

other. The lateral branches are all normal. This case is quite typical for phenomena as shown by dichotomously branching abnormal stems with opposite leaves. The small letters indicate that the leaves are situated on the side of the branch away from the observer, and these leaves are indicated by dotted contours in the figures.

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A study of some anatomical characters of North American Gramineæ. I.

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The genus *Uniola*.

(WITH PLATE XV.)

In the year 1810, when Brisseau-Mirbel said:¹ "Le seul moyen de perfectionner les familles naturelles, est à joindre à l'étude des caractères botaniques, celle de tous les faits relatifs à l'anatomie et à la physiologie," he hardly thought of the important change that would come about in systematic botany. The rapid increase in the number of species known made it evident that botanists must not content themselves with the mere external characters, but that others should be sought. Later appeared a series of researches especially by French and German authors, wherein an attempt was made to give anatomical diagnoses to a number of species; most successfully by Duval-Jouve, Radlkofer and Vesque. The importance of studies of that kind was very clear; they not only furnished additional and often even more reliable systematic characters, but they extended the study of anatomy into wider fields than ever before, until anatomy has become one of the most important modern lines of botanical science.

And the study of internal structure gave also a most striking illustration of the physiological life; it became easy to infer from the structure the conditions under which the plant had lived, whether in dry or moist localities, exposed to the sun or in deep shade, etc. Anatomy also rendered great help in the discrimination of species, as shown for instance by

¹ Sur l'anatomie et la physiologie des plantes de la famille des Labiées. (Ann. du Muséum d'Hist. Nat. vol. xv.)

Vesque,² who proved that the anatomical characters are much more distinct and precise than the organographical ones, and that species of *Capparideæ* may be easily distinguished merely by the structure of the leaves.

To speak in particular of the *Gramineæ*, we have several works of the greatest importance upon this subject. Duval-Jouve described³ species of *Agropyrum* merely by the structure of the rhizomes, culms and leaves, and he stated in his "Histotaxie des feuilles de Graminées"⁴ the principal modes of arrangement of the tissues in the leaves of this family in relation to the surrounding medium.

Furthermore Hackel in his "Monographia Festucarum Europæarum" (1882), has shown the importance of the leaf-structure as to the specific differences in *Festuca*. The same author has also observed that most of the species of the *Andropogoneæ*⁵ show very good anatomical characters; and finally Güntz⁶ has made a special study of the leaf-structure.

These studies are, however, not only of a purely scientific, but also of a practical value, and it is easy to understand, that they must be a great help, when it is necessary to identify specimens without flowers. But that this may be done it will be necessary to know the structure of a large number of species. That such determination is possible to a certain extent will be evident if we simply recall the numerous differences in the form of the rhizomes, the sheath ligule and blade of the leaves, the vernation, etc., which, combined with anatomical characters, seem likely to give very reliable results. A few attempts have already been made in the most practical manner to identify Grasses at a stage where the flowers are not developed, for instance by Samsøe Lund⁷ and Beal.⁸

We now proceed to give some anatomical sketches of our native grasses, making the beginning with the genus *Uniola*, of which five species are enumerated from this country, namely:

² Essai d'une monographie anatomique et descriptive de la tribu des Capparées. (Ann. d. Sc. Nat. Botanique, ser. 6, vol. xiii, 1882).

³ Étude anatomique de quelques Graminées, et en particulier des *Agropyrum* de l'Hérault. (Mém. d. l'Acad. d. Montpellier, vol. vii, 1870).

⁴ Ann. d. Sc. Nat. Botanique, ser. 6, vol. i. 1875.

⁵ A. et C. De Candolle: Monographia Phanerog. Prodrumi; vol. vi, 1889.

⁶ H. E. M. Guentz: Untersuchungen ueber die anatomische Structur der Gramineenblaetter, etc. Inaug.-Dissert. Leipzig, 1886.

⁷ Vejledning til at kjende Græsser i blomsterlös Tilstand. Kjöbenhavn, 1882.

⁸ W. J. Beal: Grasses of North America for farmers and students, 1887.

