FURTHER OBSERVATIONS ON *SAHNIPUSHPAM* SHUKLA

U. PRAKASH & R. K. JAIN*
Birbal Sahni Institute of Palaeobotany, Lucknow

INTRODUCTION

IN 1948, Shukla reported from Mohgaon Kalan beds of the Deccan Intertrappean series a new petrified flower to which he later gave the generic name *Sahnipushpam* (SHUKLA, 1950). But he assigned no specific name to this flower. Then, nearly six years later, two detailed accounts of this flower were published almost simultaneously, one by Verma (1956) and the other by one of us (PRAKASH, 1955). Verma called it *Sahnipushpam shuklai* and assigned it to Sonneratiaceae while Prakash described it as *S. glandulosum* showing its near approach to Myrtaceae. Though both these accounts were fairly detailed, yet some structural details, particularly about the androecium, were not known. Also there was considerable unanimity between the earlier authors (Prakash and Verma) about morphological interpretations but there were some differences in observations particularly about the structure of the pollen grains and the type of placentation. Thus, according to Verma (loc. cit.) the pollen grains are l-sulcate and the placentation is basal while according to Prakash (loc. cit.) the pollen grains are "dicolporate, syncolpate" and the placentation is probably apical. Therefore, in view of these structural ambiguities and controversial systematic position, further work on this interesting fossil flower was considered necessary.

On breaking and cutting a rich piece of chert from Mohgaon Kalan, about 100 flowers were obtained. They were cut in various planes. While most of them conformed to the descriptions given by Verma (loc. cit.) and Prakash (loc. cit.), few specimens showed some variations particularly in the number of septa or the "locules" in the ovary. But all these specimens have been considered as belonging to the same species. Thin sections were prepared from these specimens and examined microscopically.

DESCRIPTION

The following description is based on the study of all the specimens referred to above and those previously described as *Sahnipushpam glandulosum*. Since the new observations recorded here are slightly at variance with those already given it is desirable to describe these flowers afresh in detail.

General Organization — The flower is small, measuring about 5·5 mm. in height and 2·5-2·8 mm. in diameter, sessile, ebracteate, actinomorphic, hermaphrodite, monochlamydous and hypogynous.

Perianth is monochlamydous and gamophyllous. It is a tubular structure which is closely adpressed to the ovary wall but nowhere adnate to the latter (PL. 1, FIG. 1; PL. 3, FIG. 20; TEXT-FIG. 1). A cross section of the perianth taken from any region shows a quadrangular outline (PRAKASH, 1955, FIGS. 6, 7, 9, 11, 13, 14, 15; TEXT-FIGS. 16-23). It is slightly thick at the base, thin in the middle, and very thick and fleshy at the apex (PL. 3, Fig. 20; TEXT-FIG. 1). At the apex there is no distinction of any lobes or segments (PL. 1, FIG. 2; TEXT-FIG. 1). As such it is difficult to determine the number of tepals (members of perianth) which gave rise to this structure.

The tissue of the perianth is composed of thin parenchymatous cells enclosing a large number of lysigenous spaces (PRAKASH, 1955, FIG. 3). The spaces are more numerous at the base and at the apex. The vascular supply of the perianth is usually not well preserved. However, in a few longitudinal sections of the flowers, a vascular trace is usually seen from half way up the length of the perianth. It runs straight and terminates abruptly below the apex of the perianth (TEXT-FIG. 1). In one cross section comparatively well-preserved vascular bundles have been found. They are of different sizes but their exact number and manner of distribution could not be determined. How-

*Now Assistant Professor of Botany, College of Agriculture, Punjab Agricultural University, Hissar.

ever, each bundle is more or less pear-shaped in outline with a highly sclerenchymatous sheath on the phloem pole (TEXT-FIG. 2). This sheath is completed on lateral and ventral sides by thin-walled parenchymatous cells. Two small thick-walled elements lying on one side in the xylem region represent the conducting elements of protoxylem. Nearly in the middle region of the vascular bundle there are a few thick-walled elements of small diameters on one side separated by a central space. These elements probably represent the sclerenchyma of the phloem. The rest of the bundle is occupied by a continuous space which appears to be due to non-preservation of xylem and phloem.

Androecium — Stamens have been observed in about twenty or more specimens which were all cut in oblique cross sections or in longitudinal sections. Since they have not been observed in perfect cross sections of the flowers, the exact number of stamens could not be ascertained. However, in one oblique cross section of the flower, two anthers are seen, one at each adjacent angle of the perianth (PL. 1, FIG. 6; TEXT-FIG. 3). In two other similar specimens, although only one anther is seen in each flower, it is always found at one of the angles of the quadrangular perianth (PL. 1, FIG. 5; TEXT-FIG. 4). Thus it appears that there is one stamen at each angle of the perianth.

