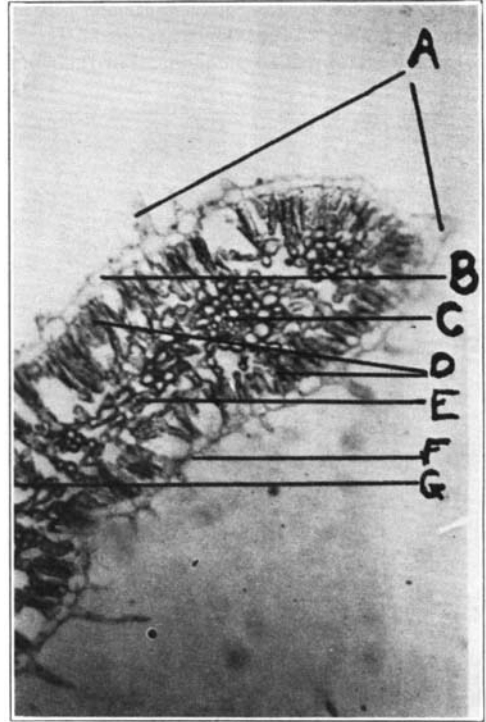


Plate No. 5.—Cross Section of the Lateral Edge of a Leaf ($\times 140$). This section shows the following structures: A—the epidermal hairs; B—the epidermis; C—a vein; D—the upper and lower palisades; E—the mesophyll; F—the stoma; and G—a glandular hair.

The leaf blade consists of the midrib which is merely an elongation of the petiole and resembles it closely, the epidermis, palisade, parenchyma and conducting tissues. In cross section, the leaf internally is composed of a distinct upper palisade and in most cases a distinct lower palisade. See Plate No. 5. In less mature leaves the lower palisade is sometimes loosely arranged and resembles the mesophyll. Between the palisade layers there are two to three rows of mesophyll.

HISTOLOGY OF THE STEM.

The stem is composed of the following regions:

1. Epidermis
2. Cortex
3. Phloem
4. Cambium
5. Xylem
6. Pith (see Plate No. 6).

Externally the stem is composed of epidermis with slightly thickened and somewhat cutinized external cell walls. There are also to be found, scattered non-glandular hairs.

Under the epidermis in the corners there are bundles of non-lignified cells whose cell walls are composed of cellulose. The corners of these cells are characteristically thickened. This tissue is the collenchyma which is the characteristic strengthening tissue found in the corners of mint stems.

The remainder of the cortex is composed of six to eight rows of tangentially elongated parenchyma cells whose walls are perceptibly thickened.

In the phloem region there are four to eight rows of cells which are not well defined since they are small and thin walled. The phloem does contain well-defined and scattered sclerenchyma fibers which contain crystals.

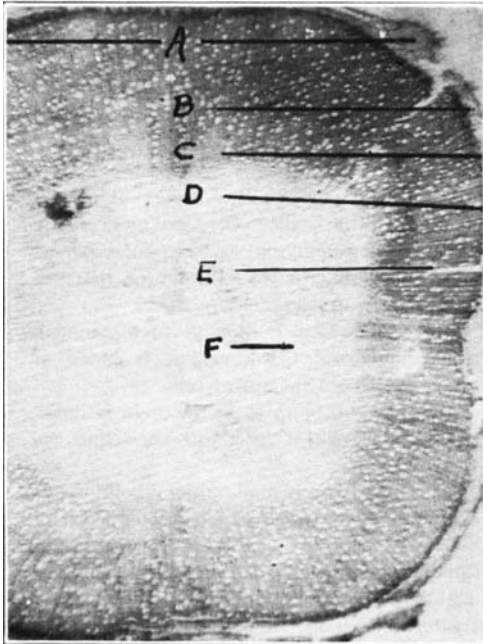


Plate No. 6.—Cross Section of the Stem ($\times 18$). The cross section of the stem shows the following structures: *A*—the collenchyma; *B*—the cortex; *C*—the phloem; *D*—the cambium ring; *E*—the xylem; and *F*—the pith.

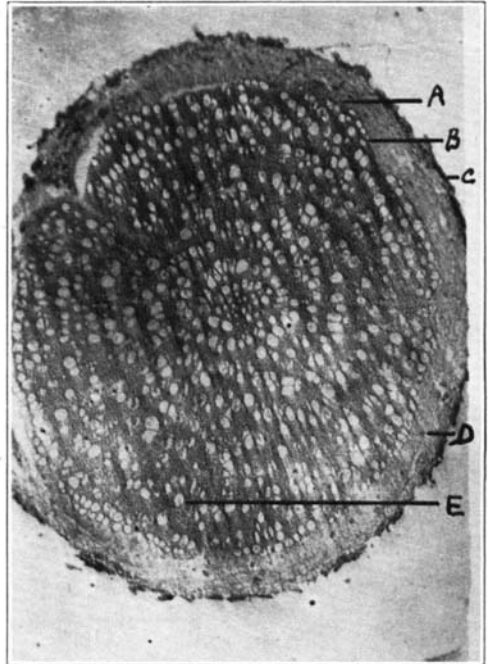


Plate No. 7.—Cross Section of the Root ($\times 25$). The section shows the following structures: *A*—the phloem; *B*—the cambium ring; *C*—the cork; *D*—the cortical parenchyma of the cortex; and *E*—the xylem.

