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CONTRIBUTION TO THE MORPHOLOGY AND ANATOMY OF THE RUSSIAN DANDELION

HARTSCHLAGER

ET AL

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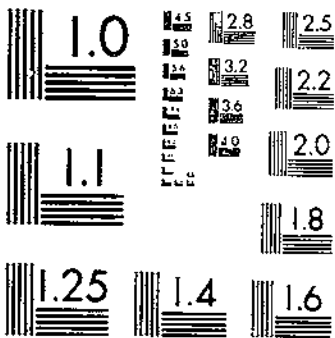
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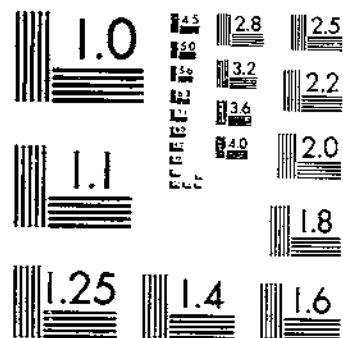
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UNITED STATES  
DEPARTMENT OF AGRICULTURE  
WASHINGTON, D. C.

DEPOSITORY

# Contribution to the Morphology and Anatomy of the Russian Dandelion (*Taraxacum kok-saghyz*)<sup>1</sup>

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## INTRODUCTION AND DISCUSSION

In plant economy the manufacture and storage of starch, sugar, latex, or other products is an expression of the general metabolism, contingent on structure and subject to external and internal influences. The capacity to synthesize and store, though bound up with the finer physiology of a plant, often depends on some anatomical modification. For example, potatoes with a broad branching medulla and a narrow cortex are apt to be low in starch; likewise, sugar beets with a low ring-density coefficient and narrow vascular rings seldom fall into the elite class for sugar production (1).<sup>3</sup> In latex-producing plants like the Russian dandelion (*Taraxacum kok-saghyz* Rodin), high performance may be primarily related to actual increase in latex tube complement, or some modification in the translocation system, or both.

To determine the relative merit of individual plants it is important to learn the nature and degree of existing correlations between structure and yield. Russian investigators (5, 6, 7) who pioneered in the breeding of *kok-saghyz* have already pointed out a number of such correlations, linking the size of the latex system with yield, but ignoring other structural features and dismissing the sieve tubes with "they

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<sup>2</sup> Acknowledgment is made to Mrs. Eugenia Artschwager for the preparation of the drawings.

<sup>3</sup> Italic numbers in parentheses refer to Literature Cited, p. 24.

are small and difficult to find." The intimate association of sieve tubes with latex cells in kok-saghyz and the role of sieve tubes in translocation suggest, however, that performance and relative development of the sieve-tube apparatus are closely linked.

This investigation was undertaken to obtain a better conception of the detailed structure of the plant as a whole and of the elements of the secondary phloem in particular to serve as a background for research in the present rubber plant breeding program.

It might be presumed that in rubber-producing plants a high latex tube complement, evidenced in a large number of latex tubes and in tubes of large bore, is correlated with high rubber yield. This has been demonstrated fairly conclusively for *Ilexea brasiliensis* (H. B. K.) Muell. Arg. (3, 4) and tentatively by Russian investigators (5, 6) for kok-saghyz. Unfortunately, high tonnage is not often linked with a high content of the product desired. Occasionally, however, among high-tonnage types individuals are found that have the structural prerequisites for high rubber content, i. e., a large latex tube complement, or latex tubes of exceptionally large bore, or both. If such individuals are also physiologically superior in that they synthesize the theoretical maximum, the breeder's goal has been realized. Often the so-called physiological superiority is in reality linked to structure, as has been shown for hevea (7) and seems strongly indicated for kok-saghyz. Although the importance or purpose of latex in the economy of latex-producing plants may not be grasped, it is known that its synthesis is related to the general metabolic rate, which must be related to the system of translocation; and in this system the sieve tubes play a major role.

Higher yields may be realized by increasing the latex tube complement through selection of individuals for tubes of greater bore, for minimum dispersion of phloem groups, and for a higher ring-density coefficient by reducing the width of the parenchyma tissue between the rings. A study of the relative proportion of sieve tubes and latex cells within a phloem group of high- and low-yielding strains should help to clarify the importance of the sieve-tube element in plant development and to ascertain its value as an indicator for rubber yield.

## MATERIALS AND METHODS

The material for study was grown in the Mesilla Valley, N. Mex., on adobe soil to which a liberal quantity of peat had been added to keep the ground from crusting during the critical germination period. Some of the seed was vernalized prior to planting by leaving it wrapped in moist burlap in the icebox at a temperature of 5° C. for a period of 7 days. The vernalized seed germinated a little earlier and somewhat more uniformly than the untreated seed.

To differentiate clearly between sieve tubes, latex vessels, and other phloem constituents, the following staining procedure was adopted.

Pieces of taproot were stained in bulk in Sudan III (Sudan III, 1 gm.; 95 percent alcohol, 100 cc.; glycerin, 100 cc.), sliding microtome or hand sections about 50 $\mu$  thick were made, and counterstaining was done with chloroiodide of zinc. In such preparations the latex stains bright orange and the sieve tubes, especially in phloem groups close to the cambium, stand out prominently because of their thick bright-blue walls (fig. 1).

For a study of latex cells alone, bulk staining in Calco Oil Blue NA in 50 percent alcohol is equally effective, perhaps even better, as the stain does not fade readily. The staining in bulk has the advantage over section staining in that a spreading of latex into adjacent cells is minimized and the making of microtome sections is facilitated.

## GROSS MORPHOLOGY

*Taraxacum kok-saghyz*, a member of the tribe Cichorieae, family Compositae, is a scapose perennial herb whose economically important characteristic is the presence of latex in its organs, especially the root.

The leaves are decumbent and form a rosette. They are 3 to 5 inches long, narrowly obovate, incised mucinate or sinuately lobed, but never serrate, as in the local species of dandelion (*T. officinale* Weber). Some leaves have margins entire or nearly so. The texture of the leaves is somewhat fleshy; the surface is glossy and has a bluish hue, the midrib is pale and distinct, the laterals less so.

The fleshy taproot of plants 5 months old is slender, cylindrical, often branched or twisted (2), with a mean diameter of about 0.7 cm. in the neck region. When the plants are widely spaced, the taproot according to Rudenskaja (5), may attain a thickness of 1.5 and even 3.5 cm. The neck region is straight and is sharply delimited from the leaf bases of the rosette (fig. 2). The ivory-white root surface has distinct cross markings and ridges. The well-developed lateral root system diverges in two opposite rows from the main root. Most laterals are long and slender, but a number of fairly thick side roots with filiform tertiaries are present.

## MORPHOLOGY OF FLOWER AND SEED

The flowers of kok-saghyz, like those of the common dandelion, are borne in close heads on leafless scapes. The latter are slender, hollow at the center, and glabrous except for a slight pubescence just below the flower head. Each head

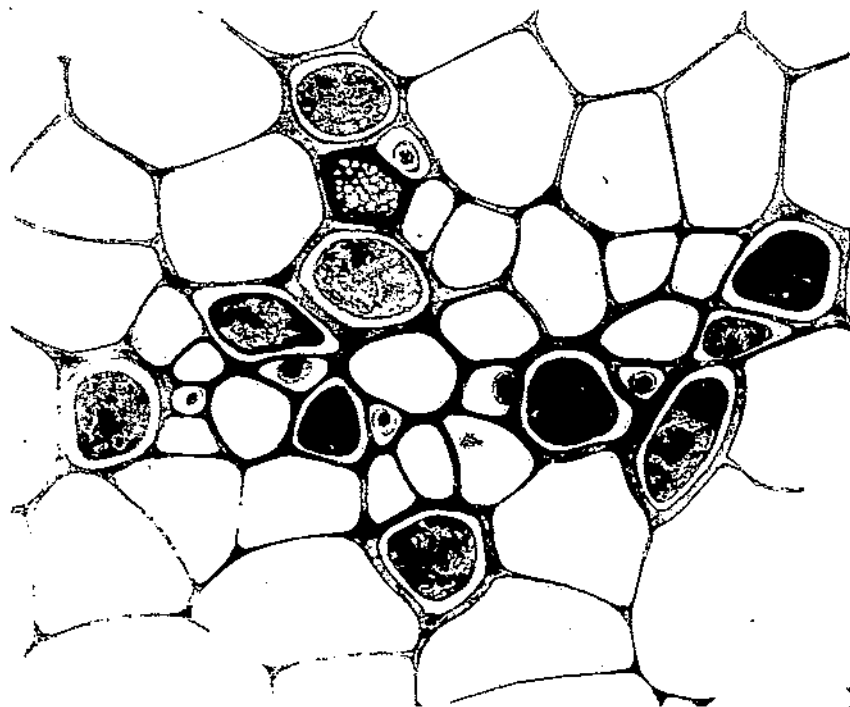


FIGURE 1.—Phloem group drawn from a photomicrograph: The cells with the dense content are latex tubes; those closely associated with the latex tubes are sieve tubes; the small cells with nuclei adjacent to the sieve tubes are companion cells; and the remaining cells are phloem parenchyma. The large cells surrounding the phloem group belong to the interzonal parenchyma.  $\times 1,155$ .