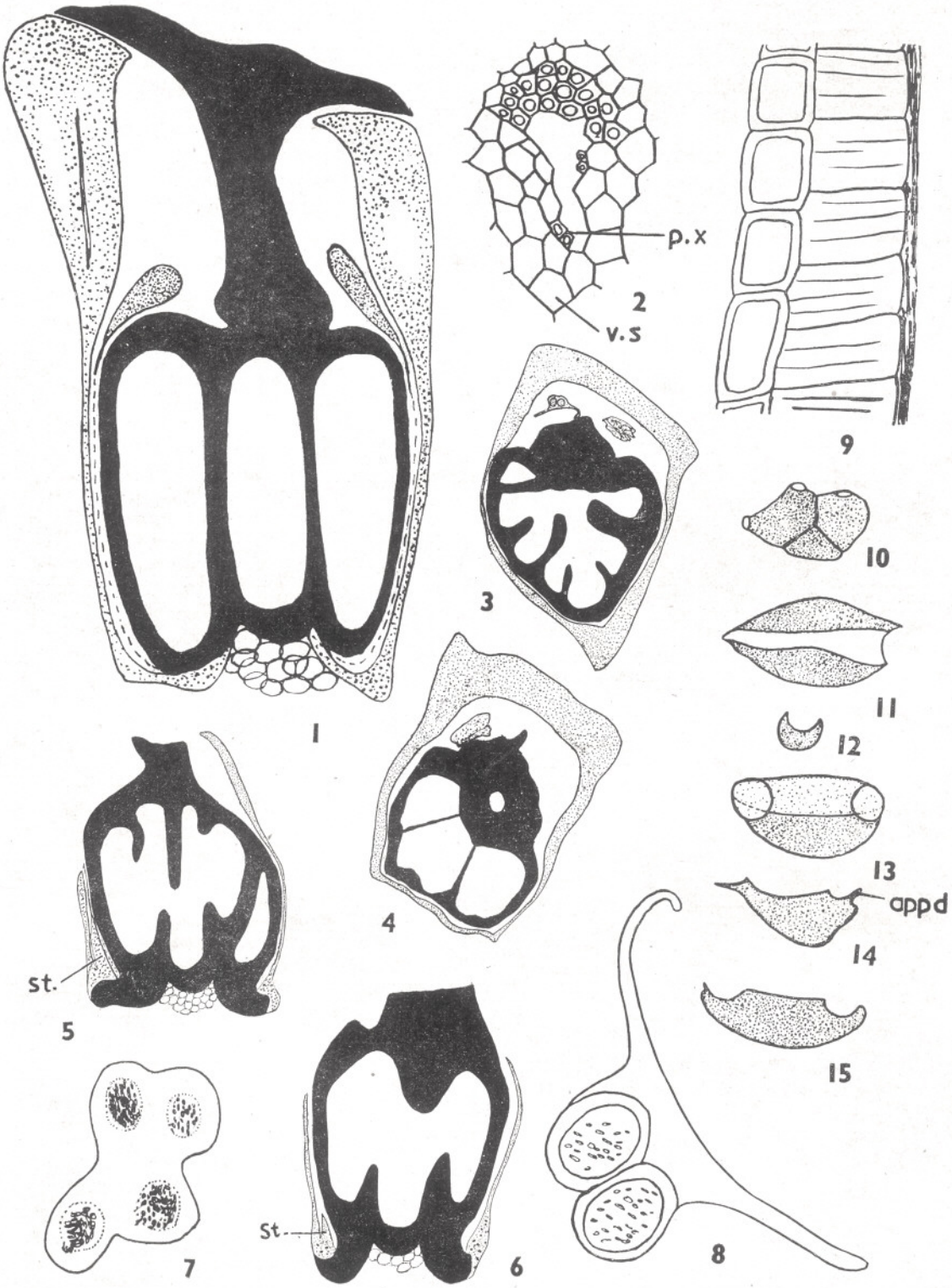
The stamens are hypogynous (PL. 1, FIG. 7; TEXT-FIG. 5). However, in one specimen one stamen appears to be slightly adnate to the perianth at the base. It is probably due to overlapping of the tissue of the filament and the perianth. In many specimens are present the basal portion of the filament from where the rest of the stamen has broken away (TEXT-FIG. 6). These stub-like bases of the filaments have been variously interpreted by previous workers as a "glandular trichome" (PRAKASH, 1955, p. 96) or a "dome-shaped gland with a pointed apex" (VERMA, 1956, p. 133). The upper part of the stamen i.e., a part of the filament and the anther, is also seen in many specimens (PL. 1, FIGS. 1, 2). Thus, in some specimens 1/3 or slightly more of the basal portion of the stamens, while in others, 1/3 apical portion of the stamen, including the anthers is frequently seen. The filament is usually crushed in the middle region where the perianth is closely applied to the ovary wall. The continuity of the filament can sometimes be established under high magnification by a thread-like structure representing the filament. Evidently, therefore, the earlier statements about the stamens being inserted at the mouth or throat of the calyx tube, were due to the study of insufficient material then available.

The filament is long and composed of somewhat thick-walled, vertically elongated, parencymatous cells. The anthers are reflexed towards the style (PL. 1, FIGS. 1, 2; TEXT-FIG. 1). It is a 4-lobed and 4-loculed structure with a small connective (PL. 1, FIG. 4; TEXT-FIG. 7). In one cross section of an anther two locules are seen intact and the other two open (PL. 1, FIG. 6; TEXT-FIG. 8), suggesting the mode of dehiscence by longitudinal slits. From the length of its valves it is evident that the dehiscence takes place right from the centre near the connective.