U. latifolia Michx., *U. gracilis* Michx., *U. nitida* Baldw., *U. paniculata* L. and *U. Palmeri* Vasey.

Uniola latifolia Michx.—A series of anatomical sections have been figured on plate xv. These sections have been taken from the middle part of a completely developed leaf.

As regards the structure of the epidermis of the superior face (fig. 1), this does not show anything of particular interest. The cells of which it consists are of different size and shape, forming longitudinal lines in the blade, and the differences depend upon situation.

The large bulliform cells⁹ lie in broad lines, covering the green parenchyma between the large nerves, and they form about six rows of rectangular, uncolored cells. Sometimes and especially toward the midrib they are interrupted by prominent and roundish groups of cells, surrounding the base of long, stiff and pointed unicellular hairs. Bordering on each side of these strips of bulliform cells there are some rows of smaller, rectangular cells, the side-walls of which are more or less undulated. They cover a small part of the green parenchyma. The stomata are to be observed here, and they form only a single line on each side of the groups of bulliform cells, while the other lines possess numerous short, very thick-walled and pointed expansions. In alternation with these thorn-shaped expansions are also to be seen short, unicellular, slightly curved and obtuse hairs. Besides these rows of epidermis cells there are still a few, from one to five, rows which cover the stereome. These consist of very short and narrow cells, the walls of which are strongly thickened.

Comparing the epidermis of the superior face, described above, with that of the inferior face, we see the following differences. The bulliform cells are entirely absent, as well as the long hairs; the short hairs are on the contrary also to be observed here together with the thorn-shaped expansions, which are still more numerous on this face. The stomata show the same distribution and number as mentioned before.

We now examine a transverse section of the whole blade, which, compared with similar sections of the other species of the genus, shows differences worthy to be considered as specific. Figs. 2 and 3 represent respectively sections from the middle part of the blade and a small lateral part, adjoining this. The median nerve (fig. 2) does not occupy the whole

⁹ Duval-Jouve; Histotaxie des feuilles de Graminées l. c. p. 316.

carene, but merely forms a centre for the entire system of the mestome. It is the strongest one, containing the farthest developed leptome and hadrome, and is supported by the largest group of stereome, but does not, however, connect the superior face of the blade with the inferior. The carene itself consists of two groups of mestome-bundles, one on each side of the median line, and these are all separated from the superior epidermis by an immense tissue of uncolored parenchyma. The uncolored parenchyma preponderates then in this part of the blade and is partly separated from the superior epidermis by six relatively strong bundles of stereome. In the lateral parts of the blade it is restricted to a single stratum inside the rows of bulliform cells.

As to the mestome bundles, there are in this species about seventy on each side of the median nerve, and they represent three different degrees of development. The largest (fig. 6) are characterized by having a layer of very thick-walled parenchyma between the leptome and the hadrome, completely enclosing the first, and both the leptome and hadrome are here strongly developed; furthermore by being supported by two large groups of stereome, above and below, just excepting the bundles of the carene, where no stereome is in connection with the superior face of the mestome. The second degree of development (fig. 8) shows smaller bundles of stereome above and below, and the leptome is not separated from the hadrome by any layer of thick-walled parenchyma; there is merely a semicircular layer of thick-walled parenchyma bordering on the leptome side. Fig. 9 illustrates one of the smallest mestome bundles, completely imbedded in the mesophyll and without any groups of stereome; there is no thick-walled parenchyma to be observed here within the proper parenchyma sheath.

As regards now the arrangement of these three different forms of mestome bundles, this is as follows: The two larger are constantly situated on each side of the groups of bulliform cells, while the smallest, those of third degree, are restricted to a position just between the bulliform cells and the inferior face of the blade. It must be remarked, however, that this arrangement does not include the bundles of the carene, for the reasons mentioned above. As to the number of these three forms, the smallest ones are the most numerous in the whole blade. It may be expressed diagrammatically as follows:

$A^* - C - B - C - A - C - B - C - A^1 - C^1 - B^1 - C^2 - B^2 - C^3 - A^2$, where A indicates the largest bundles of mestome, the median being A^* ; B shows those of second and C those of third degree. A^1 corresponds then to the strong bundle in fig. 2, marked in the same manner, and it is situated below the outermost group of stereome in the figure, separated from this by the uncolored parenchyma. C^1 is the first bundle situated between the first group of bulliform cells and the inferior epidermis. The disposition of the groups of bulliform cells may be seen in the same formula, namely, between A^1 and B^1 , B^1 and B^2 , B^2 and A^2 , just above the C 's, beginning at C^1 . This formula may not be strictly constant, but it gives, however, the general features concerning the relative number and arrangement of the mestome bundles.