FIGURE 2.—Kok-saghyz plant in bloom. From drawing of greenhouse-grown plant.  $\times 0.7$ .

is surrounded by two series of bracts that form the involucre. The outer phyllaries are broadly lanceolate (fig. 3, C, D), somewhat recurved, pointed, and provided with a prominent horn; the inner phyllaries are erect and linear lanceolate (fig. 3, B) and also are provided with a horn. The margins of both types of bracts are hyaline.

The small yellow flowers (fig. 3, A) are all perfect and alike. The calyx is usually considered to be represented by the pappus, a circle of minute white hairs at the base of the unilocular, inferior ovary. The yellow-colored corolla is inserted immediately above the ovary; its lower part forms a tube, and the upper a wide strap-shaped, five-toothed blade. The lower part of the style is enclosed by the corolla tube, the upper is free, and the tip branches to form two minute recurved stigmas (fig. 3, A). Terminating some distance below the stigma and sheathing the style are five very small anthers. The stamen filaments are diverged from the base of the corolla tube as discrete structures, but the anthers are united to form a cylinder.

After fertilization the declined bracts of the involucre turn upward again, compressing the flower head into a conical tube. In this position the head remains until the seed is mature.

The scape prior to anthesis is relatively short but elongates rapidly, elevating the flower head for more effective seed dissemination. As the seed develops, the tissue at the apex of the ovary bearing the pappus begins to elongate, pushing the pappus upward until it is at the tip of a long threadlike stalk connecting it with the apex of the ovary (fig. 4, B).

When the seed is mature, the involucre recurves again and the white seed head (fig. 2) is exposed. Each achene loosens from its point of attachment and is borne away by the white feathery pappus.

The beaked achenes (fig. 4, A) are straw-colored, somewhat obovate, ribbed, and mucronate above. The ribs are provided with upwardly directed teeth, which are especially prominent along the larger ribs.

A cross section through the lower part of an achene (fig. 4, C), taken somewhat before embryo maturity, shows in the center the young radicle surrounded by the integument and pericarp. The pericarp is prominently ribbed; the ribs are more or less equally spaced and composed mostly of thick-walled sclerenchyma fibers. The outer epidermis of the pericarp has wartlike hairs. The cells in the adjacent layer are quite large and may facilitate the absorption of water during germination. The inner cells of the pericarp and of the integument are partially disorganized. The process of disintegration in these tissues begins at time of anthesis and proceeds progressively until the fruit is ripe. Of the integument, only the outer epidermis persists as a thick-walled layer.

### SEEDLING STRUCTURE

Seeds of kok-saghyz germinate readily, especially if vernalized previous to planting. The primary root emerges from the base of the achene and grows rapidly downward, and the elongating hypocotyl carries the cotyledons with the partially enveloping remains of the achene upward. Lateral roots are initiated very early; the first ones appear at the junction of hypocotyl and root (fig. 3, B). Although a strong root system develops early in the life of the seedling, the leaf rosette expands slowly and the individual leaves remain minute in size for 2 months or more.

The primary root of kok-saghyz has a diarch stele in which the two phloem groups lie on the flanks of the primary xylem strand (figs. 5 and 6, A) and are separated from it by fundamental parenchyma that later functions as a procambial zone. The protoxylem points abut the pericycle (fig. 6, A), which is surrounded by a uniseriate endodermis. The cortex consists of six to eight layers of parenchymatous cells and is limited externally by an epidermis composed of small cells, each of which may form a root hair.

A characteristic feature of the pericycle is the occurrence of latex tubes, which, although absent in the embryo, make their appearance soon after seed germination. The first latex tubes are seen in the arches of the pericycle that lie outside the groups of primary phloem; additional ducts are soon differentiated on the central surface of this tissue (fig. 7, A). There are no ducts in the pericycle outside the protoxylem.

Vascular transition involves only a short portion of the seedling axis and agrees in general plan with that reported for various members of the Cichorieae. The cotyledons have three traces—a midrib and two lateral bundles. Beginning with



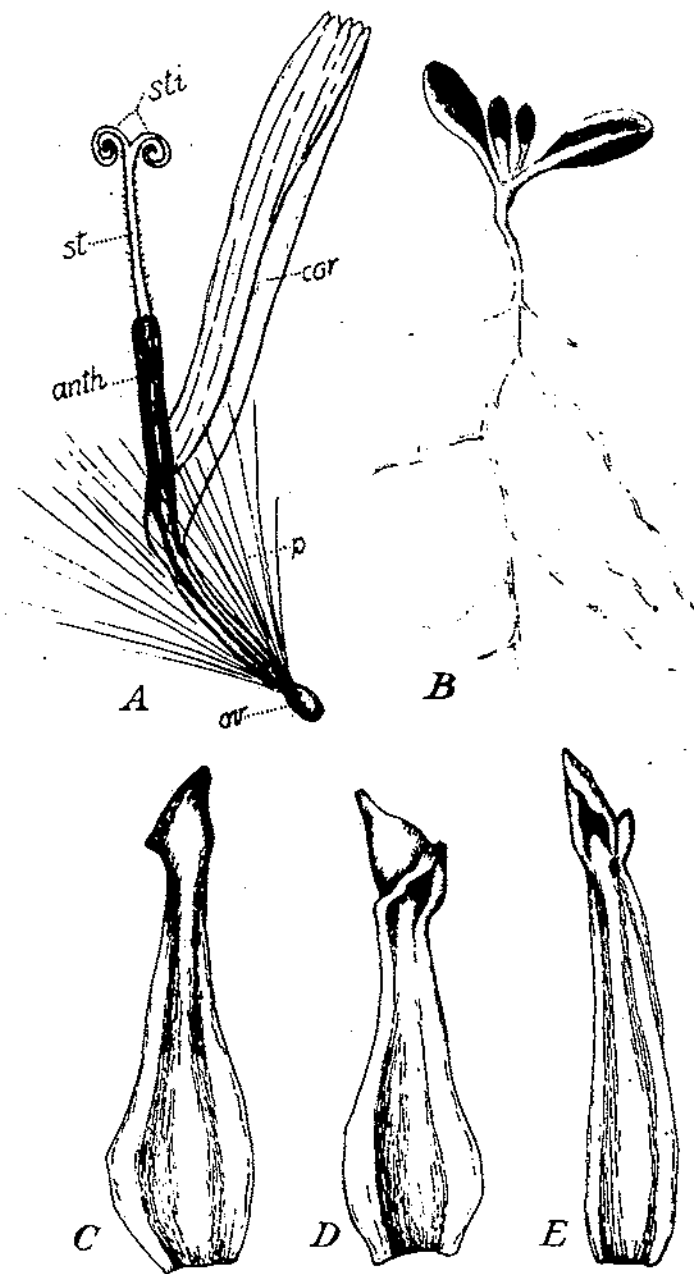


FIGURE 3.—A. Individual flower greatly enlarged: *ov.* Ovary; *p.* pappus; *cor.* corolla; *anth.* anthers; *st.* style; *sti.* stigma. B. Seedling 16 days old.  $\times 1\frac{1}{2}$ . C. Outer phyllary, abaxial side.  $\times 7$ . D. Outer phyllary, adaxial side.  $\times 7$ . E. Inner phyllary, adaxial side.  $\times 7$ .