The anther wall consists of two layers of cells (PL. 1, FIG. 3; TEXT-FIG. 9). As seen in a longitudinal section, the outermost layer or the epidermis consists of small, somewhat thick-walled, vertically elongated or more or less isodiametric cells. The inner layer consists of radially elongated cells with radial fibrillar thickenings. No spherocrystals or spicules are present and no tapetal cells have been observed. The absence of tapetal cells appears to be due to their disintegration at maturity rather than due to non-preservation. The locules are full of pollen grains.

Pollen grains have been observed *in situ* inside the anthers as well as scattered in the space between the perianth and gynaecium. In one specimen of a badly preserved anther a pollen tetrad is seen (PL. 2, FIG. 8; TEXT-FIG. 10) which appears to be of the tetrahedral type measuring about 20 μ in diameter. The 'apertures' can be vaguely seen on the dorsal pole of each daughter cell. No pollen mother cells have been seen. Thus it appears that most of the flowers were fairly mature. The pollen grain is an anisopolar boat-shaped structure measuring about 15-18 μ along the polar axis and 25-27 μ in the horizontal plane or along the equatorial axis.

As regards the apertures, in some specimens a distinct colpus is seen at the dorsal pole (= sulcus) while in others it is not traceable (PL. 2, FIGS. 9-12; TEXT-FIGS. 11-15). In the majority of pollen grains, however, there is a distinct 'areolate', possibly aperturate, area with thin, more or



TEXT-FIGS. 1-15

less circular zones at either equatorial end (PL. 2, FIGS. 9, 11; TEXT-FIGS. 13-15). In these areas the exine is exceedingly thin. On the surface of these areolate zones or 'apertures' is seen a finger-like appendage arching over it (PL. 2, FIG. 12). In this appendage both the ecto-exinous (= sexinous) and endoexinous components of the exine can be seen. Each of this areolate zone measures about 4 μ in diameter, half sunke n in the pollen grain and half bulging above the surface of the pollen grain. The distal colpus measures about 7 μ in width and is nearly as long as the equatorial axis of the pollen grain.

The exine of the non-aperturate region measures about 1 μ in thickness with ecto-exine nearly as thick as the endo-exine. It is scabrate with foveolation at subsurface focal plane. There is a slight suggestion of the presence of microstriations.

Gynaecium — It is a 4-6 carpelled syncarpous gynaecium, measuring about 4·8-5·2 mm. in height and 2-2·5 mm. in diameter at the widest part (at the apex of the ovary).

The ovary is superior (PL. 1, FIG. 7; TEXT-FIG. 1) and sometimes deeply furrowed (PL. 2, FIG. 13) opposite the septa. It is unilocular for the most part, 9-12 loculed at the basie and apex, in which 11-loculed condition ,s very common (PRAKASH, 1955, FIGS. 6, 9 11, 14, 15; PL. 2, FIGS. 14-17; TEXT-FIGS. 16-27 & 33). In the 11-loculed ovary there are five stout septa protruding radially from the ovary wall reaching almost to the centre but not meeting in the middle region (PRAKASH, 1955, FIG. 11; TEXT-FIG. 19) of the ovary. Usually alternating with these stout septa are six smaller septa which are radially only half as long as the stout septa; there being two such smaller septa in between any one pair of stout septa. In a number of other specimens the ovary is 10-loculed at the base and apex with five stout septa and five smaller septa and unilocular in the middle region where the septa do not meet (PRAKASH, 1955, FIGS. 6, 9, 15). However, in six specimens the ovary is found to be only 9-loculed at the base and apex with four stout septa and five smaller septa, the arrangement of the septa being the same as in the 11-loculed ovary (PL. 2, FIGS. 14-17; TEXT-FIGS. 24-27). In one specimen discovered recently (TEXT-FIG. 33) the ovary is 12-loculed at the base and apex with six stout septa and six smaller septa and unilocular in the middle region where the septa do not meet.

The central axis is seen at the base and apex where the septa meet (PRAKASH, 1955, FIGS. 9, 14, 15; TEXT-FIGS. 17 and 21-23). No real ovules or seeds have been found. As such it is risky to speculate about the type of placentation. However, in one specimen something like a solitary ovule or a seed per 'locule' was seen in surface view but when it was ground into a thin section no cells could be recognized. In these circumstances it is difficult to suggest the number of ovules which have been considered as arranged in two series in each locule (SHUKLA, 1950) and one ovule per sub-locule by the other earlier workers.

