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The Anatomy of some Desert Plants

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THE ANATOMY OF SOME DESERT PLANTS

BY

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Amelia L. Kellogg

ENTITLED The Anatomy of Some Desert Plants

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

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Contents.

The Anatomy of Some Desert Plants.

The anatomy of relatively few American plants has been studied in detail. Solereder in his very excellent work, " The Systematic Anatomy of Dicotyledons " , has brought together the chief anatomic features that characterize the families of dicotyledonous plants and a careful examination of this work reveals the fact that American botanists have contributed very little to the subject.

The greatest variation in anatomic structure is shown in the families whose representatives possess the widest adaptibility to environmental conditions. Schimper, Warming, Volkens and others in their ecologic studies have called special attention to changes in anatomic structure induced by environmental conditions, chiefly physical. It is with the view of adding a little to our knowledge of the anatomy of American plants, particularly such as have adapted themselves to extreme conditions, that the present study was undertaken. The plants studied are :

(1) Atriplex canesens, Wats.

(2) Atriplex Nutalii corrugata, A. Nels.

(3) Mentzelia multiflora, Gray.

(4) Cercocarpus ledifolius, H.B.K.,

of the families Chenopodiaceae, Loaseae, and Rosaceae respectively.

The material was collected in the Colorado Desert, near Palisade, Colorado, at an elevation of between five and seven thousand feet above sea level, and preserved in a mixture of the following composition:

850 cc. water,

36 cc. formalin

250 cc. alcohol (ninety-five per cent)

In the preparations of sections suitable for anatomic study, great difficulties were experienced due to the extreme hardness of the more resistant tissues of both leaf and stem. The material embedded by the ordinary method in paraffin or celloidin was utterly worthless for study. Soaking in alcohol and glycerine with or without subsequent embedding, gave no better results.

Finally, the method so successfully employed by Jeffries and Plowman[1] was tried and found to give good results. The preserved material was washed for some time in eighty per cent alcohol, and was then transferred into paraffined bottles containing a ten per cent solution of hydrofluric acid. In this acid, with two changes of solution, it remained for two weeks. The material was then washed in flowing water to remove the acid, dehydrated by passing it through solutions of thirty, fifty, seventy, eighty, ninety, ninety-five per cent, and absolute alcohol respectively, and embedded by the ordinary process in paraffin or celloidin. The harder, more resistant stems and more brittle leaves were infiltrated and embedded in celloidin. The infiltration was accomplished by transferring the tissues successively into two, four, six, eight, ten, and fourteen per cent solutions of celloidin in equal parts of absolute alcohol and ether. The material remained in the two, four, six, eight, and ten per cent solutions, respectively, for two days, and in the fourteen per cent for two weeks. It was then embedded in the usual manner.

The sections were stained in Bismark brown, fuchsin and eosin. In some cases, it was found possible to study and draw structure in detail without previous staining of the sections.

1. Atriplex canesens, Wats. (Chenopodeaceae)

2. Atriplex Nutalii corrugata, A. Nels. (Chenopodeaceae)

3. Mentzelia multiflora, Gray (Loaseae)

4. Cercocarpus ledifolius, H. B. K. (Rosaceae)

The widely different stem structure in the Chenopodeaceae led De Bary[2] to classify such stems into three classes as follows:

1. The growth in thickness of the stem is due to the formation of pericyclic rings or strips of cambium which originate and lose their activity successively, forming secondary bundles and conjunctive tissue. The successive rings thus formed vary somewhat in regularity and completeness.

2. The growth in thickness following the formation of the ring of bundles, results from the appearance around the margins of the phloem, of a ring of interfacicular cambium which forms alternately vascular bundles and intermediate tissue.

3. In the final type, a combination of the processes 1 and 2 takes place, that is, the normal cambium and normal secondary thickening appear as in type 1; this however, soon stops and further growth in thickness is continued by a new extra fasecular zone of cambium which appears outside the primary masses of phloem - according to type 2.

Solereder's classification disregards type 3, grouping all stem structures under the two extreme types described by De Bary.[3]

Atriplex canesens.