A well-defined cambium does not exist although there is a distinct line made up of compact cells which cannot be distinguished individually and which separates the phloem from the xylem.

Inside the cambium is a complete cylinder of woody tissue, highly lignified, which is composed of vessels and radially arranged fibers. The scattered vessels can be distinguished in cross section as the large isodiametric cells as compared to the small quadrangular and polygonal cells which are fibers and which are in radial rows.

The pith is located within the xylem ring and is composed of large isodiametric parenchyma cells except for a region adjacent to the xylem where the parenchyma cells are smaller and somewhat polygonal.

The longitudinal section shows the epidermis as somewhat longitudinally elongated cells. The cortical parenchyma is made up of quadrangular and longitudinally elongated cells. The phloem and xylem are difficult to distinguish but the sclerenchyma fibers are scattered through the phloem region and the crystals contained are easily detected. The xylem is composed of

pitted tracheal tubes and tracheids and the fibers are longitudinally arranged. The pitch parenchyma is made up of quadrangular cells which are arranged in longitudinal rows.

HISTOLOGY OF THE ROOT.

The root is composed of the following regions:

1. Cork
2. Cortex
3. Phloem
4. Cambium
5. Xylem (see Plate No. 7).

The cork is composed of a layer of four to nine rows of irregularly arranged cells which range in shape from tangentially elongated quadrangular cells to cells which are almost isodiametric. The outer layers of cells are compact and are often torn away and show lenticels.

The cortex which lies directly under the cork is composed of approximately 15 rows of cells. There is apparently no differentiation between phloem and cortex in the root. The body of the cortex tissues is made up of thin-walled polygonal and radially arranged parenchyma cells. Interspersed through these cells are solitary or pairs of crystal-bearing sclerenchyma fibers.

The phloem is difficult to distinguish from the cortex. However, it is made of several rows of thin-walled cells.

The cambium as in the stem is indistinguishable except as a line encircling the xylem.

The xylem is made up of a solid cylinder of lignified tissue which is composed of fibers and vessels. The fibers are arranged in radial rows of small quadrangular and polygonal shaped cells. The ducts appear as larger scattered isodiametric cells among the fibers.

In longitudinal section (Plate No. 8) there are four to nine rows of irregularly shaped, somewhat longitudinally elongated cork cells. The outer layers of cork cells are compact and difficult to distinguish individually.

Under the cork a region of approximately fifteen cells thickness is made up of longitudinally elongated polygonal parenchyma cells and scattered crystal bearing sclerenchyma fibers as is plainly shown in Plate No. 8.

The phloem and cambium are indistinguishable.

The xylem is made up of longitudinally elongated fibers, pitted tracheids and tracheal tubes.

SUMMARY AND CONCLUSIONS.

The flower heads, leaves, stems and roots of *Monarda punctata* var. *leucantha*, Nash., have been examined histologically. The histological examination substantiates the conclusions as to structures which were reached from macroscopical examination of the external features.

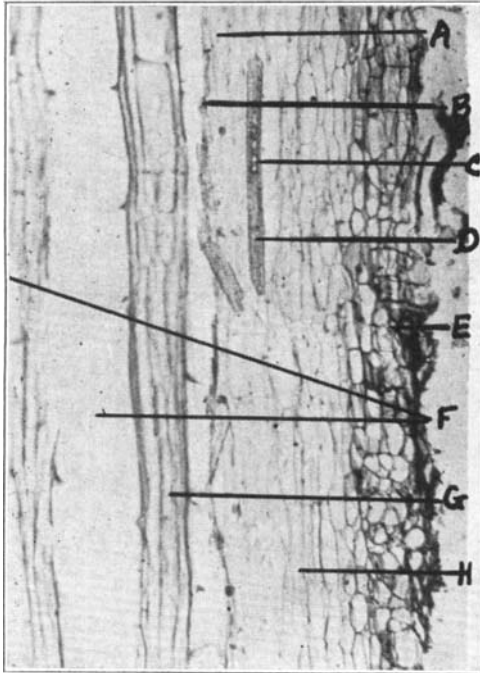


Plate No. 8.—Longitudinal Section of the Root ($\times 140$). This section shows the following structures: A—the phloem; B—the cambium zone; C—crystals in the sclerenchyma fiber; D—crystal bearing sclerenchyma fiber; E—the cork; F—the ducts in the xylem; G—wood fibers; and H—the cortical parenchyma.