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A STUDY OF THE LEAF ANATOMY OF SOME SPECIES OF THE GENUS BROMUS.

EMMA SIRRINE.

The species of genus Bromus are sometimes difficult to differentiate; hence, a study of the leaf anatomy was undertaken with a view towards a help in differentiation.

BROMUS ASPERT.*

(Pl. v. Fig. 5; Pl. vii, Fig. 8.)

Epidermis.—The cuticle in this species is quite thick. The epidermal cells are large, but are smaller and thicker walled above and beneath the primary mestome bundles than elsewhere. Stomata frequently occur on both surfaces. The upper and lower surfaces of leaf, as well as edges, are provided with trichomes, sometimes in the form of small conical projections.

Bulliform cells.—These occur on superior surface, and vary in number from three to five, and are not as thick walled as the epidermal cells. They occur between the mestome bundles, but this arrangement is not uniform, that is, they are not present between all mestome bundles.

Mestome bundles.—Twenty-nine mestome bundles occur across middle portion of leaf. The bundles are of three types: First, the primary type numbers eleven bundles. These open on both superior and inferior surfaces of leaf, *i. e.*, the leptome and hadrome are in direct contact with the stereome or separated from it only by colorless parenchyma cells; they vary in size (from the midrib to the margins of leaf); the one of the midrib is the largest. Bundles of the secondary type number seventeen. These are entirely closed, *i. e.*, chlorophyll bearing

*This was determined later as *Bromus patulus*. M. & K., by F. Lamson-Scribner.

There is an apparent repetition in papers by Miss Sirrine and Miss Pammel, in fact the same species were studied. They appeared distinct, but Professor Lamson-Scribner determined them as above.

L. H. PAMMEL.

parenchyma enclose the leptome and hadrome. They alternate with the primary bundles, except at the margins of the leaf, when three occur in succession on one side of the large primary bundle in the carene. Two of the secondary bundles are present; on the opposite side of the primary bundle in the carene, a bundle occurs which is intermediate between the primary and secondary bundles; this intermediate bundle is open inferiorly only, *i. e.*, the leptome only is in contact with the stereome. This is the only bundle of this type found in this species, but it was constant in all the *asper* sections examined. The primary bundles are enclosed by thick-walled cells, the mestome sheath; outside of this is a row of thinner-walled cells, the parenchyma sheath. In the bundles of the secondary and intermediate types, the mestome sheath occurs, while the parenchyma sheath disappears.

Carene.—The carene consists of only one bundle, which is the primary type; this conforms to the description given to others of this kind, except that it is the largest bundle. The hadrome is separated from the stereome by colorless parenchyma cells, while a single row of thick walled cells, resembling stereome, separates the leptome from the hadrome. Two large pitted ducts and two spiral ducts with an intercellular space are present. The bundle is enclosed by mestome and parenchyma sheaths. Trichomes in the shape of conical projections occur on the inferior surface of leaf above the primary mestome bundle. To one side of this a secondary bundle occurs, with pitted and spiral ducts. On the opposite side of the primary bundle the intermediate bundle occurs. This is open inferiorly only. The leptome is in contact with the stereome by means of two rows of colorless parenchyma cells, while the mestome sheath surrounds the mesophyll. In other respects it is the same as the secondary bundle.

Stereome.—Stereome occurs both on superior and inferior surfaces of the primary bundles. None is present in the bundles of the secondary type and only a very little on the inferior side of the intermediate bundle. Stereome occurs in groups of from four to six cells on the margins of the leaf. The walls of the stereome are frequently stratified.

Colorless parenchyma is found beneath all the primary bundles; it fills the space between the hadrome and the stereome, while a single row of cells enclose the whole mestome bundles. In the bundles of the secondary type it disappears entirely.

Mesophyll.—This surrounds the bundles of the secondary type and occurs between all bundles. It is made up of irregular cells, but quite uniform in size. The chlorophyll granules are quite large and numerous.

BROMUS PATULUS, M. & K.

(Pl. v., Fig. 3; Pl. vi. Fig. 6.)