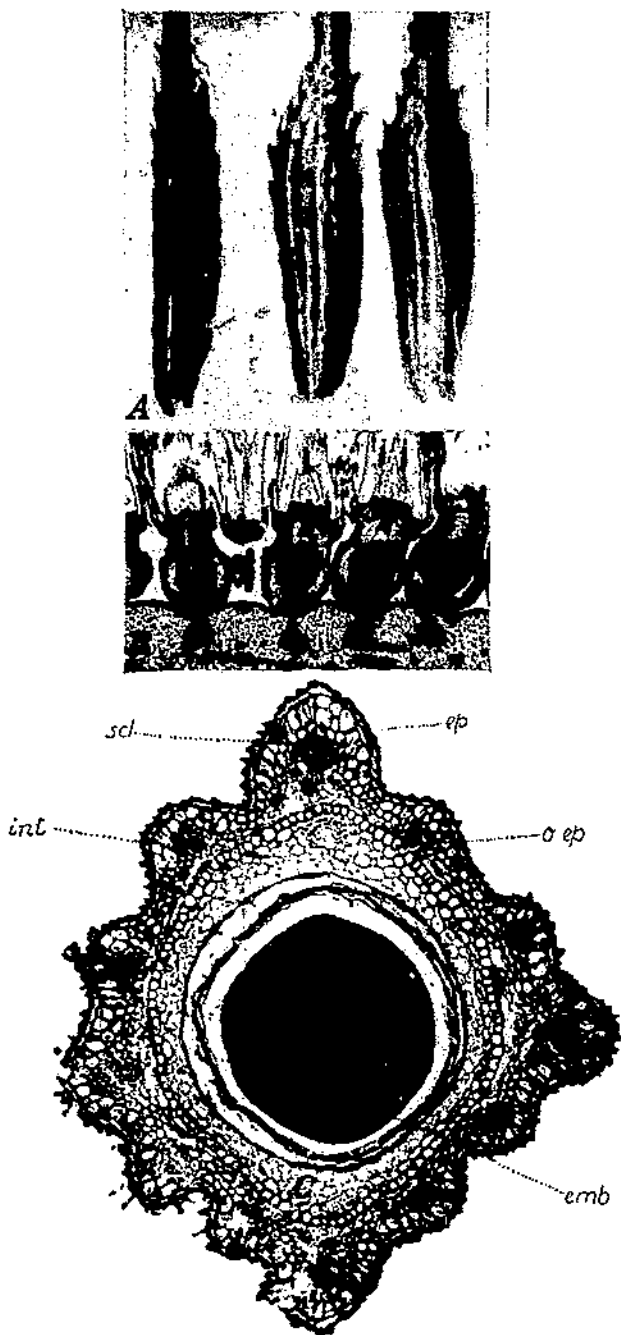


FIGURE 4.—A, Achene.  $\times 24$ . B, Longitudinal section through base of flower head at time of anthesis, showing ovary and ovule of individual flowers.  $\times 24$ . C, Cross section of achene a few days before seed maturity.  $\times 114$ . *emb*, radicle of embryo; *o ep*, outer epidermis of integument; *int*, integument; *scl*, sclerenchyma bundle in pericarp; *ep*, epidermis of pericarp.

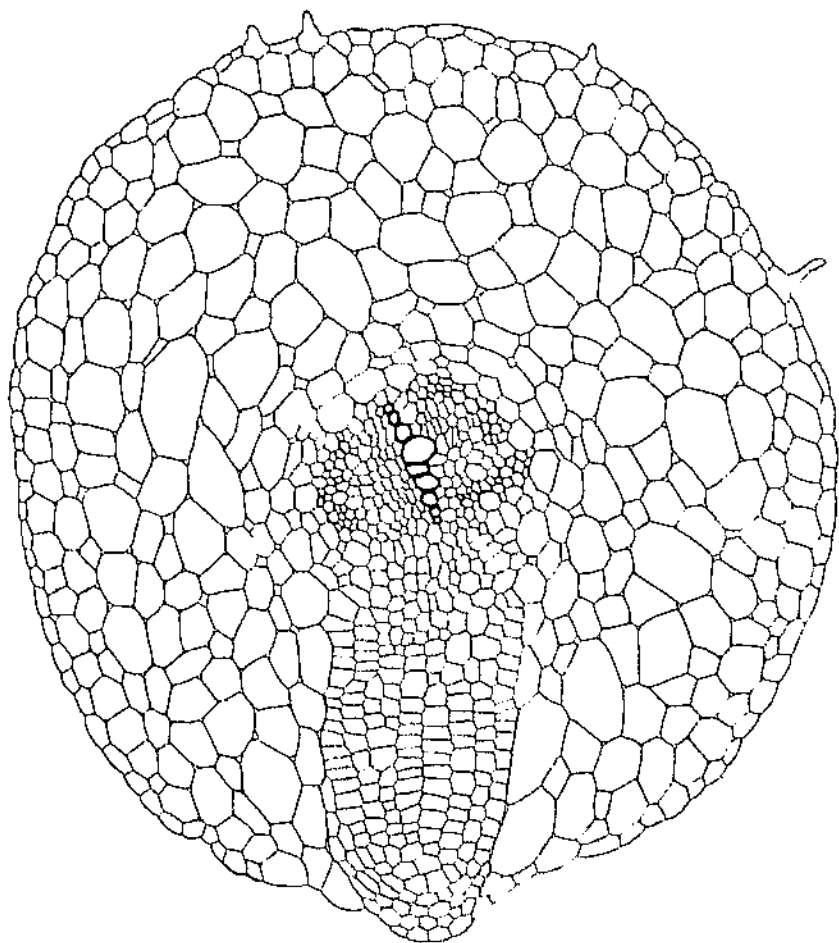


FIGURE 5.—Cross section of young taproot, showing diarch structure and origin of secondary root.  $\times 200$ .

a section through the upper third of the hypocotyl, the metaxylem is seen to differentiate progressively laterally, leaving the center of the diarch plate parenchymatous (fig. 7, *B*); simultaneously, the elongated phloem groups lying on the flanks become differentiated as four more or less distinct strands. At the level of the cotyledonary divergence (fig. 8, *A*) the xylem of the median traces forms more or less regular V-shaped bundles (fig. 6, *B*), each with two strands of phloem on the abaxial side. At right angles to the midrib bundles are the lateral traces, one of which is as yet undivided, as seen in figure 8, *A*. In very young seedlings, these lateral cotyledonary traces contain no xylem and appear to end blindly in the tissues of the hypocotyl; in serial sections of older material, however, their connection with the larger bundles can readily be followed out (fig. 8, *B*).

Cambial activity is initiated in the procambial zone between primary phloem and xylem, the cells maturing more rapidly centrifugally than centripetally, with the result that a very broad band of secondary phloem is formed in comparison with the width of the xylem (fig. 9). The secondary phloem is made up of alternating zones of phloem tissue separated from one another by rings of large-celled interzonal parenchyma. The secondary xylem is restricted to a small torus, or somewhat stellate, central core.

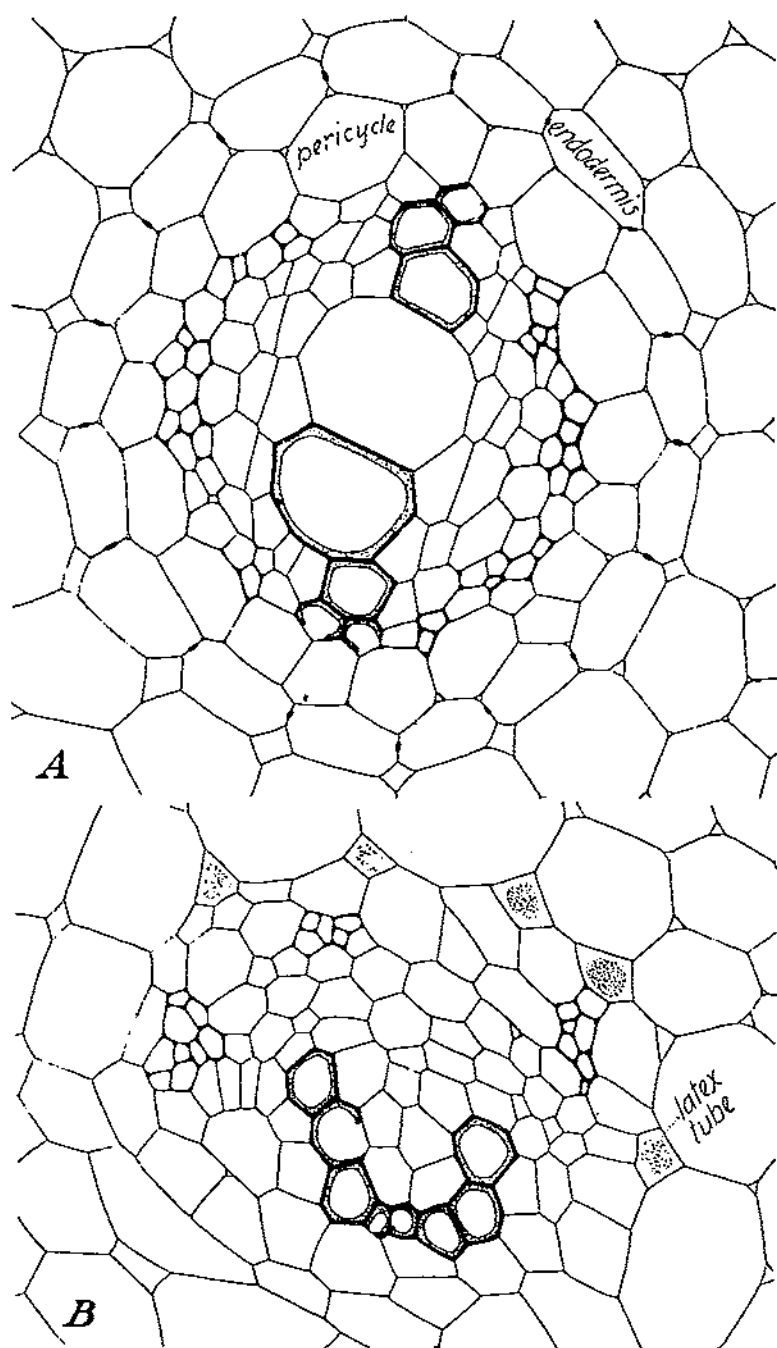


FIGURE 6.—A, Cross section through stele and inner cortex of young seedling root, showing detail of structure.  $\times 830$ . B, Cross section through cotyledonary midrib near base of cotyledon. The xylem shows the typical V-shaped structure.  $\times 843$ .

