FURTHER OBSERVATIONS ON *PENTOXYLON SAHNII* SRIVASTAVA FROM THE JURASSIC OF AMARJOLA IN THE RAJMAHAL HILLS, INDIA*

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ABSTRACT

Anatomy of thick as well as thin stems of *Pentoxylon sahnii* is described. In the former vascular bundles are concentric while in the latter they are sharply endocentric. Leaf traces originate from the centrifugal xylem of the main bundles and a number of them supply a leaf base. In the light of recent discoveries, relationship of *Pentoxylon* with allied fossil woods is also discussed.

INTRODUCTION

THE genus *Pentoxylon* was established by Srivastava in the year 1935 for the stems possessing 5-6, mesarch bundles and each having a well developed endocentric secondary xylem. Besides giving a detailed description of the anatomy of *Pentoxylon sahnii*, Sahni (1948) also suggested a correlation of this stem with the leaves of *Nipaniophyllum raoi* Sahni. Shukla (1957) instituted a new species of *Pentoxylon, P. tetraxyloides* possessing only four bundles in the stem stele. Mittre (1957) further enhanced our knowledge about the internal structure of *Pentoxylon sahnii*. He observed variations in the number of bundles from 3-9, even in the same stem and did not agree with the establishment of the new species *Pentoxylon tetraxyloids* Shukla.

In the year 1969 the present author studied the anatomy of the material of *Pentoxylon sahnii* collected from the fossiliferous locality of Amarjola and described the mode of formation of the smaller bundles found in the inner portion of cortex, alternating with the bigger bundles of stele (Sharma, 1969a). The present paper is also based on the study of a number of petrified pieces of the stems of *Pentoxylon sahnii* collected from the same locality. Besides giving further observations on the anatomical structures, origin and path of the leaf traces are also described. Relationships with *Guptioxylon* and other allied fossil woods have also been discussed.

DESCRIPTION

Stems are of different sizes ranging in diameter from 0·5-4·5 cm, but all are preserved in a similar manner. Both thick as well as, thin stems of *Pentoxylon sahnii* have been studied and found that these two types are different in their anatomical structures. However, the divisions thick and thin types of stems are purely arbitrary and no sharp line can be drawn for their separation.

Thick stems — Stems ranging in diametes from 1·8 to 4·5 cm. are included under thir category. In such stems, generally the outer surface is smooth and there are either no or only a few markings of leaf bases are present. Transverse section of a thick type of stem shows 6-7 layered periderm in the outer portion of cortex. It is made up of thick walled, squarish cells arranged in rows. Cortex is parenchymatous, 2·0-3·5 mm. wide and possesses a large number of bundles of different sizes (Plate figs. 1 & 2, Text-figs. 1 & 2) ranging from 300×100 μ to 800×600 μ. Bundles present in the inner portion of cortex (Plate fig. 3) are comparatively bigger than those of the outer side. Inner bundles are endarch and provided with well developed secondary xylem, while those of the outer side are represented by only a few tracheids and there is almost no differentiation present between the protoxylem and metaxylem elements.

The cortical bundles originate from the main bundles of the stem stele as a result of detachment of the sides of centrifugal xylem (Text-fig. 1), like *Guptioxylon endocentrica* Sharma (1972). Sometimes, the cortical bundles divide radially into two (Plate fig. 4). In the cortical bundles, phloem is represented by poorly preserved, thin walled squarish cells.