The stem structure of Atriplex canesens may be considered as belonging to type 2. The vascular bundles are embedded in prosen chymatous conjunctive tissue and arranged without definite regularity. The conjunctive tissue is conspicuous in that it is composed of very thick-walled cells containing simple pits. The arrangement is irregular, and nowhere are clearly defined medulary rays visible.

Within the vascular cylinder is a rather large pith composed of

large cells full of protoplasm and so closely crowded as to admit of no intercellular spaces.

The primary cortex is composed of parenchyma, irregularly broken areas of collenchyma, and an abundance of sclerenchymous fibres scattered along the outer margin. The cortex is bounded by a single layer of thick-walled epidermal cells.

The surface of the stem is covered with a membranous covering of collapsed water-storage hairs. These are unicellular, irregular in size and shape, and epidermal in origin. They are very numerous and, when they collapse upon maturity, form a dead membranous covering that serves to check transpiration. The leaf of Atriplex canesens is covered by similar hairs, (Fig. 1-2 Plate I)

The most striking anatomic character brought out in the cross-section of the leaf is the absence of the usual spongy parenchyma, the greater part of the leaf being made up of elongated chlorophyll-bearing cells not unlike the pallisade cells of ordinary leaves. (Fig. 1 Plate I) Very few intercellular spaces are apparent in the transsection.

The vascular bundles are located centrally within the pallisade tissue. They are characteristically surrounded by a sheath of large, thick-walled cells, nearly circular in cross-section. (Fig. 2 Plate I)

Crystals of oxalate of lime occasionally occur in the form of cluster crystals in the various tissues excepting only the vascular bundles.

The upper and lower epidermis are exactly alike. Each is composed of a single row of thick-walled cells without gelatinization or waxy deposit. In both, stomates are fairly abundant and are unaccompanied by subsidiary cells.

In the leaf, as in the stem, protection against excessive transpiration is well provided for by a membranous covering of collapsed hairs,

previously described in connection with the stem. (Fig.1-2 Plate I)

Atriplex Nutalii corrugata.

The anatomy of Atriplex Nutalii corrugata, the second species of Atriplex examined, is so nearly identical with the above described species as to warrant no further comment on structural details. Both correspond very closely to Atriplex Hamilus described by Volkens in his study of Egyptian-Arabian Desert plants.[4]

The most important anatomical character of the family of Loaseae is its hairy covering. The hairs may be described as :

1. simple, unicellular hairs of varied length whose walls may or may not be silicified;

2. unicellular, conical, charp-pointed hairs and strongly silicified. The surface is covered with sharp or blunt spines directed either forward or backward;

3. unicellular, strongly silicified, barbed hairs of variable length and often comparable to a many-fluked anchor. The stalk is sometimes covered with recurved spines;

4. long, unicellular, hooked, or climbing hairs with a high multicellular base. These bear several sharp hooks at the apex and show active protoplasmic movement;

5. long, unicellular, slightly silicified, sickle-like hairs, without protoplasmic movement;

6. unicellular hairs, slenderly filiform, with local tuber-like swellings at the base and sharply attenuated at the apex or apex with barbs;

7. long, strongly silicified, unicellular stinging-hairs with a multicellular base and frequently containing a yellow fluid which has a very irritating effect upon animals;

8. short, simple, multicellular hairs;

9. multicellular glandular hairs with an uniserate stalk of varied length and with a unicellular head.

Other characters essential to the Loaseae are hairs that are calcified rather than silicified; also crystolith-like structures for the most part impregnated with carbonate-of-lime. These usually occur in the unicellular hairs, excepting only the stinging hairs, and their subsidiary cells.[5]

Mentzelia multiflora.

Mentzelia multiflora possesses the several kinds of hairs described under types 1, 2, 3, and 6, excepting that they are calcified rather than silicified. This is proved by the fact that they withstood most rigid treatment with the hydrofluric acid that was used in the preparation of sections for study. Others are crystolith-like structures impregnated with carbonate-of-lime. These are restricted to the larger unicellular hairs and their subsidiary cells.

The stem consists of a woody cylinder, including narrow medullary rays, fairly wide vessels with simple perforations and with bordered pits in contact with parenchyma as well as the wood prosenchyma. The wood prosenchyma has fairly wide lumina. (Fig. 1 Plate III).