The ovary wall is very thick, highly lignified and externally studded with a large number of minute, spherical, sessile glands all over (PL. 2, FIGS. 18, 19; TEXT-FIG. 28). There is a thick cuticle outside the epidermis. The epidermis is made up of small, more or less isodiametric cells, the continuity of which is usually broken by the presence of glands. The glands are about 35-60 μ in

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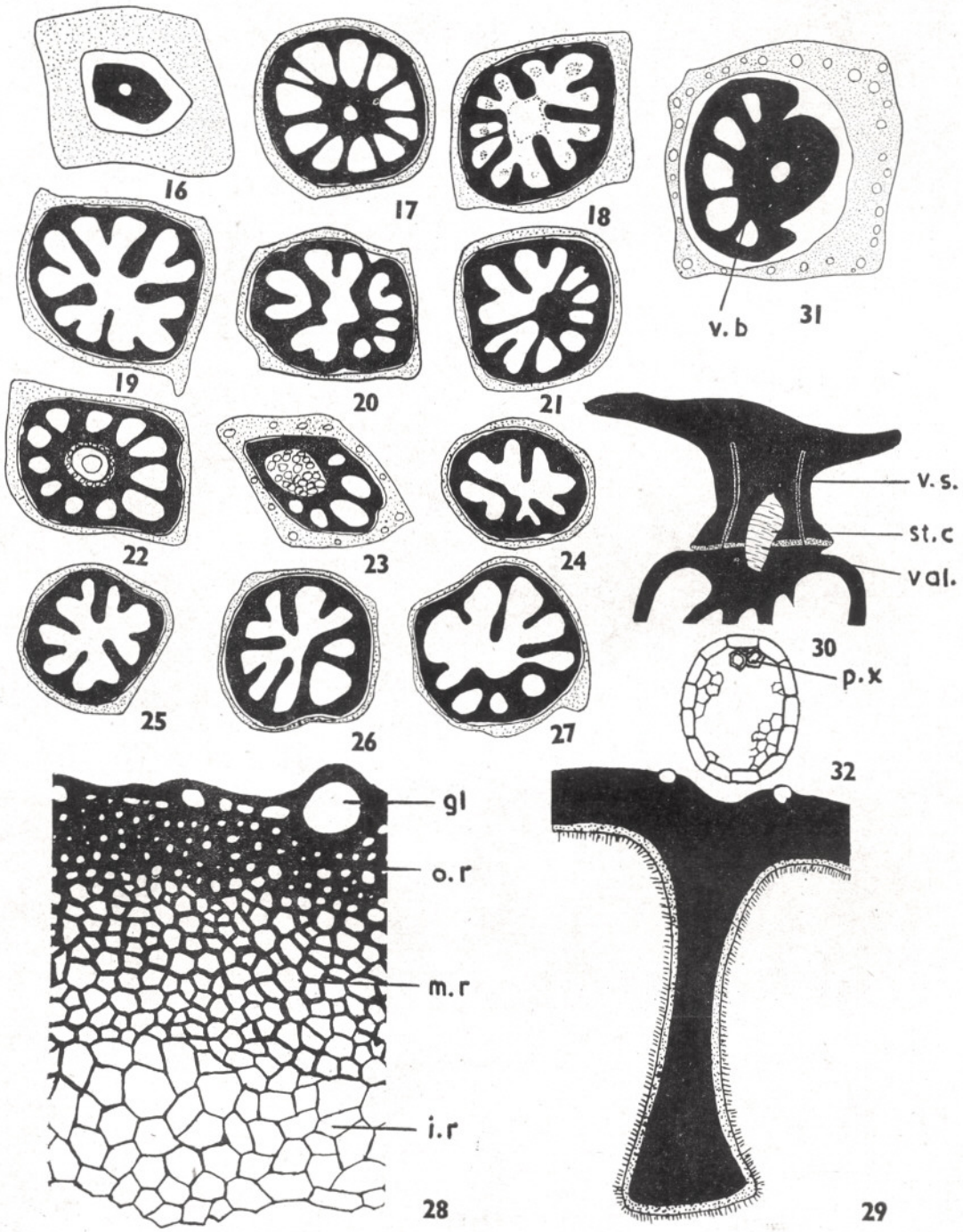
TEXT-FIGS. 1-15 — *Sahnipushpam shuklai*. 1, A semi-diagrammatic longitudinal section of a flower. ×20. 2, cross-section of a vascular bundle from the perianth. d.s. — dorsal sclerenchyma, p.x.— protoxylem elements, v.s.— ventral sheath of parenchyma. × 500. 3, an oblique cross-section of a flower showing anthers of two stamens, one half dehisced and the other crushed and deformed. × 10. 4, an oblique cross-section of a flower showing one deformed anther at one of the angles of the perianth. × 10. 5, L.S. of a flower showing the basal 1/3 part of a stamen. (st.) × 15. 6, L.S. of a flower showing the basal stub of a stamen. (st.) × 15. 7, cross-section of an anther with pollen grains. × 100. 8, cross-section of a half dehisced anther. × 100. 9, L.S. of anther wall. × 1000. 10, a pollen tetrad. × 1000. 11, dorsal view of a 1-colpate pollen grain. × 1000. 12, equatorial view of a pollen as seen from one of the equatorial ends. × 1000. 13, lateral view of a pollen grain (dorsal pole partly seen). × 1000. 14, equatorial view of a vertical section of a pollen grain showing the structure of the finger-like appendage (appd.) × 1000. 15, equatorial view of a vertical section of a pollen grain with two "pores" one at each equatorial end. × 1000.