This is a small early form determined as *B. nivilis*.

Epidermis.—The epidermal cells of this species are large, regular, thick-walled with a strong, well developed cuticle; the cells above and beneath the carene are smaller and thicker than elsewhere; the leaf is more involute than that of any other species studied, unless possibly *Bromus racemosus*. Trichomes are numerous,—some very long and slender, others are short and thick. Stomata occur on both surfaces of the leaf.

Bulliform cells.—The bulliform cells vary in number from three to five, and are not as apparent as in some of the other species studied. These cells occur on superior surface of leaf between the mestome bundles.

Mestome bundles.—These number from twenty-five to thirty and are of two kinds. The bundles of the primary type number from nine to eleven, represented by the principal bundle of the carene. This is open both to the upper and lower surfaces of the leaf, *i. e.*, the leptome is in direct contact with the stereome, while the hadrome is separated from it only by colorless parenchyma cells. The secondary bundles number from sixteen to eighteen. The leptome and hadrome are entirely surrounded by chlorophyll-bearing parenchyma. In the largest bundle of the primary type the stereome is very abundant, while in the smaller ones, it is reduced in some instances to a single row of cells; the leptome and hadrome are well developed in these bundles and they are separated from each other by thick-walled cells resembling stereome. Both spiral and pitted ducts, as well as the intercellular space, are well defined. The secondary bundles are surrounded by colorless parenchyma without stereome. The leptome and hadrome are differentiated. Two secondary bundles occur on margins of leaf.

Carene.—The carene consists of one typical primary bundle with leptome and hadrome well developed and separated from each other by thick-walled parenchyma cells; the pitted and spiral ducts are well developed and also the intercellular space is conspicuous. On one side of this bundle is another primary

bundle, smaller than the mid-bundle but open superiorly and inferiorly, *i. e.*, the leptome and hadrome are in contact with the stereome, but this bundle differs from the first described, in that it has inferiorly only a single row of stereome running from the bundle to the epidermal cells, while in the first one there is a large amount of stereome on inferior surface. The stereome beneath this second bundle conforms with that found in the other primary bundles of this species. All these primary bundles are surrounded by two sheaths: an outer, thin-walled colorless row of cells, the parenchyma sheath and inside, this a thick-walled row of cells, sometimes incomplete, the mestome sheath. The bundle on the other side of the central bundle is one of the secondary type. No stereome occurs in connection with these bundles; they are entirely closed, that is, wholly surrounded by chlorophyll-bearing parenchyma. These bundles are enclosed by a mestome sheath but the parenchyma sheath is absent. The leptome and hadrome fill the entire space inside the mestome sheath unless possibly a few thick-walled cells between them.

Stereome.—This occurs only above and below the primary bundles, and on the margins of the leaf.

Colorless parenchyma occurs below the stereome of all primary bundles, and forms a sheath for the whole primary mestome bundle.

Mesophyll.—This surrounds not only the secondary bundles but occurs between all the primary and secondary bundles.

BROMUS INERMIS.

(Pl. v, Fig. 4; Pl. vii, Fig. 10.)

Epidermis.—In this species we find large, regular, and well developed epidermal cells with a thick cuticle; the cells are smaller and the cuticle thicker under and above the mestome bundles than elsewhere. The epidermal cells are slightly longer on superior surface of leaf than on inferior surface. Trichomes absent. Stomata occur on both surfaces of leaf, but especially between the bulliform cells.

Bulliform cells.—These are large, varying in number from three to seven, only present on superior surface of the leaf.

Mestome bundles.—These number thirty-five, and are of three types, as in some specimens of *Bromus asper*. First, those of the primary type; these are open both on anterior and inferior surfaces of the leaf, *i. e.*, the leptome is in direct contact with the stereome and the hadrome, separated from it only by

colorless parenchyma cells. These primary bundles are enclosed by the parenchyma and mestome sheaths. Those of the secondary type are entirely closed and surrounded by chlorophyll-bearing parenchyma. Third is an intermediate type, open only inferiorly; the leptome is in contact with the stereome, while the hadrome is surrounded by chlorophyll-bearing parenchyma cells. These intermediate bundles occur in only two places in the leaf,—one is found in the carene and one at the margin of the leaf.