Besides the proper parenchyma sheath of green or sometimes uncolored cells, never wanting in the mestome-bundles of the Gramineæ, some of these bundles show the presence of another sheath or at least a layer of thick-walled parenchyma inside this. A distinct thick-walled sheath is shown in fig. 6, enclosing the leptome, and we are able to trace it also in the small bundles (fig. 8), though not in the smallest ones (fig. 9). Schwendener¹⁰ has called attention to the presence of this parenchyma, which in several instances looks very much like what the same author has called a "mestome-sheath." But in *Uniola latifolia* there is no mestome-sheath; for the reaction with concentrated sulphuric acid proved that the thick-walled cells, whether they form a closed sheath or not, merely belong to the mestome parenchyma. Furthermore, if it had been a mestome-sheath it would also have been present in the smallest bundles. The proper parenchyma sheath showed in some instances (fig. 7), a thickening of the cell-walls, especially in the cells which border on the leptome side.

Now, concerning the arrangement of the stereome-bundles, we have already seen in the description of the mestome that the arrangement is nearly identical. There is one group above and below the two largest mestome-bundles, but none at the smallest ones, and there are merely six isolated groups on the superior face of the carene, which are not in contact with the mestome. Besides there is also one rather strong group in each of the outermost parts of the blade, the margins.

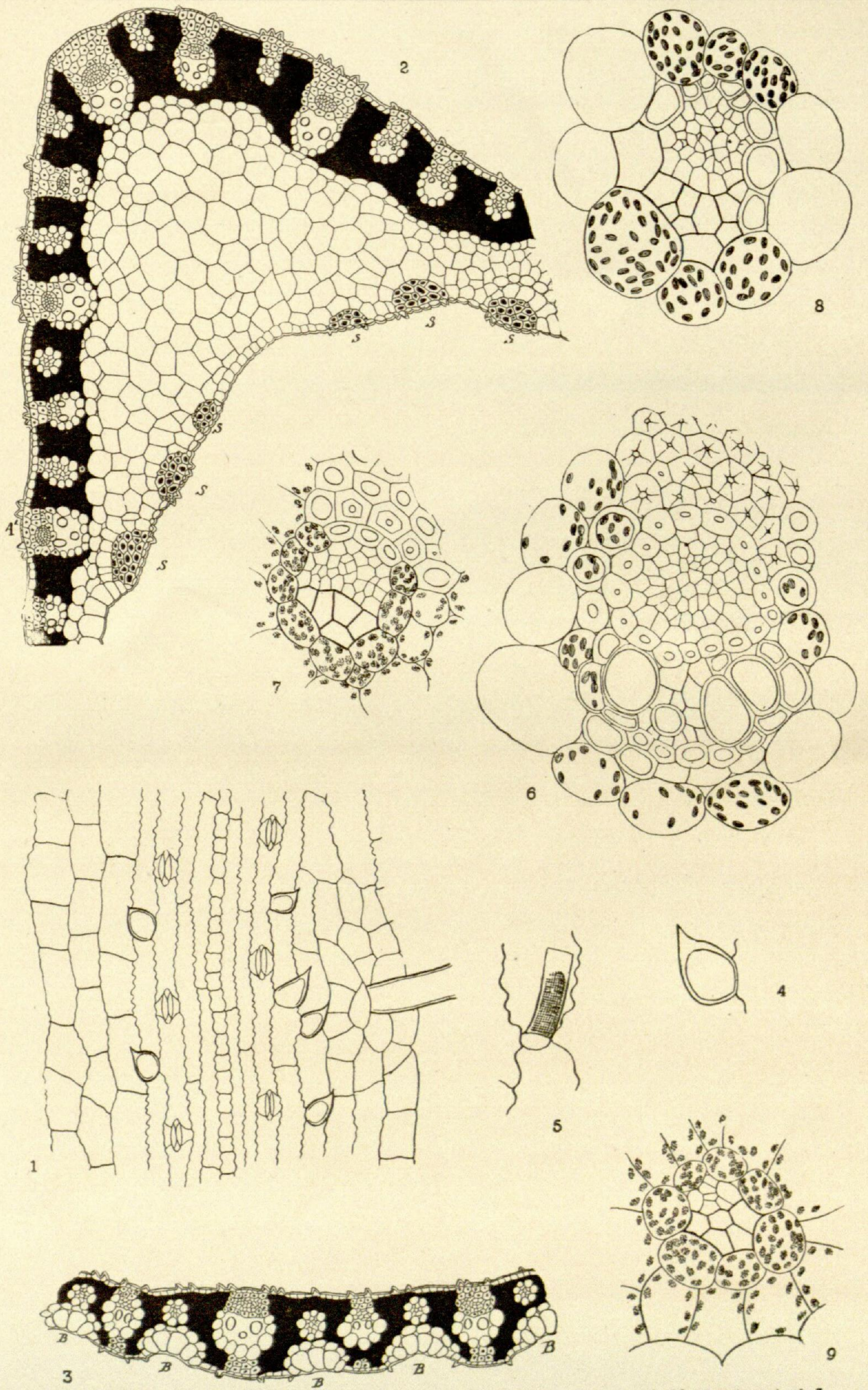
¹⁰ S. Schwendener; Die Mestomscheiden der Gramineenblaetter. (Sitzungsberichte d. wiss. Acad. Berlin, 1890).