In the cortex there are also present a large number of sclerotic nests of different

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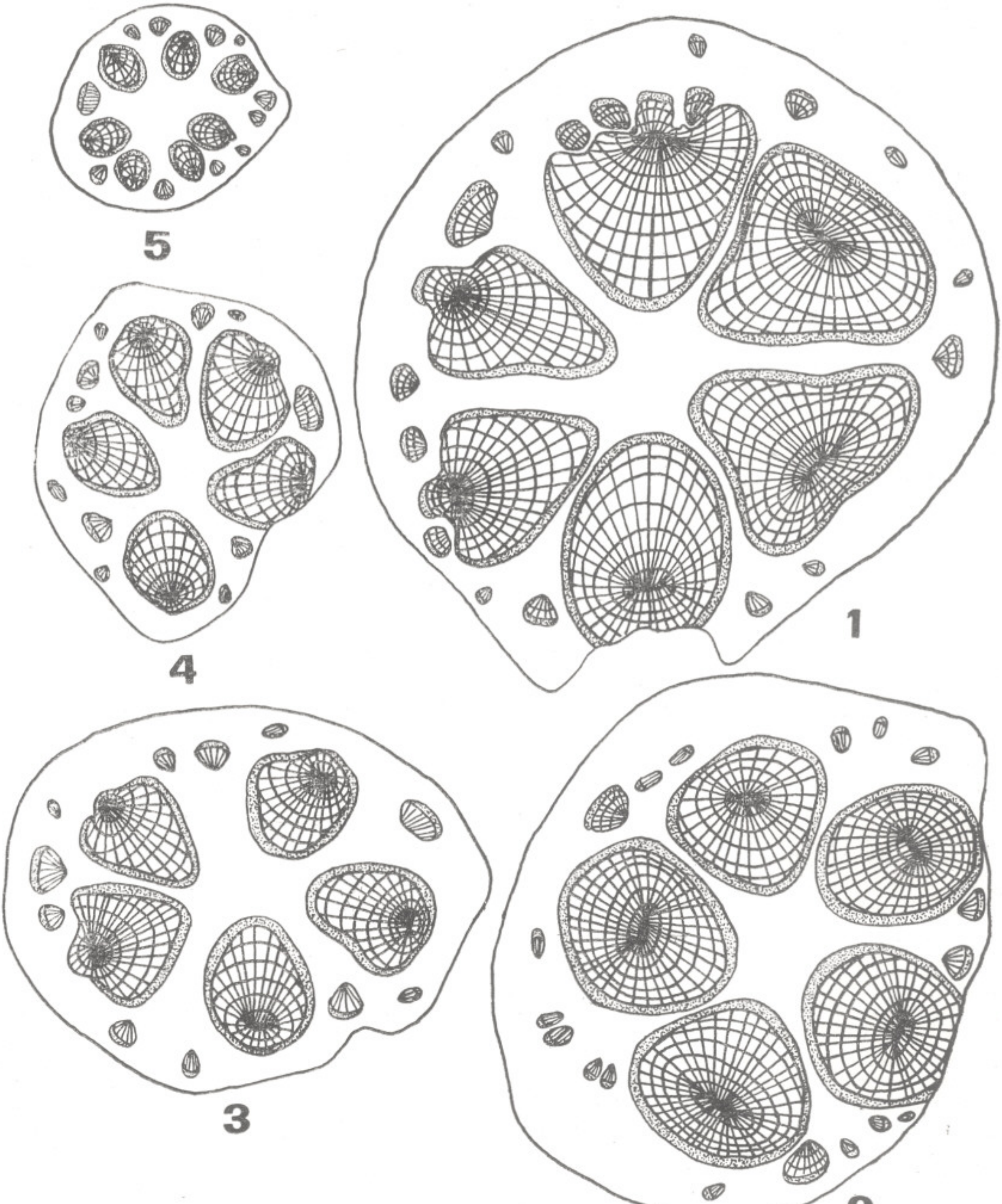


TEXT-FIGS. 1-5 — *Pentoxylon sahnii.* T.S. stems. 1. Origin of cortical bundles from the sides of centrifugal xylem of the main bundles. 2. Concentric nature of bundles in the stele of thick stems. 3. & 4. Endocentric bundles forming the main steles of thin stems. 5. Sharply endocentric bundles of the main stele and a number of endarch cortical bundles in a thin stem. × 8. (Camera lucida sketches).

sizes. They are of two main types. One is found in association and adjacent with the phloem of the cortical bundles (Plate fig. 2), while others are seen irregularly scattered in the cortex (Plate fig. 1). The former is made up of circular cells having a diameter of 20-30 μ, while the latter are squarish and varying in size from 50×60 μ to 70×80 μ.