Carene.—The carene consists of one mestome bundle. A large bundle open above and below, *i. e.*, the leptome and hadrome are in contact with the stereome. The pitted ducts are irregular. The stereome is more abundant above than below the bundle. This is true of all the open bundles in this species; the leptome is separated from the hadrome by a layer of thick-walled parenchyma cells, while the whole bundle is enclosed in both parenchyma and mestome sheaths. On one side of this primary bundle a secondary bundle occurs; this is entirely closed by chlorophyll-bearing parenchyma cells. Leptome and hadrome are present with a few thick-walled cells between them, and the whole enclosed by a mestome sheath. On the opposite side of the primary bundles is one of the intermediate type.

Stereome.—This occurs on the margin of leaf above and below the primary bundles, and above the intermediate bundles.

Colorless parenchyma is more or less developed below all the bundles of the primary type.

Mesophyll is found between all bundles, surrounding the secondary and below the intermediate bundles. It consists of elongated cells filled with chlorophyll.

BROMUS SECALINUS.

(Pl. vi, Fig. 2; Pl. viii, Fig. 9.)

Epidermis.—In this species, the epidermal cells are large and regular on inferior surface with an occasional cell projecting outwardly. On the superior surface of the leaf the cells are somewhat smaller and of same general shape. The leaf is somewhat involute. Small trichomes in the shape of conical projections are present on the inferior surface of the mestome bundles. Epidermal cells are smaller where it covers the primary mestome bundles in this species, as in all studied. Stomata present on both surfaces.

Bulliform cells.—These occur only on superior surface of leaf and vary in number from three to seven. These cells are large and well marked, especially the central cells of the group; the outer are smaller and blend with the epidermal cells. The cuticle is not so strongly developed over the bulliform cells as elsewhere.