Other tissues are a central pith composed of large, somewhat angular thick-walled cells; a well marked cambium; and a pericycle of large irregularly shaped parenchyma cells. The epidermal cells vary in size and shape from the ordinary brick-shaped cell to the more complex hair-like structures, previously described. (Fig. 1 Plate III).

The leaf of Mentzelia multiflora is oval in cross-section. Regarding its structure, it may be pointed out that the stomata have no subsidiary

cells, but are surrounded by a variable number of ordinary epidermal cells. They occur at irregular intervals throughout the ring of epidermis.

There is a rather conspicuous central vein with clearly differentiated zone of xylem and phloem, - also a network of tracheids running free in the mesophyl.

The mesophyl consists of a spongy parenchyma surrounding the central vein, gradually becoming differentiated into pallisade-like cells as it approaches the epidermis. (Fig. 1 Plate II).

The epidermis of the leaf is similar to that of the stem except that the cells are larger in proportion and thicker-walled and the hairs are longer and stronger. Upon the outer surface occurs a triple layer of cutin not present on the epidermis of the stem. (Fig. 1 Plate II).

Specific anatomical characters are almost entirely lacking in the Rosaceae. According to Solereder and others the following are the most prevalent characters:

1. the lack of simple uniseriate clothing hairs;

2. the presence of bordered pits in the prosenchymatous groundwork of wood in almost all woody species.

Cercocarpus ledifolius.

The stem of Cercocarpus ledifolius is typically woody and possesses bordered pits in the prosenchymatous groundwork of wood. The vascular cylinder is a fairly wide region consisting of small lumined wood cells and narrow medullary rays extending as a conspicuous band out through the rather well preserved phloem. There is a central pith of large circular heavy-walled cells. The cortex is rather wide and consists of irregularly shaped parenchyma cells, increasing in size as they near the epidermis. The epidermis consists of small, circular cells, regular in size and shape, and

with a thick deposit of cutin on its outer surface. (Fig. 1 Plate IV).

A large amount of tannin and silica, deposited in the cells of parenchymatous tissues of this stem, gives it a very conspicuous character.

The leaf of this same plant is peculiar in cross-section in that there is a prominent mid-rib from which the blade curls back on either side, giving the entire structure an appearance not unlike the figure three. This mid-rib contains a single vein with a definite xylem and phloem broken by narrow bands of parenchyma cells. (Fig. 1 Plate IV). Below the mid-vein is a crescent of spongy parenchyma meeting the small crowded pallisade-like cells above - which comprise the bulk of the internal tissues. The lateral veins proceeding from the mid-rib pass slightly upward and are distributed through the mesophyl. Each of the lateral veins is surrounded by a sheath of heavy-walled cells, one layer deep. (Fig. 1 Plate V).

A conspicuous layer of hypodermis occurs just below the epidermis. It is composed of large thick-walled cells abundantly supplied with tannin. This is also true of the cells composing the bundle-sheaths.

The epidermis consists of a single layer of very small cells with a well developed deposit of cutin on the outer surface. Stomates are abundant on the lower surface of the leaf. Transpiration is reduced by a dense mat of unicellular clothing hairs and the peculiar curling of the leaf. The hairs are entirely restricted to the under surface of the leaf on either side of the prominent mid-rib. (Fig. 1 Plate V).

In the pallisade-like cells of the mesophyll, a considerable quantity of silica is deposited.

In the study of the above American desert plants, belonging to the families Chenopodiaceae, Loasaceae and Rosaceae, no new or distinct characters, not already noted, were discovered.

References.

[1]Jeffries - Plowman: Botanical Gazette, Volume XXXVII June 1904, pp.456.

[2]De Bary: Comparative Anatomy of Phanerogams and Ferns, pp. 490.