There are 5-6, unequal bundles in the stem stele (Text-figs. 1 & 2). Primary xylem is seen in the form of only a crushed structure. Secondary xylem is either equally developed both on the centrifugal as well as centripetal sides (Text-fig. 2) or it is more on the latter side (Text-fig. 1), forming an endocentric bundle. Shape of a bundle depends upon the formatio of conrtical bundles, which originate from the centrgifual part of the main bundle. In thick stems, leaf bases occur distantly and so the cortical bundles are not produced frequently. Thus the centrifugal xylem is generally well preserved in such stems, giving a concentric appearance to the bundle. Cortical bundles are cut off from either sides of the centrifugal xylem that is why there are generally two cortical bundles alternating with the bundles of the stele (Text-fig. 2).

Secondary xylem is compact like the conifers and without xylem parenchyma (Plate fig. 8). Wood rays are uniseriate and 1-8 cells in height. Tracheids are provided with annular and spiral thickenings in the region of protoxylem, while the metaxylem tracheids are provided with uni or biseriate, contiguous bordered pits on their radial walls. There are 1-2, large and simple pits in a cross field (Sharma, 1969a).

Phloem is preserved as a dark brown tissue outside the secondary xylem (Plate fig. 5). It consists of squarish or rectangular thin walled cells arranged in rows. Phloem is present surrounding the entire secondary xylem. It is comparatively less developed on the centrifugal side than the inner side of the bundle.

Thin stems — Under this category there are included the stems ranging in diameter from 0·5-1·6 cm. Outer surface is provided with a number of transversely elongated leaf bases. Cortex is 0·8-1·6 mm. wide and is provided with a large number of cortical bundles (Text-figs. 3, 4 & 5). Cortical bundles are of different shapes and sizes (Text-figs. 6 & 7) ranging from 120 ×80 μ to 200×250 μ. Larger bundles are endarch while in the smaller bundles the protoxylem elements are not differentiated. Like the thick stems, the cortical bundles originate from the centrifugal part of the main bundles. The latter are sharply endocentric (Plate figs. 6 & 7) having well developed centripetal xylem. Centrifugal xylem is either completely absent (Text-fig. 7) or it is represented by only a few rows of tracheids (Text-fig. 6). In the former case the outer boundary of the centripetal xylem is limited by 2-3 rows of thin walled, rectangular, cambium like cells. While in the latter case, a dark line of crushed cells separates the centripetal xylem from the centrifugal xylem.