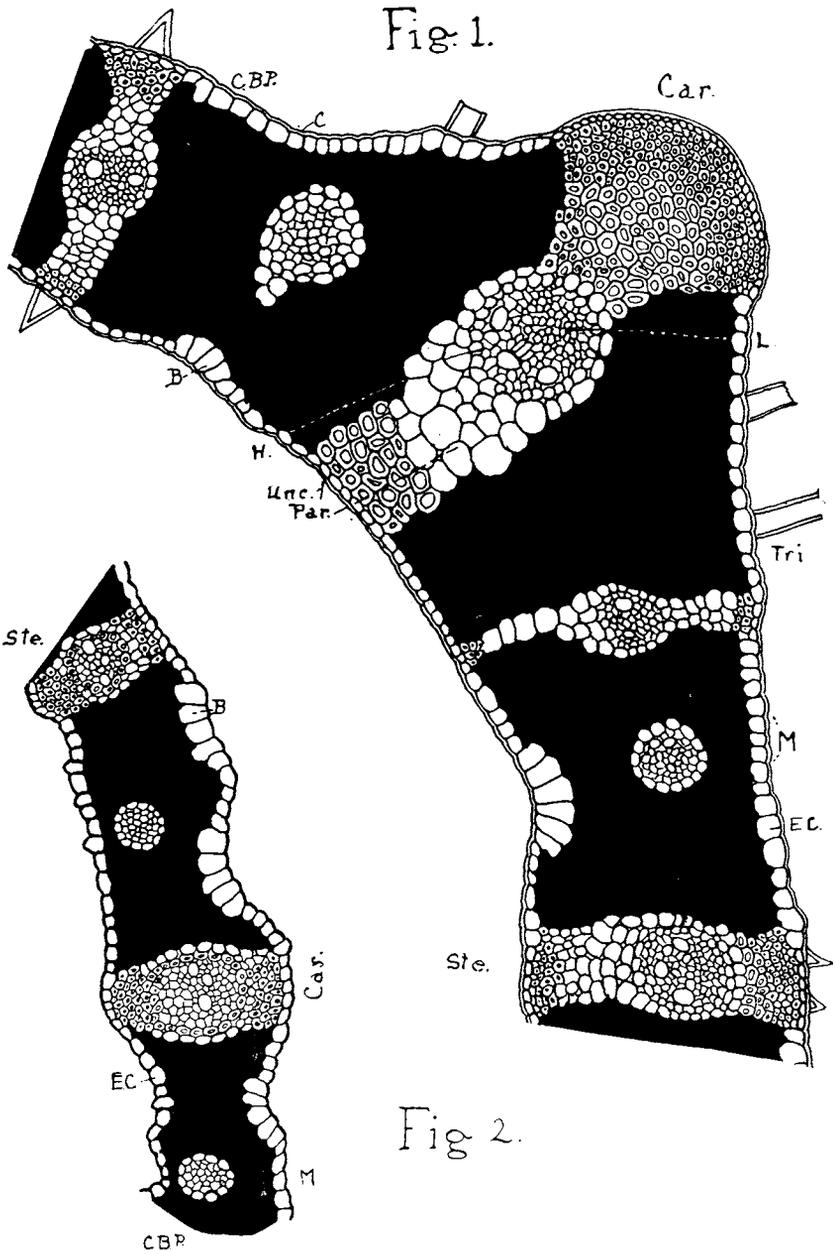
Mestome bundles.—These number from thirty-three to thirty-five and are of three types. First, primary, in which superior and inferior surfaces of leaf are open, *i. e.*, the leptome is in direct contact with the stereome and the hadrome separated from it only by the uncolored parenchyma cells. From thirteen to fifteen of these bundles are present, varying in size from the carene to the tip of leaf. In the secondary type, leptome and hadrome are entirely surrounded by chlorophyll parenchyma. The bundles in this type number from fifteen to seventeen; they alternate regularly with those of the primary type except between the sixth or seventh primary bundles counting from the mid-rib where two of the secondary type occur in succession. Only two bundles of the intermediate type occur. These are found near the margins of the leaf. They have leptome in contact with stereome only. Surrounding all the bundles occur both parenchyma and mestome sheaths.