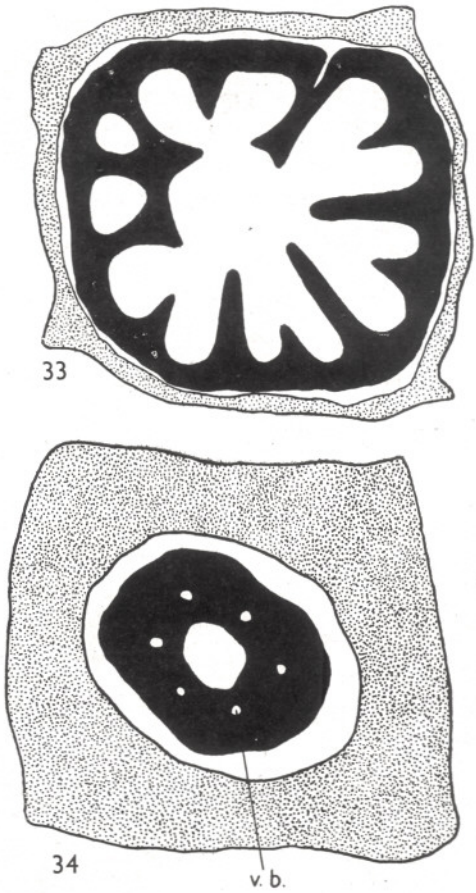
TEXT-FIGS. 16-32

diameter, nearly half sunken in the ovary wall and half bulging above like a ?pustule under the cuticle. Below the epidermis there are a few layers of very thick-walled cells which are polygonal in cross section. These layers of highly thick-walled cells are longitudinally continuous even under the glands, thus presenting a wavy region of thick-walled cells below the epidermis. Below this are many layers of comparatively less thickened cells, with polygonal outline in cross section and vertically elongated as seen in longitudinal sections of the ovary wall. The inner region of the ovary wall is made up of few layers of parenchymatous cells. The inner epidermis lining the locules is provided with many small hairy projections.

Each septum, is, likewise, made up of thick-walled cells with a few layers of thin-walled cells lining it (TEXT-FIG. 29). The thick-walled cells are polygonal in cross section with a large lumen. Also from the septum small hairy projections hang into the locules.

The vascular supply of the ovary and its septa could not be recognized.

The style is one, short and stout (PL. 3, FIG. 21; TEXT-FIG. 30), measuring about 0·96-1·5 mm. in length and 1·2-1·4 mm. in diameter, sometimes with one or more arm-like appendages. It is more or less circular to roundly angular in cross-section. In the centre there is a stylar canal measuring about 0·25-0·28 mm. in diameter (PL. 3, FIGS. 21, 23; TEXT-FIG. 30). It has many horizontal valves. These valves or the partitions are composed of only a few layers of elongated thin-walled cells. In none of the specimens that have been studied so far, the continuity of this canal could be traced into the stigma. The basal region of the style from where it breaks off from the ovary is very well indicated by a transverse zone of thin-walled cells in contrast to the small thick-walled cells above and below it. The vascular supply of the style, though recognizable, is not very well preserved. A cross section of the style of 11 and



TEXT-FIGS. 33, 34 — 33, cross-section of a flower with 12-loculed ovary. ×20. 34, cross-section of a flower of twelve loculed ovary passing through the style showing six vascular bundles (v.b.) arranged round the stylar canal. × 20.

12-loculed ovary shows six vascular bundles arranged in a ring round the stylar canal (PL. 3, FIGS. 22; TEXT-FIGS. 31, 34). However, in a few specimens the style shows only five vascular bundles (PRAKASH, 1955, FIG. 13 & TEXT-FIG. 28) but here it has not been possible to correlate this with the number of septa per ovary. It is only

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TEXT-FIGS. 16-32 — *Sahnipushpam shuklai*. 16-23, serial cross-sections of a flower from the apex downwards. ×10. 24-27, cross-section of some flowers with 9-loculed ovary. ×10. 28, cross-section of ovary wall. o.r.— outer-region, gl.— gland, m.r.— middle region, i.r.— inner region. ×325. 29, diagrammatic cross-section of a septum and part of the ovary wall showing hair-like projections lining the locules and the surface of the septum. × 65. 30, L.S. of the upper part of gynaecium showing the vascular supply (v.s.) of the style and the stylar canal (st. can.) with horizontal valves (val.). × 16. 31, an oblique cross-section of a flower of an eleven loculed ovary showing six vascular bundles (v.b.) arranged round the stylar canal. × 10. 32, cross-section of a vascular bundle from the style. p.x. — protoxylem. ×320.

from the number of these vascular bundles and the number of septa per ovary that we can determine the number of carpels, which thus appear to be six for 12 and 11-loculed ovary. The individual bundles are not well preserved. However, they are much simplified in structure when compared to the vascular bundles of the perianth. Each bundle is encircled by a parenchymatous sheath (TEXT-FIG. 32). Towards the outer periphery, there are 1-2 small thick-walled elements of protoxylem. The rest of the bundles show stray cells at places, but mostly it is occupied by a continuous space representing the phloem and xylem which could not be preserved.

The stigma is one, terminal and somewhat discoid. It forms an umbrella-like structure covering the rest of the flower below. It is thick in the centre and thins out towards the margin (PL. 3, FIG. 21; TEXT-FIG. 1). No papillae could be observed on the surface of the stigma. Sometimes, there are some arm-like appendages from the lower surface of the stigma. The tissue of the stigma consists of loose, thin-walled, cells. No vascular traces could be recognized in it.