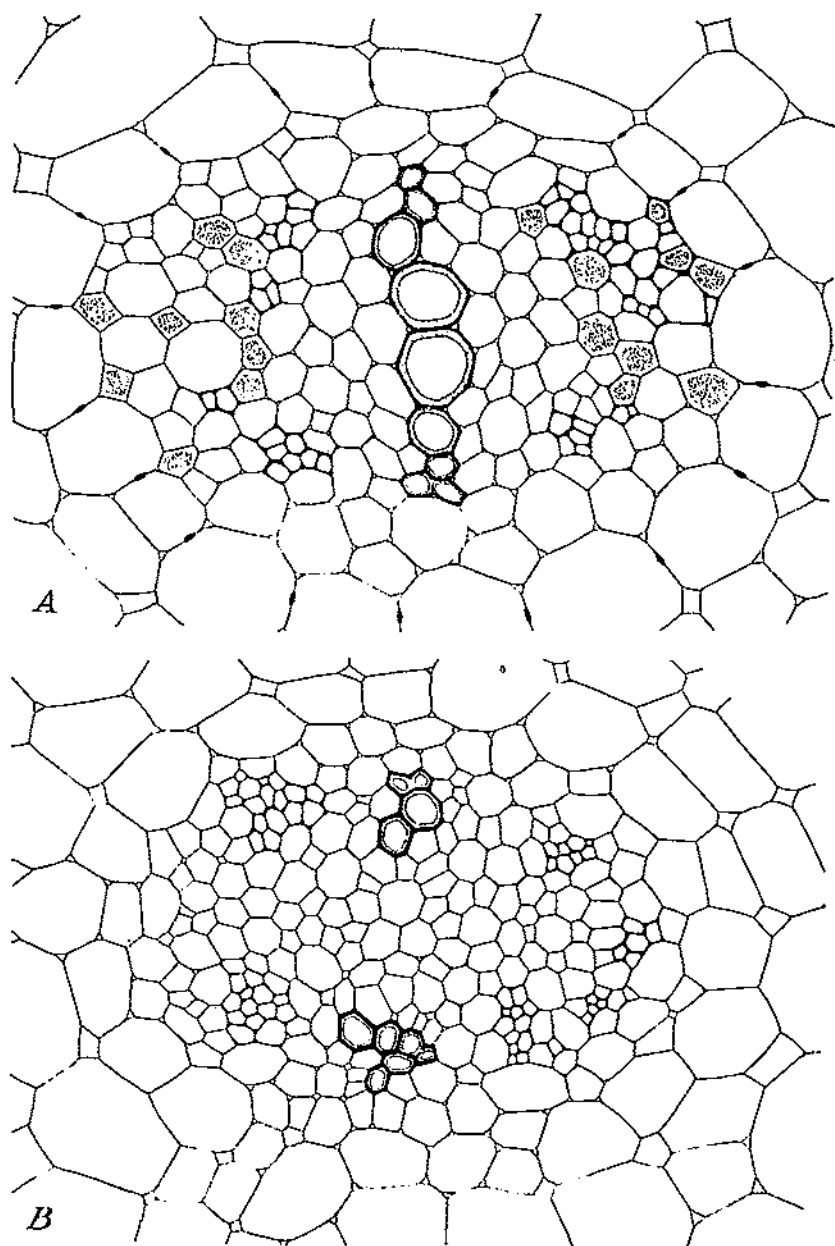


FIGURE 7.—A. Cross section through lower hypocotyl of young seedling, showing latex tubes in pericycle as well as on central surface of pith.  $\times 757$ . B. Cross section through upper hypocotyl, showing lateral differentiation of xylem and the parenchymatization of the center of the primary xylem plate.  $\times 757$ .

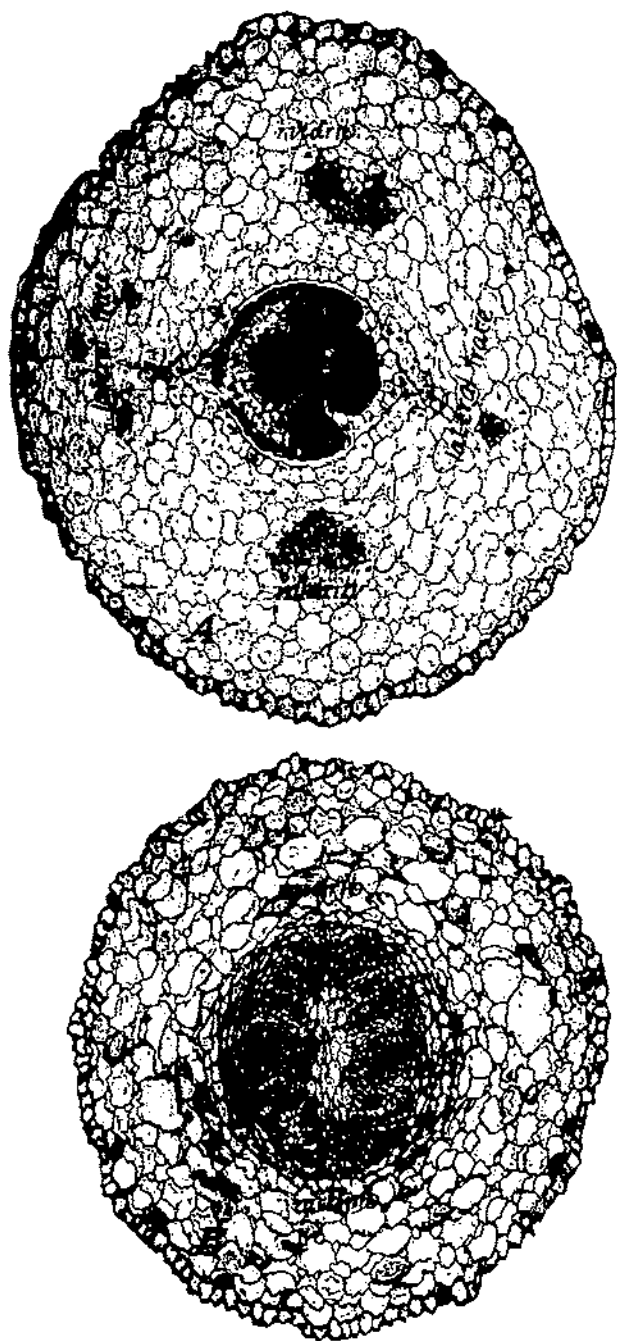


FIGURE 8. A, Cross section through cotyledonary collar of 6-day-old seedling.  
× 107. B, Cross section of 12-day-old seedling just below cotyledonary collar.  
× 80.

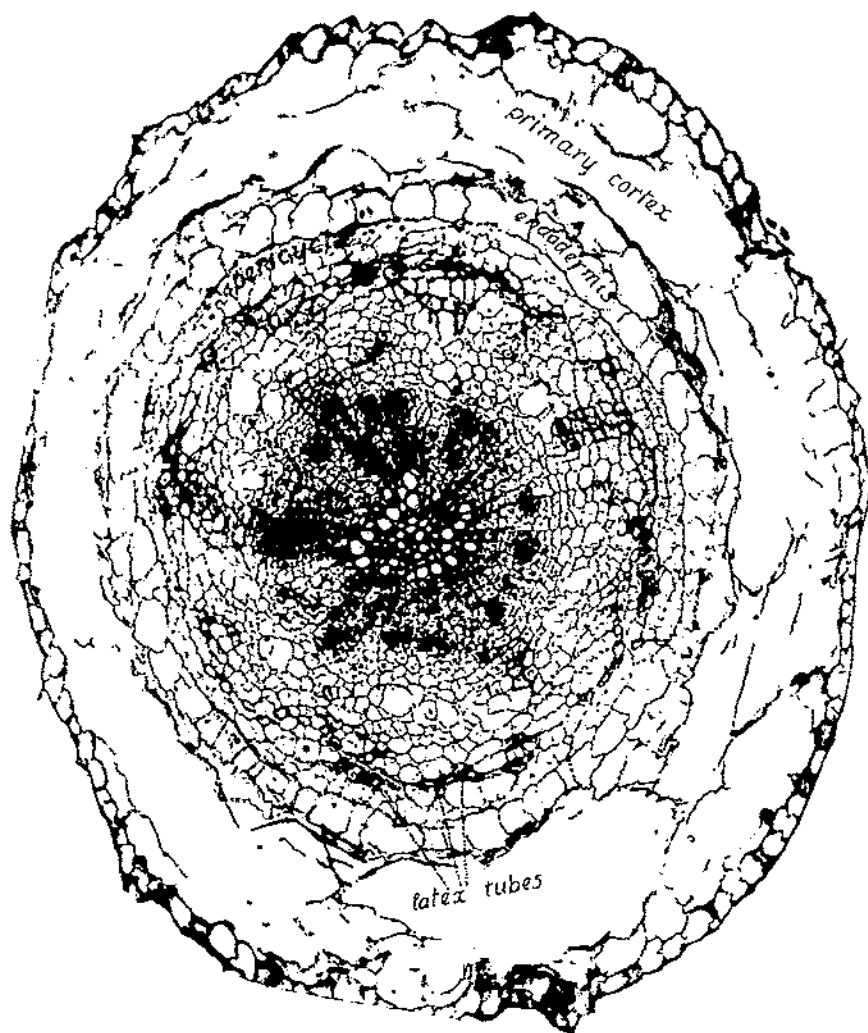


FIGURE 9.—Cross section of taproot of 5-week-old seedling, showing disintegration of primary cortex, enlargement of endodermis, and origin of periderm in the pericycle.  $\times 90$ .