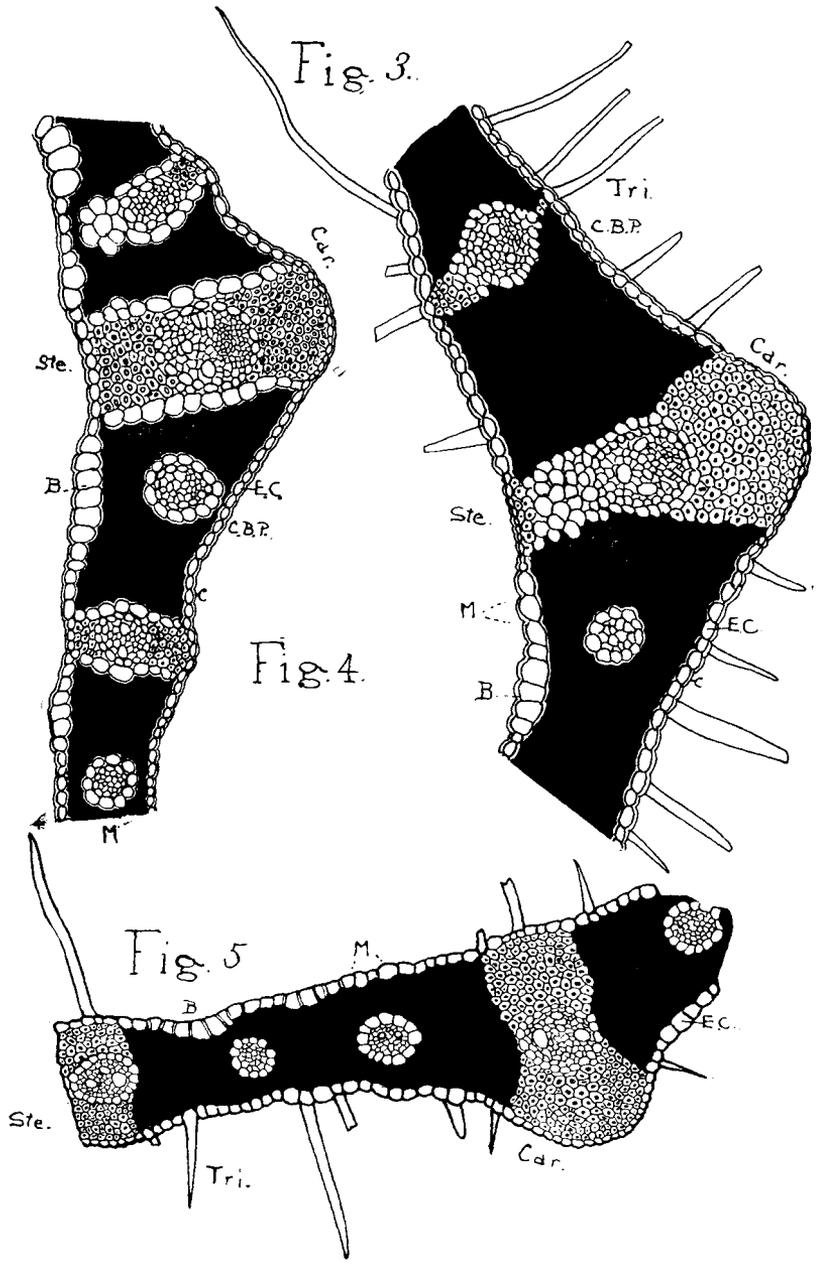
Carene.—Only one bundle present in the carene. It is of the first type and is remarkable for the large amount of stereome on the superior surface of leaf. The leptome and hadrome are separated from each other by two rows of thick-walled parenchyma cells. The leptome is separated from stereome only by the parenchyma and mestome sheaths, while the hadrome is separated from the stereome by a large number of colorless parenchyma cells. On either side of the carene, the small secondary bundles occur. In these the leptome and hadrome seem to be in direct contact with each other. Both sheaths are present.

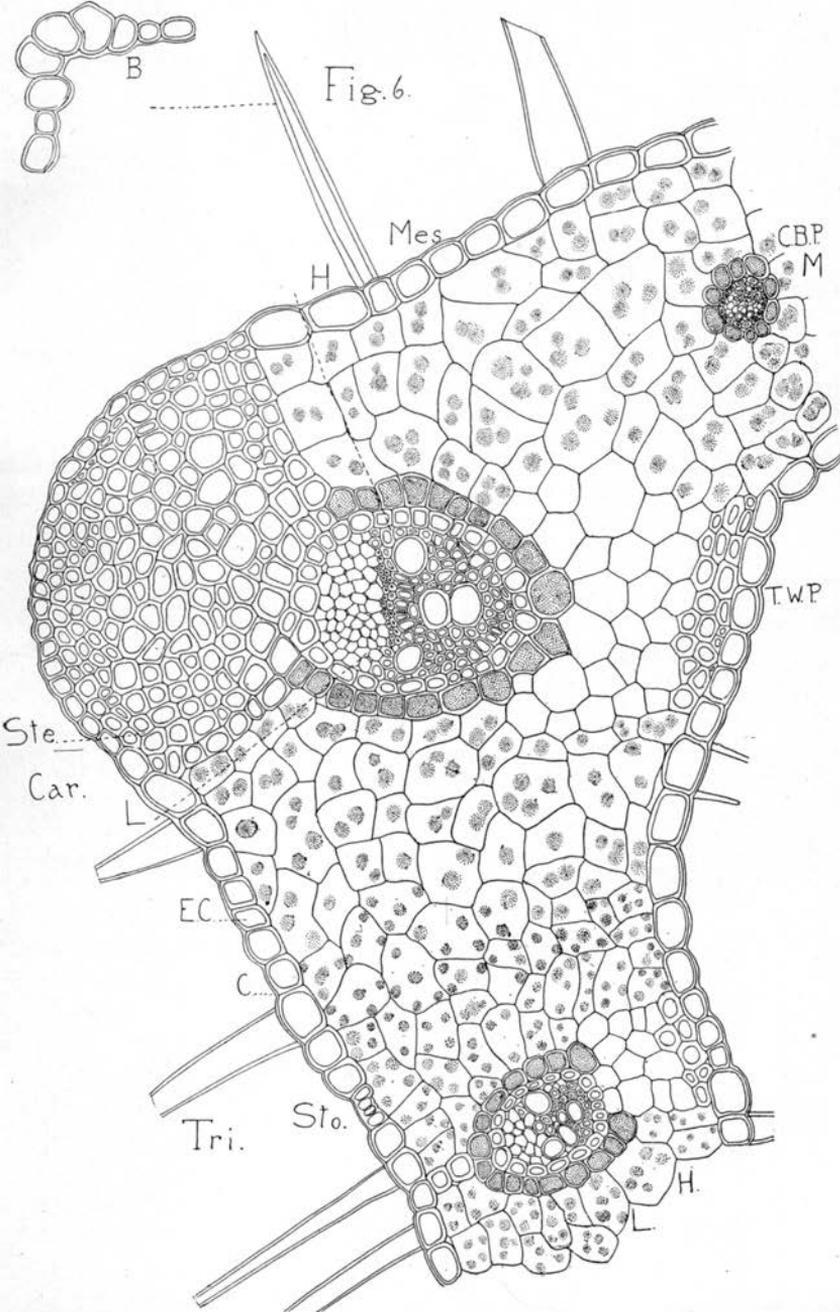
Stereome.—No stereome occurs around the secondary bundles. It is abundant on superior and inferior surfaces of the primary type and on superior surface of the intermediate bundles. A group of these cells also on margins of leaf. Stereome cells are marked with small canals.