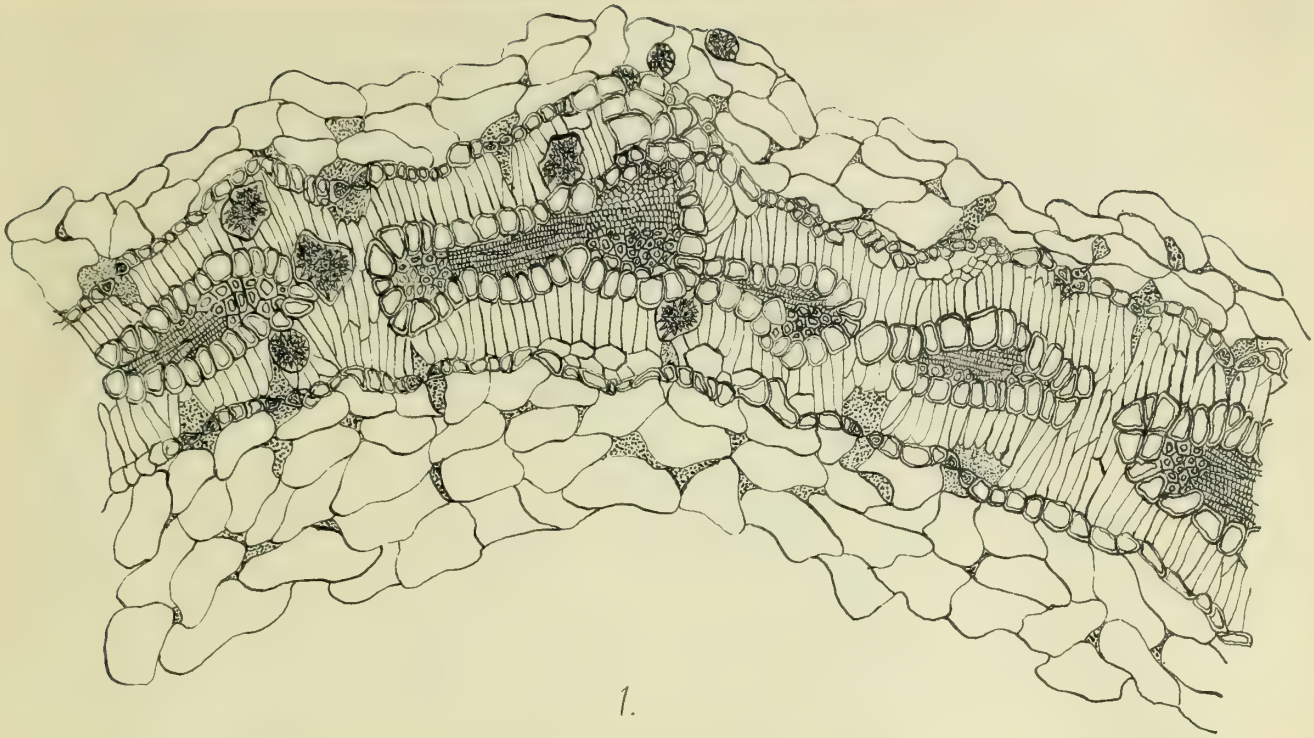
[3]Solereder: Systematic Studies of Dicotyledons, pp 655.

[4]Volkens: The Flora of the Egyptian-Arabian Desert.

[5]Observed by Solereder: The Systematic Study of Dicotyledons, pp.380.

Plate 1. Figure 1 - 2.

Middle and end sections of the cross-section of the leaf of Atriplex canesens - showing covering of collapsed water-storage hairs - bundle sheaths, - pallisade-like mesophyll, etc.