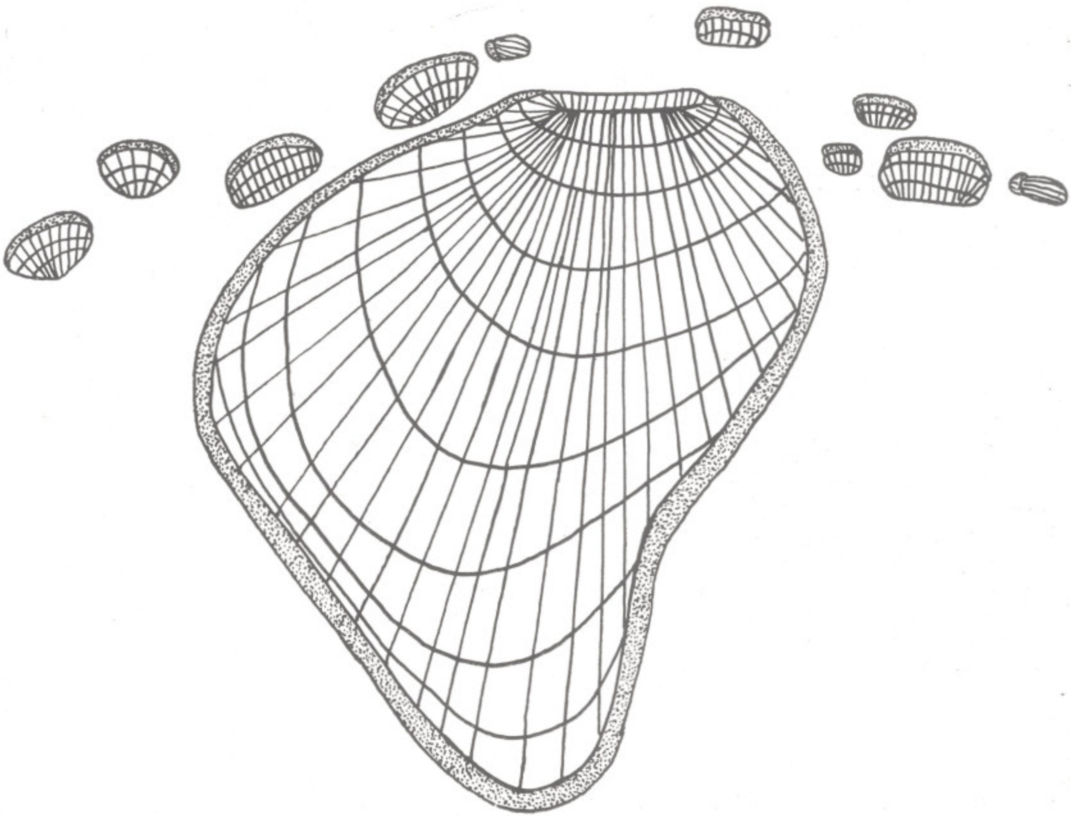
Cortical bundles are cut off on either sides of centrifugal xylem. Sometimes, the central portion of centrifugal xylem is also detached from the main bundle (Plate fig. 7) leaving only the centripetal xylem (Text-fig. 7). In thin types of stems, formation of cortical bundles is quite frequent (Text-fig. 6) and so the centrifugal xylem is poorly represented.

Sclerotic nests are present in the cortex. Their concentration is more in the outer portion of the cortex and all are made up of similar type of cells, unlike those of the thick stems. The sclerotic nests are found in association with the cortical bundles, but not necessarily with all.

Phloem is preserved as a dark brown layer surrounding the centripetal xylem (Plate fig. 7). It is also present outside the centrifugal xylem but forming a comparatively narrower layer and generally ill preserved.

Medullary rays are parenchymatous and 200 to 450 μ wide. Pith is also made up of thin walled cells and is provided with a number of sclerotic nests like the cortex (Plate fig. 9). It is angular and 300 to 500 μ wide.

From the account given above it is clear that in the stem of *Pentoxylon*, there are 5-6, independent bundles forming the main stele of the stem. Each bundle has its own secondary growth without disturbing the others. Both centripetal as well as centrifugal xylems are present in a bundle, the former is more than the latter. Cortical bundles are produced from the sides of the centrifugal xylem. They are collateral and endarch in the beginning. These bundles travel upward and obliquely outward through the cortex for several internodes before they pass out to the leaf base.