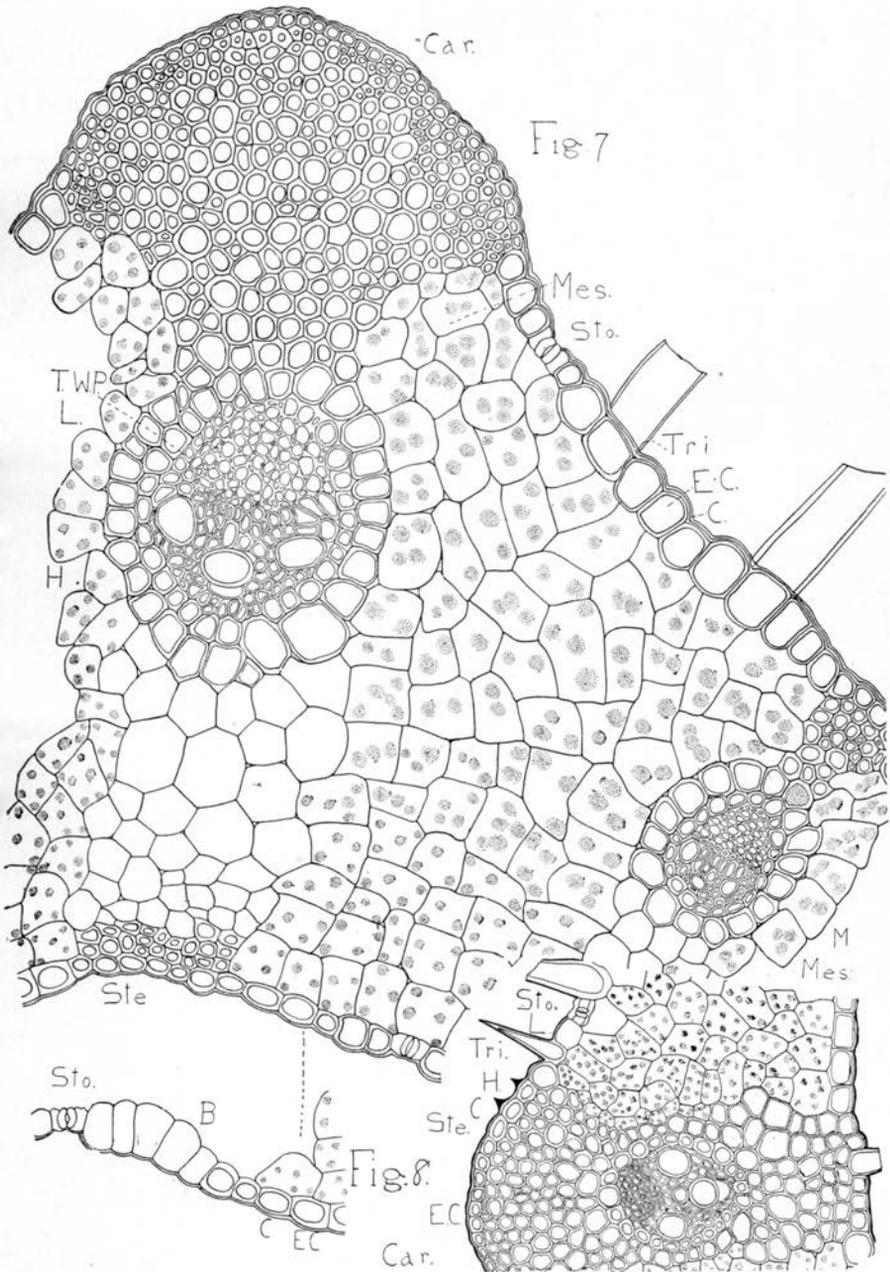
Colorless parenchyma.—This occurs beneath all primary bundles, while a sheath encloses all the bundles.