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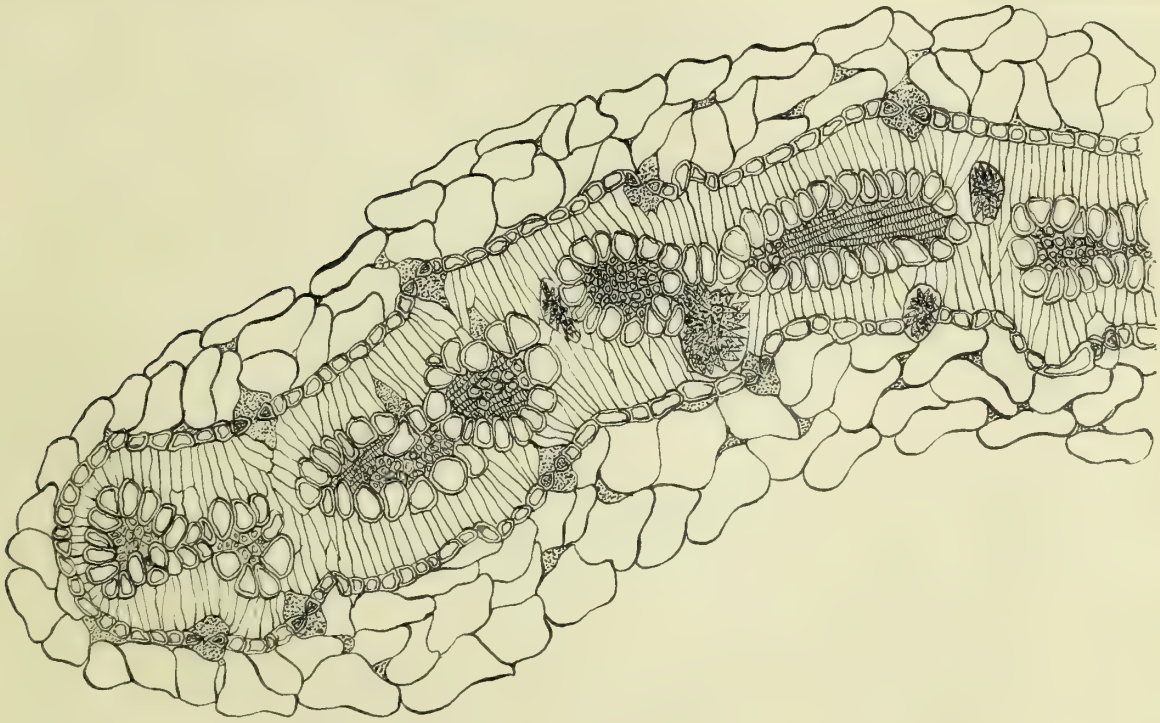

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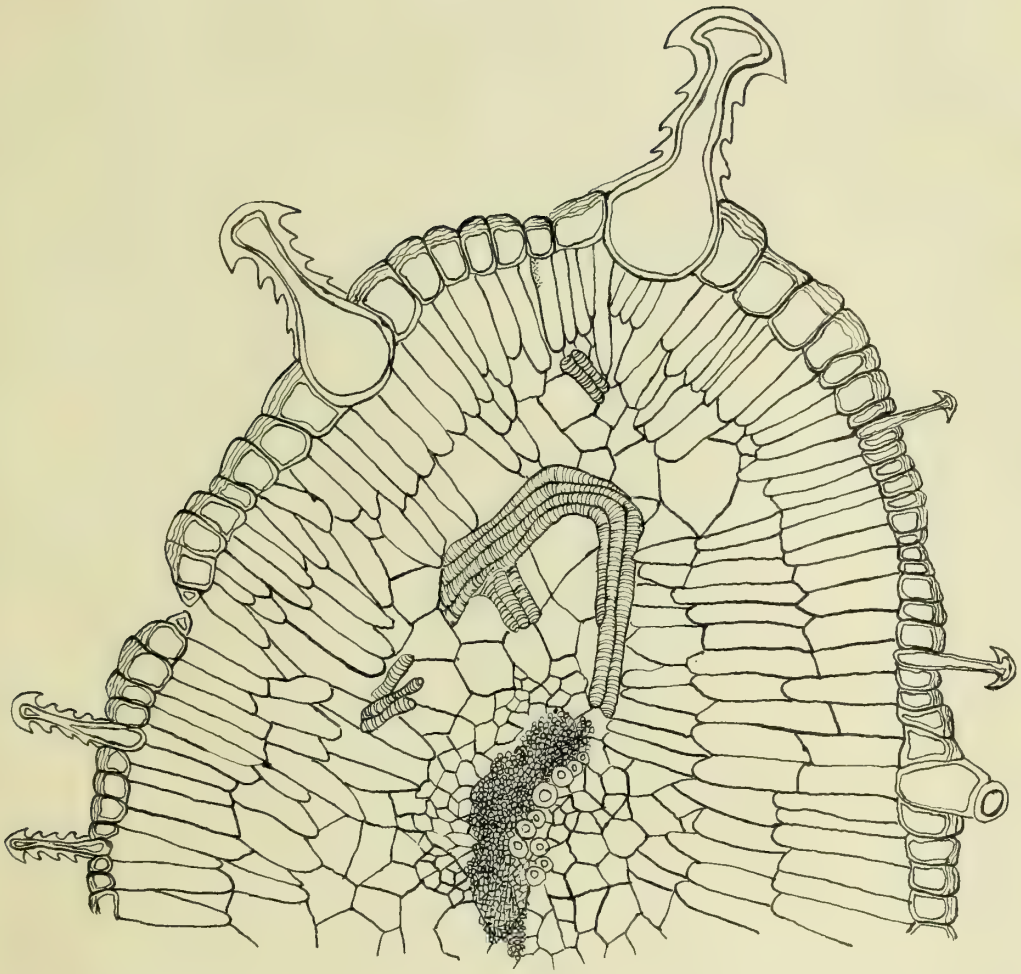
Plate 2. Figure 1.