DISCUSSION

Nomenclature

As already pointed out, the generic name *Sahnipushpam* Shukla (1950) was published without any specific epithet. After six years two specific names were given almost simultaneously, viz., *Sahnipushpam shuklai* Verma (1956) and *S. glandulosum* Prakash (1955). The latter name was contained in " The Palaeobotanist ", Vol. 4 which was actually published in December 1956 (*see Palaeobotanist,* Vol. 7, No. 1). The name *S. shuklai* Verma was published a few months earlier in the same year. Therefore, in accordance with the International Code of Botanical Nomenclature the name *S. shuklai* Verma has priority over *S. glandulosum* Prakash which is a later synonym of *S. shuklai.*

Sahnipushpam shuklai is the only species of the genus and hence it is the type of the genus *Sahnipushpam* Shukla.

Morphology

Inflorescence — No inflorescence of *Sahnipushpam* has been found so far. However, a cross section of the flower taken from any region shows a squarish outline. This, along with the small size and ebracteate nature of the flower, suggests that probably the flowers were compactly arranged in a spike. Further, the basal portion of the thalamus, where we should find the vascular supply to the various floral whorls being furnished, does not come out with the flowers. This indicates that either the flowers were a little sunken in the peduncle or the bases of adjoining flowers were fused with each other, above which region the flowers have broken away.

Bract — As regards the suspected presence of a bract (PRAKASH, loc, cit.) the observed facts are against it. Though a large number of straw-like things are found in association with these flowers, yet none of them has been found in organic connection with the latter. Therefore, so far as we know there is no bract in these flowers.

Perianth — The outer tubular structure in the flowers has been described as " calyx tube " and considered to be hypanthium in morphology. Prakash (loc. cit.) did not mention anything about its origin, but Verma (loc. cit.) considered it to be of receptacular origin. A hypanthium is appendicular or partly appendicular and partly axial or receptacular in origin, being produced, at least partly, by the fusion of the bases of calyx, corolla and androecium and usually the ovary wall too. But the presence of distinct ovary wall, hypogynous stamens and absence of corolla leave no doubt as to the fact that the outer tubular structure is nothing more than a gamophyllous monochlamydous perianth which is truncate at the apex and cannot be compared with a hypanthium. As such no question of its being receptacular in origin arises at all.

Because of the truncate apex, it is difficult to ascertain the number of tepals which gave rise to this tubular structure. Prakash (loc. cit.) had tried to count the number of " vascular bundles " (vascular traces) in the perianth. But because of poor preservation it could not be done satisfactorily. In this connection three points are worth noticing, viz., (1) the quadrangular outline of the perianth, (2) the presence of one stamen at each of the four corners of the perianth and (3) the 4-6 carpellary, syncarpous gynaecium. This organization of the flower is inconsistent with its being a pentamerous flower. The 4-angled outline of the flower,

no doubt, is at least partly due to the spatial condition in which the flowers must have been disposed on the inflorescence. But partly it may be due to the number of segments which gave rise to this structure. The latter suggestion is inspired by the presence of one stamen at each of the four corners. Therefore, the number of tepals might have been four. But for the present it is rather difficult to be quite sure about it.

No corolla or a second whorl of perianth is present.

Androecium — As regards the androecium, the earlier authors believed that the stamens were borne on the mouth or throat of the calyx tube. But as seen above, they are distinctly hypogynous. The filament is usually crushed in the middle region and we generally see only a part of the stamen near the mouth of the perianth and a part at the base. It is the latter part of the stamen that has been mistaken for a " dome-shaped gland with a pointed apex " or a " stalked gland or a glandular trichome " by earlier workers.

As regards the number of stamens, Verma (loc. cit.) thought that possibly they might be numerous while the available data shows that they could not be more than four or less than two in number.

The attachment of the anthers has been described as dorsifixed (PRAKASH, loc. cit.). But after examining all the specimens this observation could neither be disclaimed nor confirmed. However, the mode of dehiscence is clearly longitudinal.

Pollen Grains — As regards the structure of pollen grains, Verma (loc. cit.) has shown them to be 1-sulcate whereas Prakash (loc. cit.) has described them as " dicolporate syncolpate ". Evidently these observations were based on inadequate material. The present study of sufficient material has shown that they are anisopolar, boat-shaped structures, with or without a distal colpus (= sulcus). The two areolate, more or less circular zones at each equatorial end of the pollen grains have been mistaken for colpi and the real colpus for an elongated os.

The finger-like appendage arching over the areolate circular zones at equatorial ends is a peculiar structure of interest. However, its morphology is not understood.

Gynaecium — A typical ovary is 11-loculed at the base and apex and unilocular in the middle region where the septa do not meet in the centre. Though, the bigger septa reach almost to the centre yet they do not meet there. The smaller septa are radially half as long as the bigger ones. These smaller septa have been termed as " secondary septa " in earlier accounts. The term " secondary septa " implies their late origin in the ontogeny of the ovary. But this is a point that cannot be ascertained in the fossil material. At the same time the other possibility, that they may be primary septa, cannot be ruled out. Thus, it is better to avoid this term (secondary septa) for smaller septa. Their description as smaller septa is quite adequate for the present.