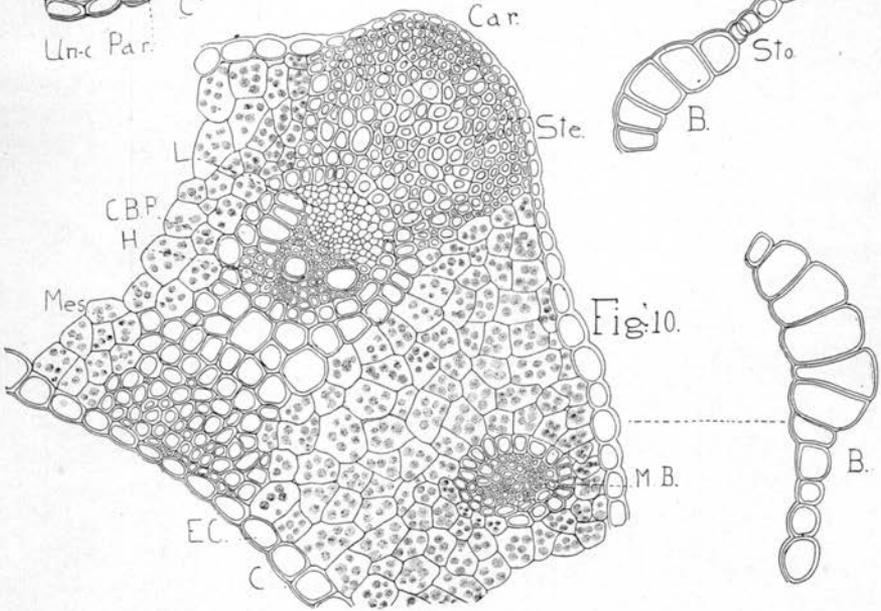
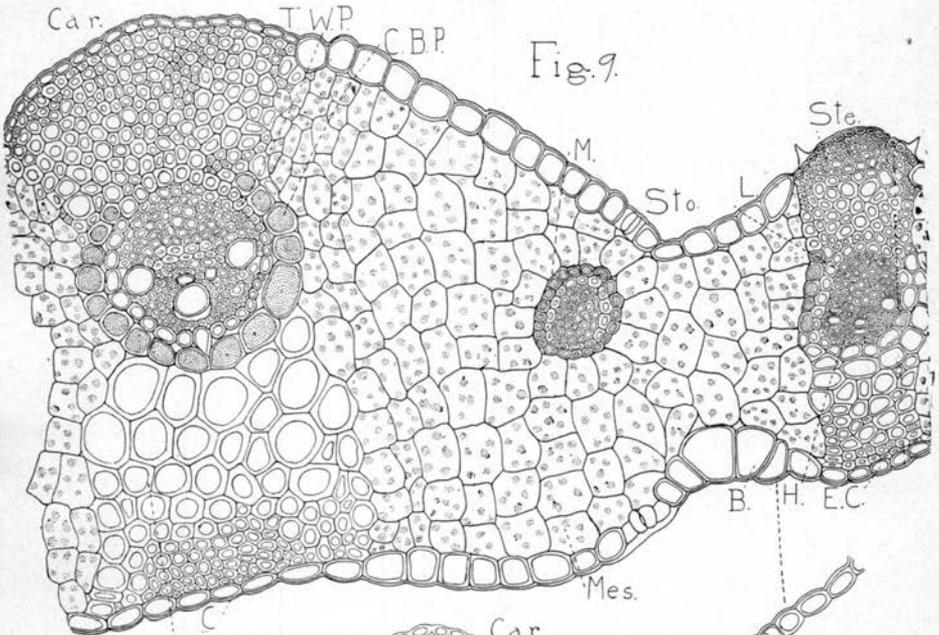
Mesophyll.—This surrounds all the secondary bundles and occurs between the other two types, and on inferior portion of the intermediate type.