Cross-section of the leaf of Mentzelia multiflora, showing mid-vein (xylem and phloem) - network of tracheids running free in mesophyll - hooked trichomes, etc.



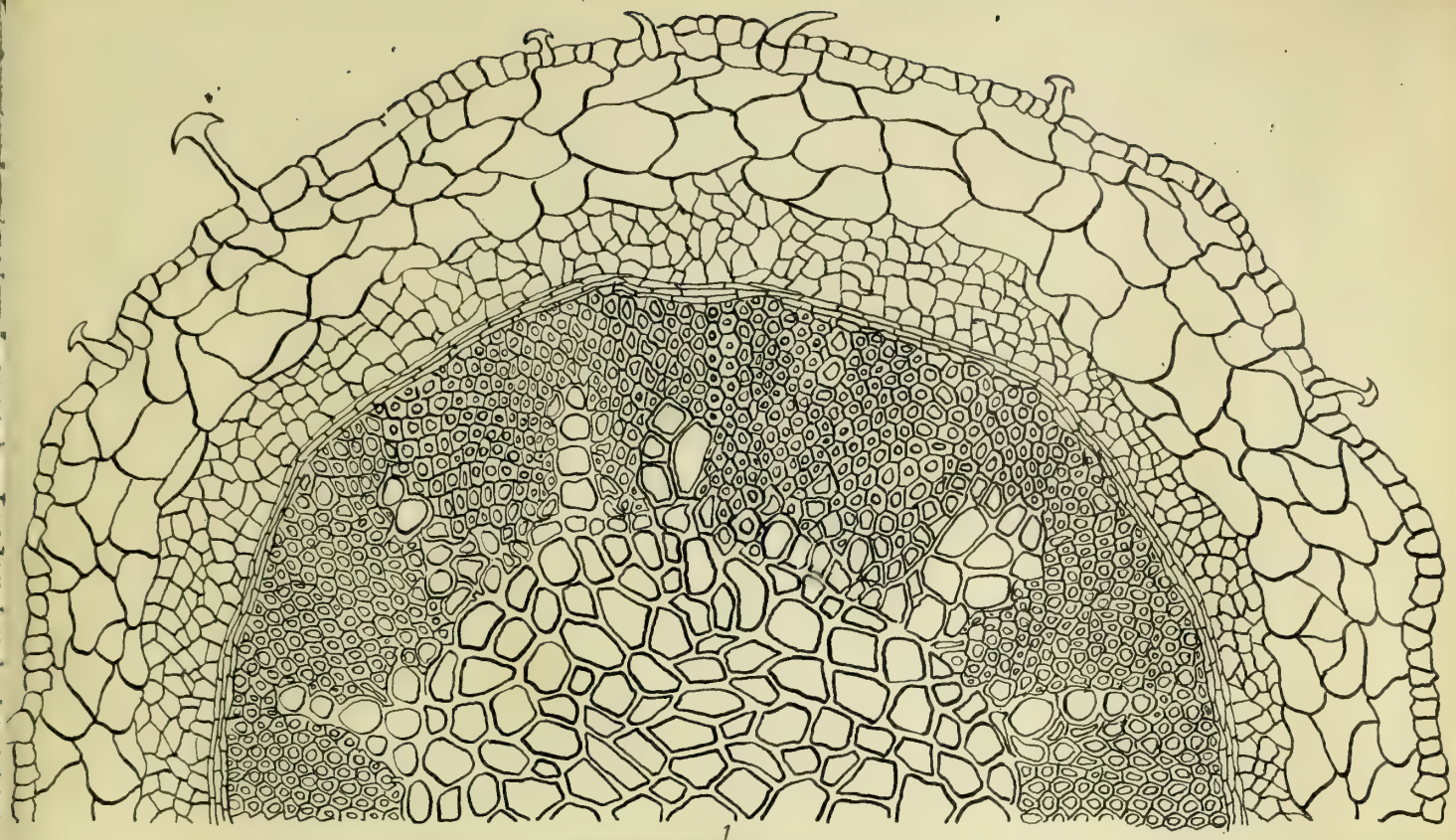
1.