The various elements of the phloem are differentiated in close proximity to the cambium. As they enlarge and are pushed outward they exert an increasing pressure on the endodermis and the primary cortex. The cells of the endodermis enlarge greatly, both tangentially and radially (fig. 9), whereas the cells of the primary cortex rupture and collapse, and the entire tissue, including the epidermis, is sloughed off.

Concomitant with the degeneration of the primary cortex is the development of a periderm, which takes over the protective function of the primary cortex. Periderm development begins in seedlings about 4 to 5 weeks old. Its formation is initiated with a conversion of the cells of the pericycle by tangential divisions into a band of meristematic tissue. From this phellogen, thin-walled cork cells are formed to the outside, but formation of phelloderm cells by reciprocal division does not take place. The periderm as a whole forms a thin ivory-white covering five to eight cells wide.

## ANATOMY OF THE MATURE TAPROOT

## GENERAL STRUCTURE

A median horizontal section through the fleshy taproot shows a small woody core and a broad band of secondary phloem in which the tissues are arranged in concentric bands, the rings of phloem alternating with bands of parenchyma (fig. 10, *A*).

## XYLEM

The secondary xylem is not a complex tissue, as it consists only of vessels and parenchyma. The parenchyma cells are thin-walled, elongated, and pointed. The vessels show much variation in size and are round, elliptical, or somewhat angular in cross section (fig. 11, *B*). Vessel members are without ligular projections beyond the perforation plate and are of varying length (120 $\mu$ -210 $\mu$ ). Perforation plates are horizontal and the perforation simple. The secondary walls are in the nature of close-ringed and scalariform thickenings (figs. 12 and 13, *B*).

## PHLOEM

The secondary phloem of each concentric ring when viewed longitudinally forms an interconnected unit, although in cross section it may appear to be made up of discrete individual groups separated from one another by parenchymatous cells (fig. 13, *A*). The groups are more or less continuous in the region near the cambium, but are forced progressively farther apart toward the periphery (fig. 10, *A*).

The composition of the phloem is more or less alike for all groups, though it shows variation in size and relative proportion of its component elements. All have a common origin in the cambium (fig. 11, *A*) and are differentiated very early in close proximity to this zone (fig. 11, *B*). In tangential section the cells of the cambium appear fusiform and are arranged in definite horizontal rows (fig. 13, *B*). During the height of the growing season the cambium forms a very broad band (fig. 11, *B*) in which the formation of new cell walls by means of phragmoplasts may be observed in a number of adjacent cells (fig. 12). The tiered arrangement of the cambium cells, noted above, is maintained to a certain extent by all phloem derivatives in their subsequent development (fig. 13, *B*, *C*).

The elements that comprise the secondary phloem are sieve tubes, companion cells, phloem parenchyma, and latex tubes (fig. 1).

The sieve tubes are always closely associated with the latex vessels and are equal in size to the smaller ones of the latter. Their walls are relatively thin except in the region of the sieve plates, where they may exceed in thickness the walls of the latex cells (fig. 14). The longitudinal walls seen in section are typically beaded (fig. 12), whereas in surface view they show small solitary pits irregularly placed (fig. 15, *B*). A single sieve plate occupies nearly the entire transverse wall and appears to be perforated by a large number of small circular pores, as seen clearly in figure 14, *A* and *C*. Sometimes the plates appear to be sloping more or less steeply, and sometimes two and even three fields seem to form one large plate. In many instances, however, this aggregation is the result of closely neighboring sieve tubes veering from their course to continue in a different direction.

Occasionally solitary sieve plates or groups of two or three (fig. 15, *C*) are seen in longitudinal section, giving the impression of large lateral fields. Although such lateral fields are sometimes found between neighboring sieve tubes as a normal occurrence, in most cases there exist terminal plates of sieve tubes that have veered from their course in the formation of anastomoses or on account of encroaching latex tubes.

The length of the individual sieve tube segment is on the average 100 $\mu$ , whereas the width is about 10 $\mu$ . Much variation in length is found, however, as can be clearly seen in the height of the different tiers in the radial section (fig. 10, *C*); and whenever anastomoses occur, the length of the sieve tube varies even more.

Although the sieve tubes of *Kok-saghyz* are relatively narrow compared with those of members of the Cucurbitaceae, they form in their entirety a well-developed system capable of expediting translocation and making rapid growth possible.



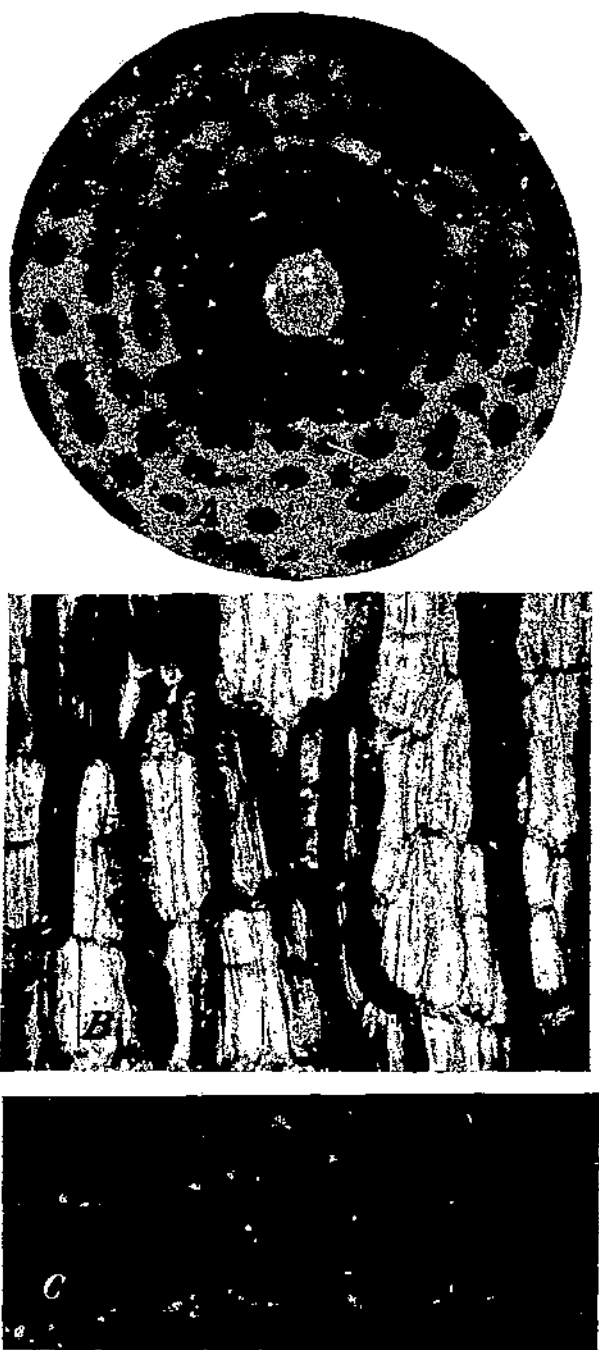


FIGURE 10.—*A*, Unstained section of mature root, showing concentric rings of phloem.  $\times 25$ . *B*, Longitudinal section through phloem, showing distribution of latex tubes.  $\times 246$ . *C*, Cross section through portion of central rings, showing number and distribution of latex tubes.  $\times 121$ .