BROMUS BREVIARISTATUS.

(Pl. iv, Fig. 1; Pl. vii, Fig. 7.)

Epidermis.—The epidermal cells are large and nearly rectangular, with a thick cuticle. The cells are a trifle smaller on inferior surface of leaf than on anterior, while on superior and inferior surfaces of mestome bundles they are much smaller than elsewhere. Conical projections occur both anteriorly and inferiorly on primary mestome bundles. Stomata are present on both surfaces, while trichomes are long and quite abundant.

Bulliform cells.—The bulliform cells are large and vary in number from three to six.

Mestome bundles.—Forty-one bundles present, of two types. Those of the primary type are open on both inferior and superior surfaces, *i. e.*, leptome is in direct contact with stereome, while hadrome is separated from it only by colorless parenchyma. These primary bundles vary much in size, and also in the amount of stereome and colorless parenchyma. The secondary bundles are somewhat better developed in this species than in other species studied, in that both mestome and parenchyma sheaths are present, also spiral and pitted ducts. There is an indication of an intermediate bundle at the margin of the leaf.

Carene.—Carene consists of only one bundle, and with the exception of size, the large amount of stereome and colorless parenchyma is exactly the same as those in the other species.

Colorless parenchyma.—The colorless parenchyma occurs beneath all primary bundles, while a sheath encloses all the bundles.

Stereome.—This is abundant on both inferior and superior surfaces of the primary type of bundles and on superior surface of the intermediate bundles.

Mesophyll.—This surrounds all the secondary bundles and occurs between the other two types, and on the inferior portion of the intermediate type.

EXPLANATION OF PLATES.

All drawings made with a camera and drawn to the same scale. The abbreviations used are: C., cuticle; E., epidermis; E. C., epidermal cells; Sto., stomata; Tr., trichomes; B. C., bulliform cells; Ste., stereome; Mes., mesophyll; C. B. P., chlorophyll-bearing parenchyma; Car., carene; M. B., mestome bundles; H., hadrome; L., leptome; Unc. Par., uncolored parenchyma; T. W. P., thick-walled parenchyma.

PLATE iv, Fig. 1, *Bromus breviaristatus*. Fig. 2, *Bromus secalinus*.

PLATE v., Fig. 3, *Bromus patulus*. Fig. 4, *Bromus inermis*. Fig. 5, *Bromus asper*.

PLATE vi, Fig. 6, *Bromus patulus*.

PLATE vii, Fig. 7, *Bromus breviaristatus*. Fig. 8, *Bromus asper*.

PLATE viii, Fig. 9, *Bromus secalinus*. Fig. 10, *Bromus inermis*.