Plate 3. Figure 1.

Cross-section of the stem of Mentzelia multiflora - showing the relative location of tissues.

Plate 3. Figure 2.

Cross-section of the stem of Cercocarpus ledifolius - showing the location of tissues.



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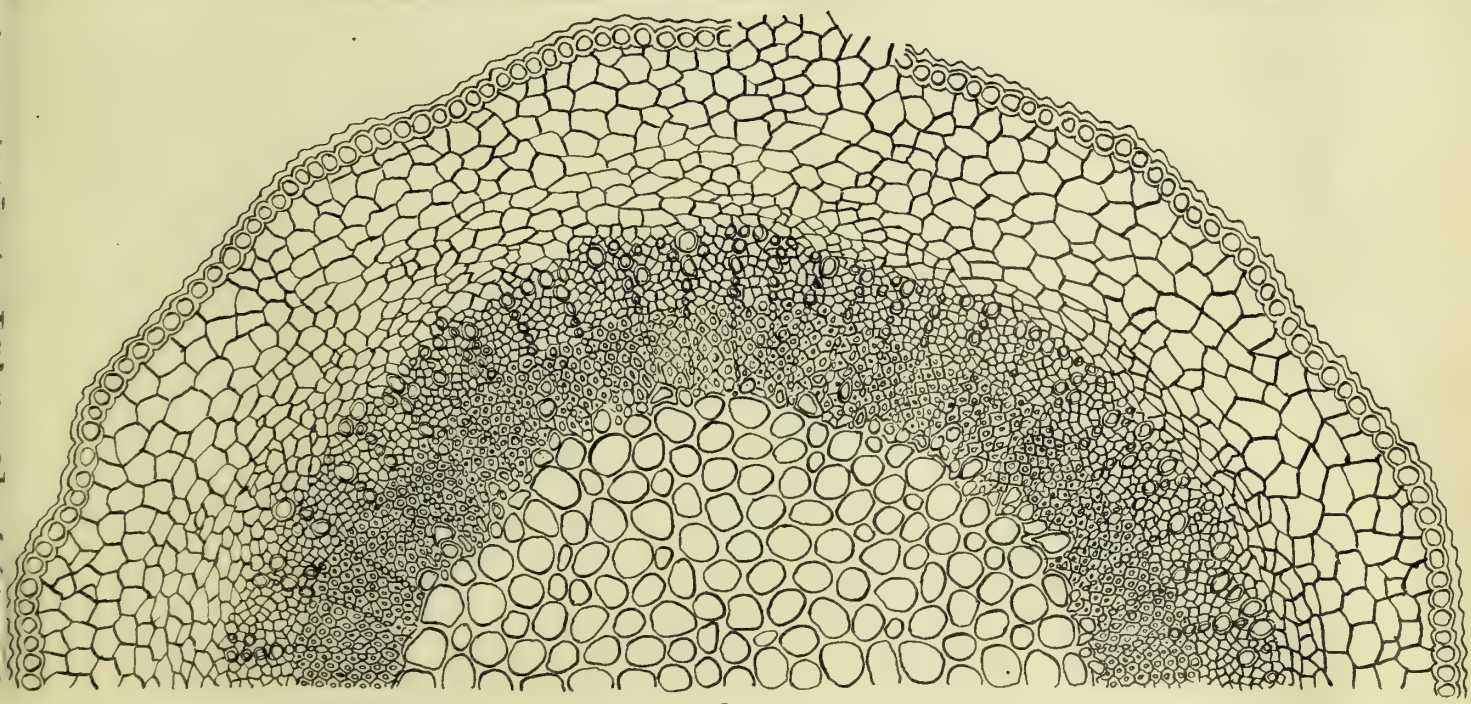