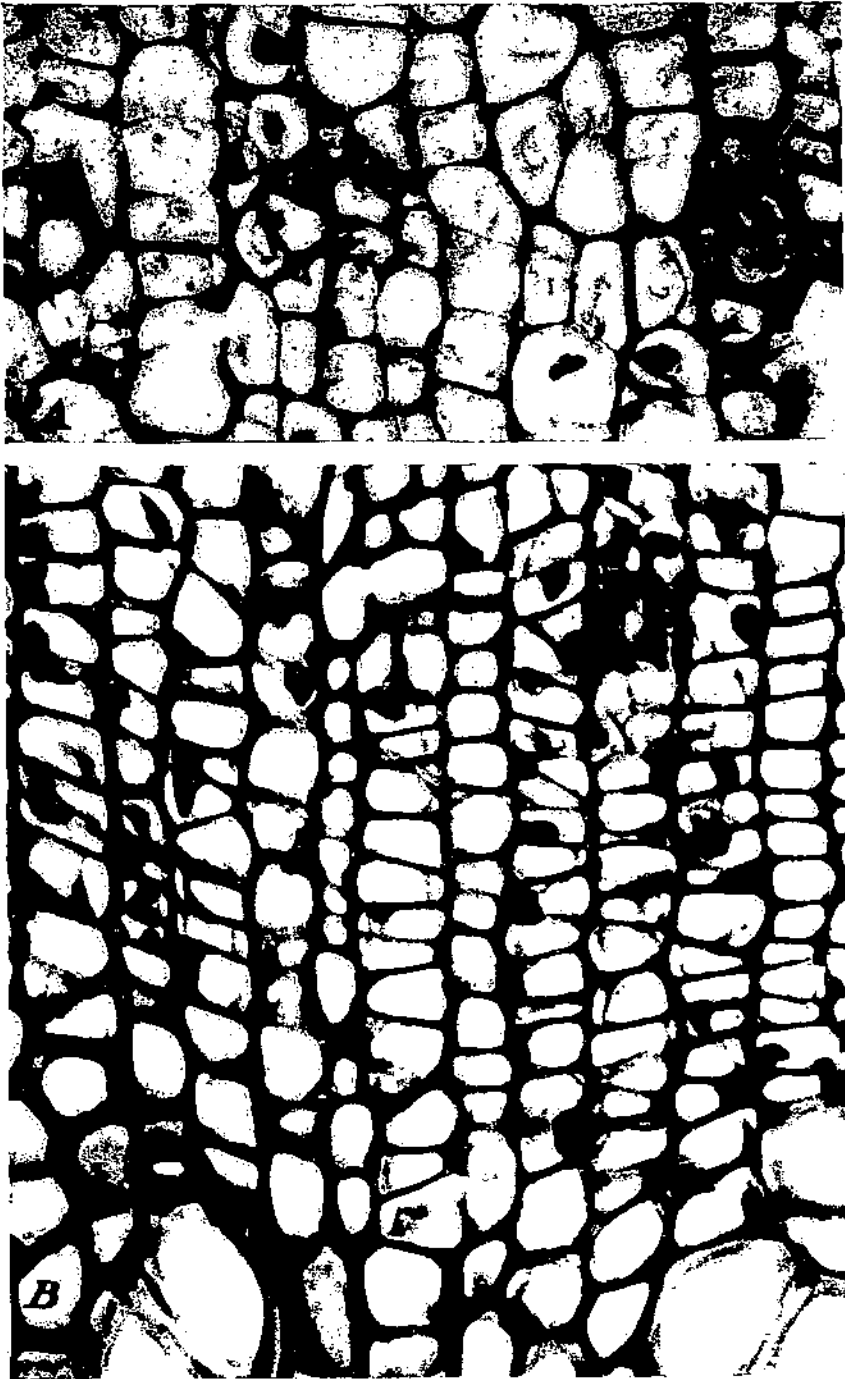


FIGURE 11.—A, Phloem bundles in region near cambium. The large, thick-walled cell to the right is a sieve tube.  $\times 1,350$ . B, Cambium zone of actively growing taproot with a few xylem cells central of the cambium.  $\times 855$ .

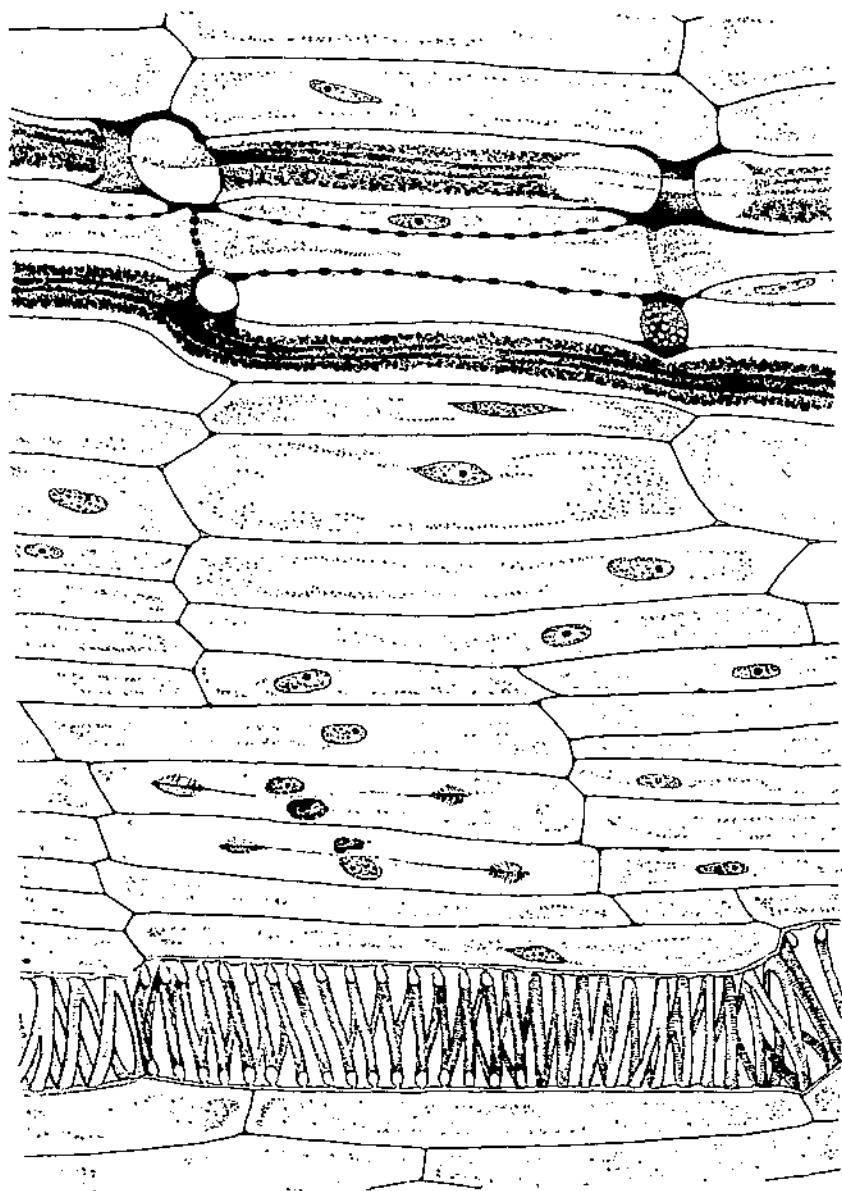


FIGURE 12.—Radial section through central part of pith of taproot. The xylem is composed of typical scalariform elements with horizontal porous end walls. Cell division in the cambium zone is very active, with several of the cells containing phragmoplasts and developing cell plates.  $\times 440$ .

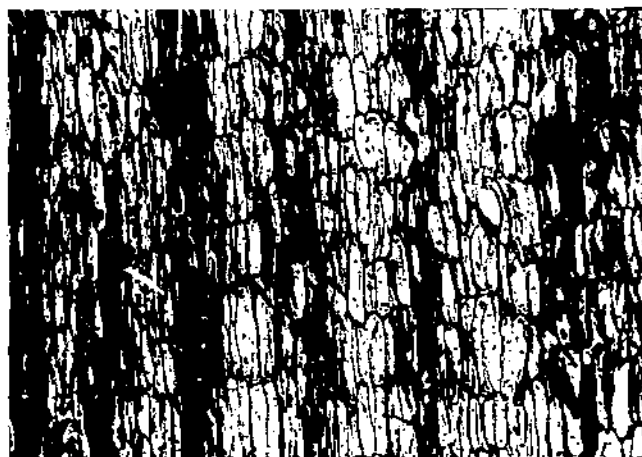
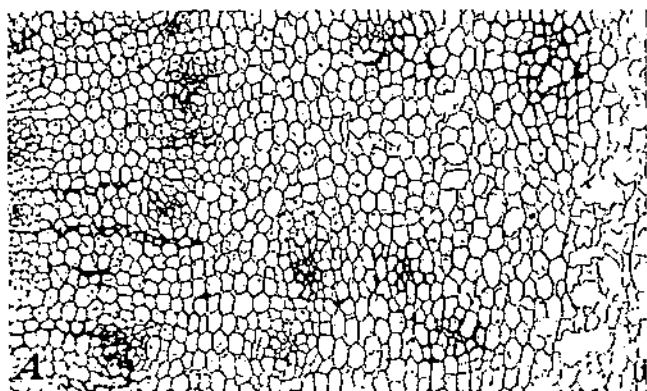


FIGURE 13. A. Cross section through middle zone of large root, showing size and distribution of phloem groups.  $\times 101$ . B. Longitudinal section of young actively growing root, showing tiered arrangement of elements of secondary cortex. At the left is seen a xylem vessel with scleriform wall thickenings.  $\times 101$ . C. Longitudinal section through phloem of old root.  $\times 101$ .