As regards the number of carpels composing the gynaecium, it is slightly difficult to determine due to the absence of usual criteria, e.g., the number of separate segments of the stigma or well defined number of locules in the ovary. However, a cross section of the style of 12 and 11-loculed ovary shows six vascular bundles arranged round the stylar canal (PL. 3, FIGS. 22, 23; TEXT-FIG. 34). The cross section of the style of a flower with 10-loculed ovary would possibly show only five similar vascular 'bundles', Thus, it seems that each vascular bundle in the style and two septa of the ovary represent one carpel. This implies that an ovary with 12 and 11-locules where one septum is lacking (or obliterated ?) is made up of six carpels and 10-loculed ovary is made up offi ve carpels. As regards 9-loculed ovary, we do not know the number of vascular bundles in the style, but it is clear that it is further reduced as indicated by the loss of two septa when compared to the usual 11-loculed ovary. This would perhaps suggest a trend towards reduction in the gynaecium. This evolutionary trend towards reduction in the ovary coupled with the fact that the ovary wall is highly lignified in a stage prior to seed formation, the observed absence of seeds or ovules in the ovary, the closure of the stylar canal in the upper part and the non-receptive or non-papillate surface of the stigma strongly support the idea that the ovary of these flowers was already non-functional or the flowers were functionally unisexual (staminate).

In the absence of ovules or seeds in the ovary it is not possible to determine the type of placentation. Therefore the suggestions that the placentation is axile or basal

or apical are mere conjectures. Also whether it was apical, sub-apical, axile, sub-basal or basal cannot be determined.

As regards the absence of central axis in the middle region where it is represented by ill-defined tissue, it may be due to disorganization or non-preservation. But the presence of a distinct epidermis on the free ends of the septa suggests that probably the axis had already lost connection with the septa before it got disorganized or destroyed.

The earlier workers have described "fruits" of *Sahnipushpam* as loculicidal and septicidal woody capsules. These descriptions were based on mutilated flowers of *Sahnipushpam* which they thought represented the fruits. But there is nothing to prove that they were fruits. In fact the ovary wall is highly thickened and deeply grooved externally (PL. 2, FIG. 13). These grooves were mistaken for sutures of dehiscence. The absence of seeds inside such specimens is not consistent with their comparison with fruits.

Affinities

According to earlier workers the affinities of *Sahnipushpam* can be traced to Sonneratiaceae or ?Myrtaceae. The affinities with Myrtales have, obviously, been inspired by the presence of glands on the ovary and the consideration that the outer tubular structure is hypanthium. But the presence of hypogynous stamens, superior ovary and the absence of free lobes of perianth militate against any relationship of these flowers with Myrtalean families. In short there is no definite evidence, even to show, that it is a dicotyledon ! Therefore, it is necessary to examine all grounds for considering it to be a dicotyledon.

It was, obviously, the supposed pentamerous organization of the flower which led the earlier workers to consider it as a dicotyledon. But it has already been shown above that it is not a pentamerous flower. The presence of glands on the surface of the ovary cannot decide whether it is monocotyledon or a dicotyledon. The characters of foliage, stem and seeds, if they were known, could have easily decided this issue. But now we have only the vascular bundles, the pollen grains and the organization of the flower for determining its affinities. The pollen grains are well preserved. They are anisopolar with a colpus on the dorsal pole (sulcus). Therefore, they are " monocotyledonous ". According to Erdtman (1952, 1954) monocotyledonous pollen grains are found in some dicotyledonous families also, viz., (1) Magnoliaceae, (2) Himantandraceae, (3) Calycanthaceae, (4) Annonaceae, (5) Eupomatiaceae, (6) Myristicaceae, (7) Monimiaceae, (8) Nympheaceae, (9) Degeneriaceae, (10) Piperaceae, (11) Saururaceae, 12) Chloranthaceae, (13) Canellaceae and (14) Aristolochiaceae. Out of these, the first nine (Ranalian) families can be easily eliminated due to the presence of polypetalous perianth and apocarpous gynaecium in them. Similarly the next three families, viz., Piperaceae, Saururaceae and Chloranthaceae (Piperales), can be eliminated due to the absence of perianth in them. Out of the remaining two families, Canellaceae can be excluded owing to the presence of monadelphous stamens and free sepals. In Aristolochiaceae, the ovary is inferior to semi-inferior.

Thus, we find that this flower cannot be assigned to any extant family of dicotyledons bearing monocotyledonous pollen. Also, there is no evidence, so far as we now know, to prove that it is a dicotyledon. However, if later researches should prove that it is a dicotyledon, then probably it can be placed in a new family and possibly a new order of Monochlamydeae in dicotyledons.

On the other hand, the structure of the pollen grains suggest monocotyledonous affinities of these flowers. However, the pollen morphological characters alone are not enough to determine its correct systematic position. Therefore, considering all the important characters together, such as small, sessile, ebracteate, actinomorphic, bisexual (or functionally unisexual), monochlamydous, hypogynous flowers with syntepallous perianth, at least two (or possibly four) hypogynous stamens with longitudinally dehiscing anthers and anisopolar boat-shaped pollen grains and a syncarpous ovary of four or more carpels with a single style and a discoid stigma, this flower shows affinities with Cyclanthaceae and Araceae among monocotyledons.