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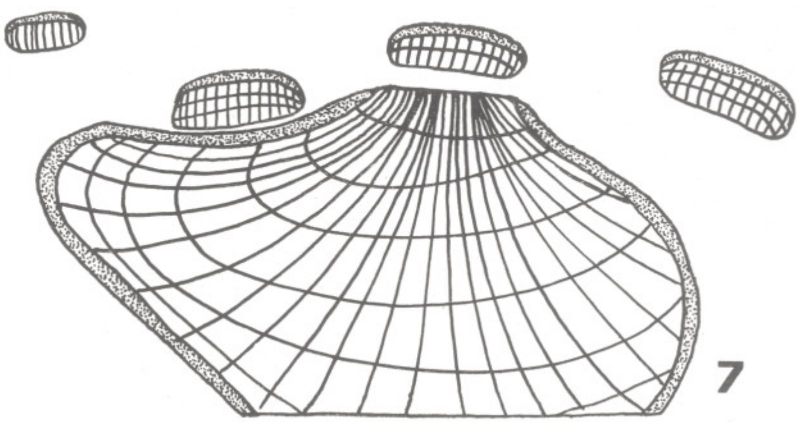

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TEXT-FIGS. 6-7 — *Pentoxylon sahnii.* T.S. stems. 6. An endocentric bundle of the stele of a thin stem with poorly developed centrifugal xyglem. Cortical bundles are numerous and of different sizes. 7. Absence of centrifugal xylem in the bundle of a stem stele. × 60. (Camera lucida sketches).

During their way from the point of origin to the leaf base, the cortical bundles reduce in size and loss their secondary xylem, so much so, that in the outer portion of cortex, these bundles are provided with only a few tracheids. A number of cortical bundles supply a leaf base.

RELATIONSHIP

Pentoxylon was described to be closely related with the medullosan plants on the one hand and with the conifers on the other hand (Sahni 1948, Delevoryas 1955, Stewart & Delevoryas 1956, Mittre 1957, Sharma 1969a). Archangelsky and Brett (1961) correlated it with the Triassic stem genus *Rhexoxylon* Bancroft. Some of the recently described stems like *Guptioxylon amarjolense* Sharma (1969) and *Guptioxylon endocentrica* (1972) from the Jurassic of Amarjola in the Rajmahal Hills have further advanced the frontiers of our knowledge in finding out the relationship of *Pentoxylon*. *Guptioxylon* is provided with 4-6 bundles in the main stele, each having a well developed and compact secondary xylem like the one found in *Pentoxylon*. The nature of ground tissue is also like the latter. But in *Guptioxylon* the pith is provided with a number of medullary bundles which are absent in *Pentoxylon*. Out of the two known species of *Guptioxylon*, *G. amarjolense* and *G. endocentrica*, the latter is nearer to *Pentoxylon*. In it there are six endocentric bundles each having a well developed secondary xylem on the centripetal side. The cortical bundles originate in the same way from the sides of centrifugal xylem as in *Pentoxylon*.

So a line of evolution can be drawn from the Palaeozoic stem genus *Medullosa* through *Guptioxylon* to *Pentoxylon*. During this course, loss of medullary bundles took place besides, an overgrowth on the centripetal side of the secondary xylem. This line of evolution must have diverged from the primitive type of medullosan stems, as the leaf traces are still possessing well developed secondary xylem in both *Guptioxylon* and *Pentoxylon*. Presence of secondary xylem in a leaf trace is regarded as a primitive feature (Stewart & Delevoryas, 1956).