FIGURE 11.— *A*, Phloem group from outer region of root: sieve plates in face view.  $\times 1,103$ . *B*, Phloem group from central region.  $\times 1,030$ . *C*, Phloem groups from cambial region.  $\times 655$ .

The number of companion cells associated with a sieve tube is usually limited to one (fig. 1). These cells are much narrower than the sieve tubes of similar length, and they join the latter usually with bluntly pointed ends just below the sieve plate.

In addition to sieve tubes and companion cells, parenchyma is found also in the phloem groups. These cells are not always distinguishable from the sieve tubes in cross section, as they often have the same size and similar delicate walls. In longitudinal section they are recognized by the presence of nuclei.

From the latex cells continuous nonseptate passages are formed by the resorption of the end walls. There are frequent cross anastomoses (fig. 10, B) between adjacent latex tubes, and it is through these lateral branches that the vessels of the same cylinder are connected with one another. There are no connections between latex tubes of different cylinders.

The number of phloem groups in the peripheral cylinders is smaller than in the central ones (fig. 10, A). This is due to a passive separation of the groups as the periphery lengthens, growth in thickness increases, and the cambium forms new cylinders. Cross sections of mature roots often show, especially in the peripheral cylinders, latex tubes running longitudinally, indicating that even in widely spaced groups interconnections of latex tubes are maintained within a cylinder.

Since there is a certain ratio between latex vessels and other phloem constituents within a group, the number of latex tubes per unit area of root cross section decreases toward the periphery. Rudenskaya (8), who made a special

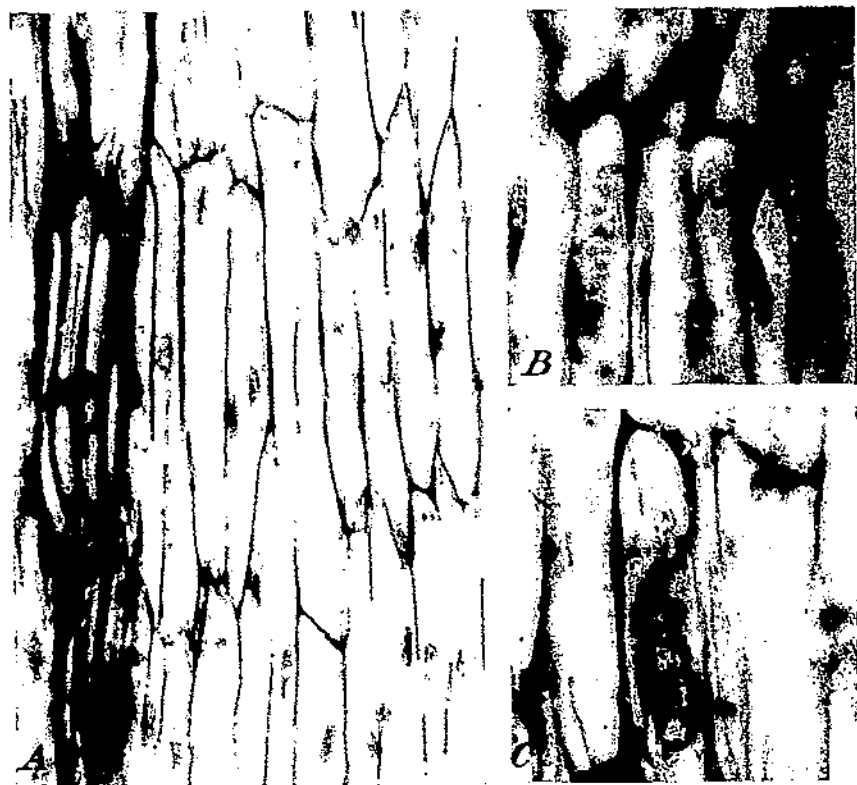


FIGURE 15.—A. Tangential section through cambium region of large root; young phloem group at left.  $\times 661$ . B. Longitudinal section of phloem, showing sieve plates in section and pitting of lateral walls in face view.  $\times 661$ . C. Longitudinal section of phloem, showing a group of five sieve plates in face view.  $\times 661$ .

study of the size and distribution of latex vessels within different cylinders, found in one instance 88 latex tubes in the peripheral cylinder and 268 tubes in the much shorter seventh cylinder inward. This great increase she ascribes, in part, to an intensified differentiation of latex tubes in the cylinders formed during the height of the growing season.

There is a good deal of variation in the size of the latex tubes within a phloem group and between groups of the same and different cylinders. The greater part of the large latex tubes, with an average bore of  $20\mu$ , is found in the broad middle zone of a root cross section. The tubes of the peripheral cylinders have a somewhat smaller bore, and those in the youngest rings, near the cambium, are not yet fully matured.

Although the sieve tubes attain adult size soon after differentiation from the cambium, the latex vessels continue to enlarge; but their expansion also tapers off soon, so that their size for the larger part of the cross sectional area remains constant.

As cell differentiation is rapid and continuous in kok-saghyz plants that are grown as annuals, the elements of the secondary phloem remain structurally unchanged even in the peripheral zone below the periderm. To be sure, the phloem groups in this region are constantly accommodating themselves by stretching to the ever-enlarging radius of the root, and in this process they have their meshes flattened out often to such an extent as to appear to be running longitudinally when a cross section is examined. It is to be expected that some of the mature phloem elements should become distorted and flattened in this process, but even here the terminal sieve plates of the sieve tubes remain for the most part structurally unchanged (fig. 14, A).

The larger lateral roots often approach the taproot in size (2) and correspond to it in structure. As in the taproot, the secondary phloem is made up of a number of concentric cylinders, whereas the surface is covered by a protective periderm.

## ANATOMY OF FILIFORM LATERAL ROOTLETS

The filiform laterals comprising the bulk of the root system lack a periderm and have little secondary growth. The sole of these rootlets is usually diarch; though among the larger ones, triarch plates are occasionally found. In the larger and older rootlets, a considerable number of metaxylem elements may be added to the xylem plate, giving the central part the appearance of a solid core. In these roots there is generally also some cambium activity, with most of the elements differentiating as secondary xylem. Radial disorganization among primary cortical cells with resulting air chambers is of common, though not general, occurrence.

## STRUCTURE OF THE LEAF

The leaves of kok-saghyz are in a rosette, decumbent or ascending, and very variable in size and shape. As the plant develops, new leaves are progressively differentiated—as many as 32 during 4 months of growth. Savchenko (7) attempted to correlate the number of leaves in a rosette with the number of phloem cylinders in the taproot, claiming that a new ring of phloem is formed by the cambium with each newly differentiated leaf. Though such a correlation may exist, it can be only relative, as the number of leaves always greatly exceeds the number of phloem rings.

Differences in the gross morphology of the leaf have already been pointed out. The leaf is relatively fleshy (up to 0.37 mm. thick), and the midrib and larger veins tend to blend with the lamina. The leaf surface is practically glabrous, though upon close inspection a few slender multicellular hairs are observed, especially along the margin of the veins. The epidermal cells are of medium size and in surface view very sinuous; the cuticle is striate (fig. 16, A, C). In surface view, the striae appear to form minute contour lines radiating especially from the guard cells (fig. 16, A). The stomates are of the common type, but with the guard cells thickened locally to form projecting ridges (fig. 16, B, C). They are very numerous, more so on the lower surface. In the small leaves of fall-sown outdoor plants as many as 200 were counted to the square millimeter, while in the larger fleshy leaves of greenhouse plants only about half as many were observed. There are two or three rows of rather short palisade cells and several rows of spongy parenchyma. The vascular bundles are collateral. In