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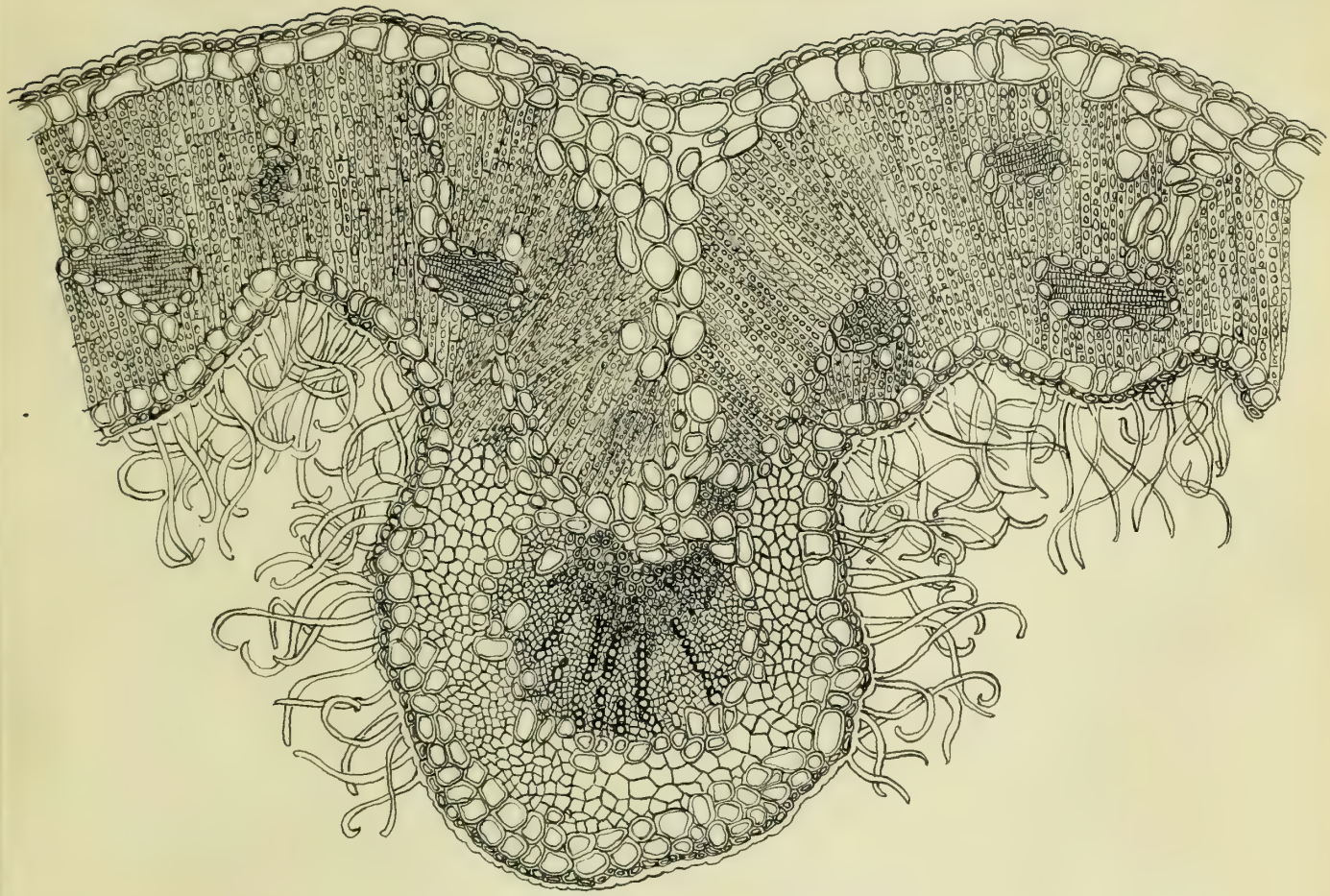
Plate 4. Figure 1.

Middle part of cross-section of the leaf of Cercocarpus ledifolius - showing the mid-vein and other most conspicuous characters.



1.

Plate 5. Figure 1.

Cross-section of the leaf of Cercocarpus ledifolius - showing curled blade, location of stomata, hairs, etc.

1.