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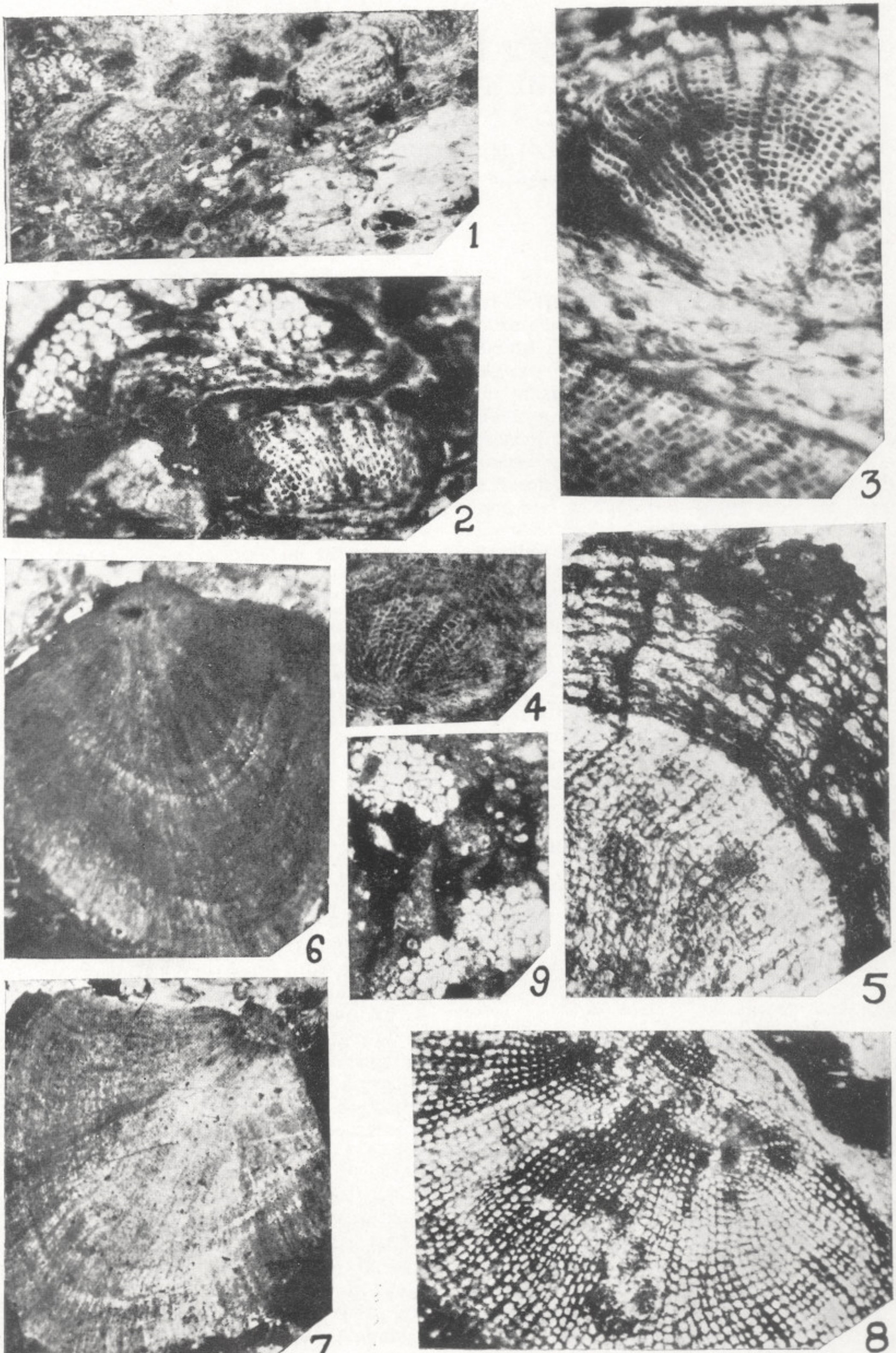
EXPLANATION OF PLATE

Pentoxylon sahnii Sristavava

1. Cortical bundles and sclerotic nests in the ortex. Sclerotic nests associated with the bundles are made up of circular cells, while in others the cells are squarish. × 80.
2. Cortical bundles and the associated sclerotic nests. × 120.
3. An endarch cortical bundle in the inner portion of the cortex. × 120.
4. A radially dividing cortical bundle. × 120.
5. A thick darkish layer of phloem outside the secondary xylem. × 120.
6. An endocentric bundle of the stem stele with poorly represented centrifugal xylem. × 48.
7. An endocentric bundle of a thin stem. Central portion of the centrifugal xylem is also seen detached from the bundle. × 48.
8. An endocentric bundle of a thick stem. Secondary xylem is compact and without xylem parenchyma. × 80.
9. Pith with a number of sclerotic nests. × 120.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