The mesophyll in this species forms in a transverse section an interrupted line, being in immediate contact with the epidermis of the inferior face, except where it is interrupted by the large mestome-bundle of first or second degree. It is on the contrary almost entirely separated from the superior epidermis by the stereome and the uncolored parenchyma under the bulliform cells. The mesophyll showed a rather firm structure without any lacunes.

These are the general features of the anatomical structure of the leaf of *Uniola latifolia*, and it will be shown in a following paper that these characters as compared with the corresponding ones in the other species are of truly specific rank.

U. S. National Museum, Washington, D. C.

EXPLANATION OF PLATE XV. — *Sections of the leaf of Uniola latifolia.*
 Fig. 1. Epidermis of the superior face, $\times 240$. Fig. 2. Transverse section through the middle part of the blade, the carene. The black part of the figure represents the mesophyll, which borders on the large uncolored tissue of parenchyma. The mestome bundles with their parenchyma sheaths and groups of stereome are to be seen in the mesophyll. Six rather large bundles of stereome (*S*) are to be seen on the superior face, the concave part of the carene. $\times 75$.
 Fig. 3. Transverse section through a part of the blade, next to that figured in fig. 2. Five groups of the large bulliform cells are to be seen at *B*. $\times 75$.
 Fig. 4. Thorn-shaped expansion from the superior face, $\times 320$. Fig. 5. Hair from the inferior face, $\times 320$. Fig. 6. Transverse section of one of the largest mestome bundles of the carene, showing the partly green parenchyma sheath, the leptome above and the hadrome below. The leptome is surrounded by a sheath of very thick-walled mestome-parenchyma bordering on a group of stereome. $\times 560$. Fig. 7. Transverse section of a small mestome bundle, that next to the midrib. Three cells of the green parenchyma sheath show a distinct thickening of the cell wall. A group of stereome borders on the leptome side. $\times 560$. Fig. 8. Transverse section of a small mestome bundle from one of the lateral parts of the blade. There is a horseshoe-shaped sheath of thick-walled parenchyma on the leptome side, and the proper parenchyma sheath shows four uncolored cells, while the other ones contain chlorophyll. $\times 560$. Fig. 9. Transverse section of a small mestome bundle, not far from that figured in fig. 8. The parenchyma sheath is perfectly green, and there is no thick-walled parenchyma inside this. $\times 560$.



HOLM on UNIOLA.