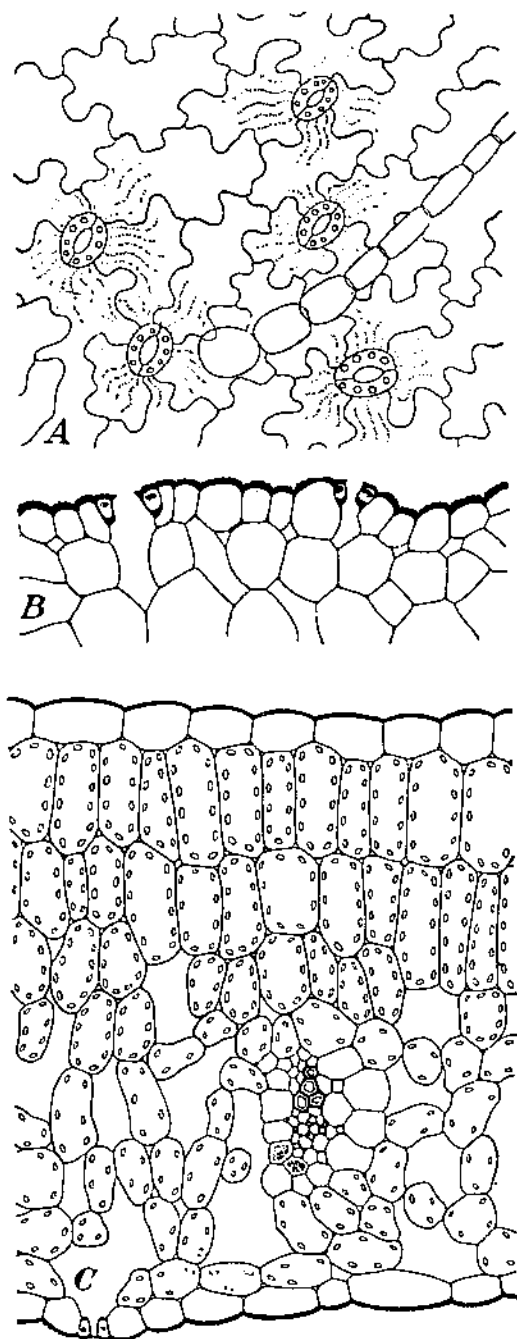


FIGURE 16.—A, Lower leaf surface, showing stomates, multicellular hair, and striation of cuticle.  $\times 258$ . B, Epidermis and outer cortex over midrib region; note striation of cuticle.  $\times 328$ . C, Cross section through lamina of leaf.  $\times 215$ .



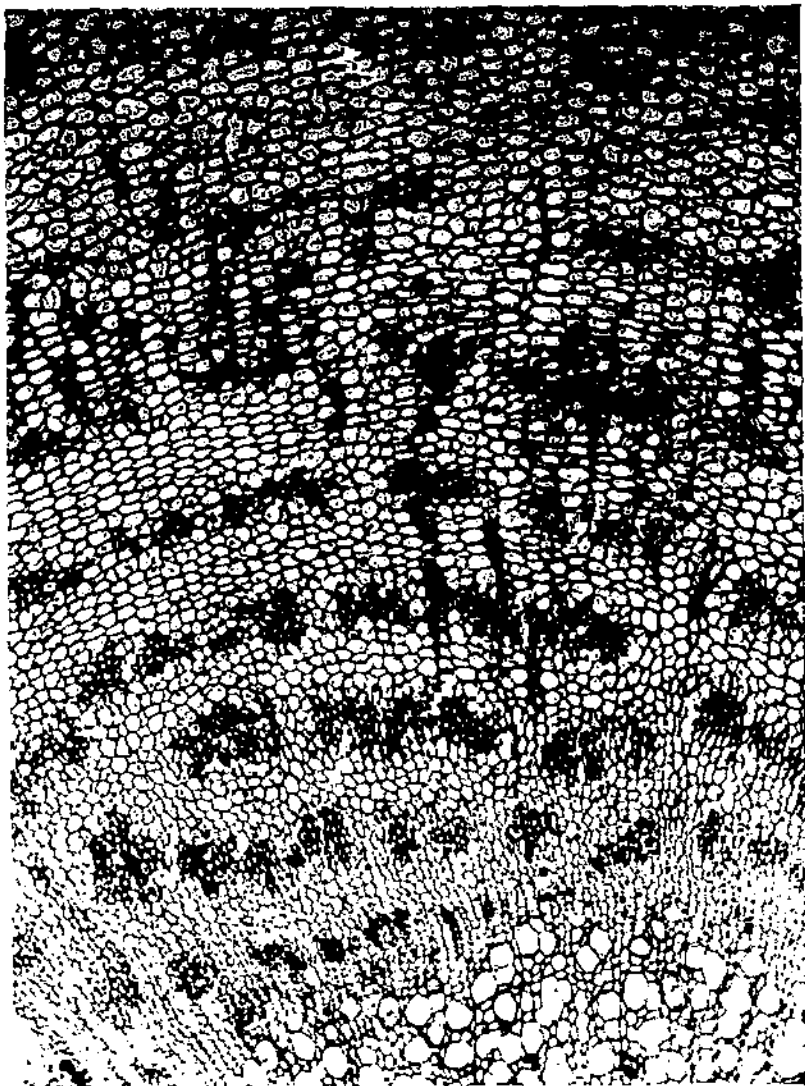


FIGURE 17. Cross section through root of local dandelion.  $\times 120$ .

the main bundles there is a prominent pericyclic cap around the abaxial pith, with latex cells occurring in the peripheral layer of the cap. There is some cambium activity in the larger bundles of midrib and lamina. Very prominent latex vessels accompany the pith of even the smallest bundles (fig. 16, C), except the ultimate veinlets, which consist of single solitary tracheids.

#### STRUCTURE OF THE SCAPE

A cross section of the scape shows a circle of vascular bundles separated from the epidermis by a cortex eight cells wide, the outer cells collenchymatously thickened. Small and large bundles alternate. The large bundles have prominent pericyclic caps, with latex cells in the peripheral layer of the pericyclic and the central surface of the pith. A prominent localized endodermis, contain-

ing large compound starch grains, caps each bundle. Limited cambium activity results in reciprocal differentiation of secondary xylem and phloem. The cells of the epidermis are greatly elongated axially; the stomates are of the type found in the leaf.

### COMPARISON WITH LOCAL DANDELION

Structurally, the low-yielding local dandelion (*Taraxacum officinale*) (fig. 17) differs from kok-saghyz primarily in possessing latex tubes of smaller bore. The larger xylem core found in the taproot of the dandelion has even a slight structural advantage, in that it gradually increases the circumference of the cambium and makes possible the initial differentiation of a progressively larger number of phloem groups, thus preventing an excessive dispersion of the phloem groups in all but the most peripheral rings.

The filiform rootlets of the non-rubber-bearing dandelion (fig. 18), which grows as a weed in the Mesilla Valley, often have their cortical cells enlarged and filled with mycorrhizal fungi. Similar infestations have been observed in roots of kok-saghyz.

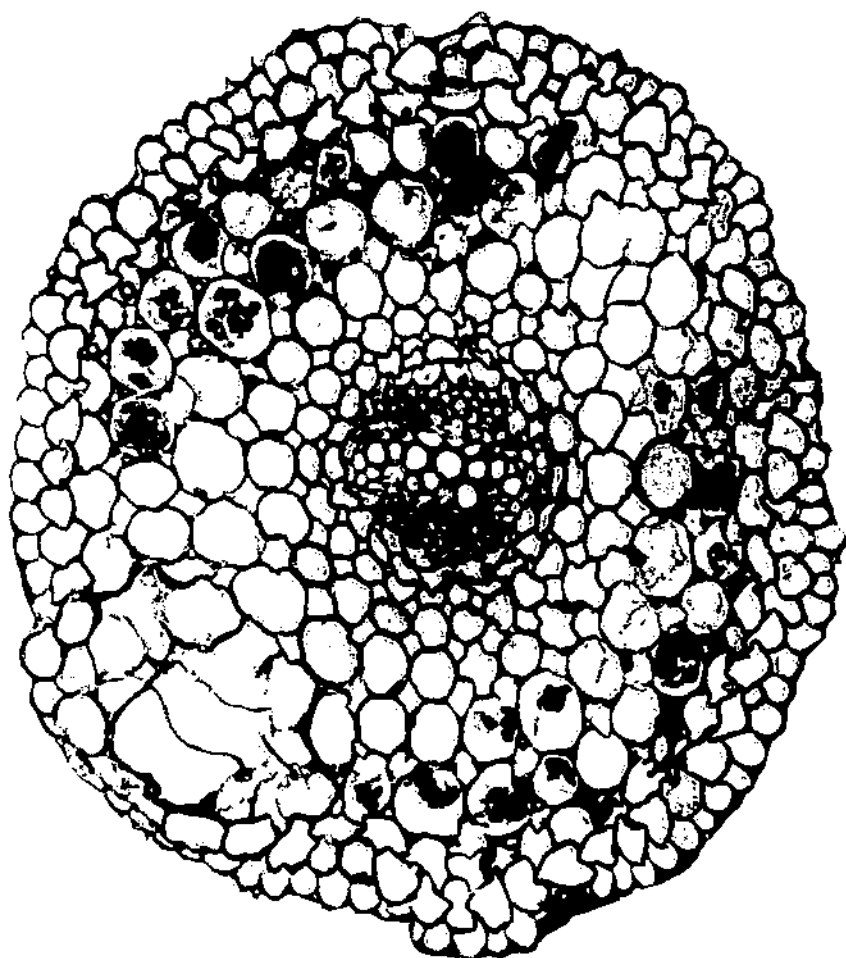


FIGURE 18.—Cross section of filiform lateral of dandelion, showing chytrids in cells of cortex.  $\times 410$ .

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