As regards Cyclanthaceae, hypogynous condition is found only in some species of *Spharadenia* and *Stelestylis* (HARLING, 1958). But in most other characters, e.g., of perianth, androecium, style and stigma, the members of Cyclanthaceae differ considerably from *Sahnipushpam*.

So far as Araceae is concerned, it is a family of great morphological diversity, particularly in its floral characters (Engler

and Krause, 1905-1920; Arber, 1925, pp. 189-191). But a more or less uniform character of the family is the production of a compound berry resulting from a compact spike. As regards the floral organization of *Sahnipushpam*, it can be easily fitted in Araceae. But immediately two questions arise, viz., (1) what is the type of inflorescence ? and (2) what kind of fruits are produced ? Factually we are ignorant about these aspects. However, as shown above, there are indications that possibly the flowers were borne on compact spikes. Also the existence of large numbers of flowers in close approximation in the chert indicates their release from a central column (spadix) either by decay from their points of attachment just prior to deposition, or normal deciduous release from the spadix at the time of anthesis. The first of these possibilities seems quite reasonable in view of the absence of developed seeds. As regards the fruit of *Sahnipushpam* there are indications (as shown above) that these flowers were functionally staminate which would, obviously not produce seeds or form fruits. The morphology and variability of the pollen grains of these flowers particularly the dipolar thinning of the ends and the distal colpus (sulcus) conform well with Araceae. The anther wall also conforms to the aroids. In Araceae there are some genera which have bisexual flowers and some others posses tetramerous flowers also with fleshy perianth and 2-4 stamens. But to be precise there is no living genus in Araceae to which we can confidently refer this flower.

DIAGNOSIS

No generic diagnosis is so far available for *Sahnipushpam* and in view of the new observations, the specific diagnosis also needs revision. Therefore, both the generic as well as the revised specific diagnoses are given below.

GENERIC DIAGNOSIS

Genus — *Sahnipushpam* Shukla

Flower small, sessile, ebracteate, actinomorphic, " bisexual ", hypogynous, monochlamydous, usually quadrangular in cross section; perianth gamophyllous, tubular, truncate and fleshy at the apex. Stamens few (probably four), hypogynous; filament long; anther 4-celled, dehiscence longitudinal; pollen grains small, anisopolar, with or without a distal colpus. Gynaecium syncarpous, carpels (6-5); ovary superior studded with glands on the external surface with 12-9 incomplete septa; septa of two sizes, all meeting in the centre at the apex and the base; style 1, stout, with a stylar canal; canal divided by thin horizontal valves; stigma 1, more or less discoid, covering the rest of the flower.

Type — *S. shuklai* Verma.

REVISED SPECIFIC DIAGNOSIS

Species — *Sahnipushpam shuklai* Verma syn. *S. glandulosum* Prakash

Flowers about 5-5·5 mm. in height, 2·5-2·8 mm. in diameter at the widest part; perianth quadrangular in cross section, slightly thick at the base, thin in the middle and thick and fleshy at the apex with lysigenous spaces inside, closely applied to the ovary wall. Stamens at least two, with a persistent base, usually crushed in the middle; anthers long, 4-loculed; pollen grains anisopolar, boat-shaped, oblate, 15-18 $\mu \times$ 25-27 μ, distallo-aperturate, with two areolate, thin, circular, possibly aperturate, zones at equatorial ends, measuring about 5 μ in diamter half bulging above the surface, usually arched over by a finger-like appendage; colpus when present, long about 7 μ wide in the centre; exine thin about 1 μ thick, finely striated in sub-surface focus. Ovary superior, unilocular for the most part, 12-9 loculed at base and apex, made up of highly thickened cells, studded with glands on external surface; stigma more or less umbrella-like; placentation, fruits and seeds unknown.

Locality — Mohgaon Kalan, District Chhindwara of Madhya Pradesh and Mahurzari, District Nagpur of Maharashtra, India.

Horizon — Deccan Intertrappean series.

Age — Tertiary (Probably Eocene).

Hypotypes — B.S.I.P. Nos. 5505, 5510, 10372, 32737.

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EXPLANATION OF PLATES

Sahnipushpam shuklai

PLATE 1

1. Longitudinal section of a flower to show the general organization. Note more or less 1/3 apical part of the stamen. × 18.

2. Longitudinal sections showing the swollen apical part of the perianth (p.) with lysigenous spaces (lys. sp.). × 30.

3. Longitudinal section of the wall of an anther. × 1000.

4. Cross-section of an anther showing four locules with pollen grains. × 120.

5. Oblique cross-section of a flower showing one stamen at one angle of the perianth. The stamen (st.) is partly dehisced and crushed. × 25.

6. Oblique cross-section of a flower showing two stamens (st.) one at each angle of the perianth (p.). Note one of the stamens half dehisced as seen in cross-section. The other stamen is crushed. × 25.

7. Longitudinal section of the basal portion of the flower showing the basal more than 1/3 part of the stamen. fil.= filament. × 25.

PLATE 2

8. A tetrad of pollen grains. Note the 'apertures' (apt.) on the distal pole. × 1000.

9. Lateral view of a pollen grain. Note its anisopolar construction, two areolate zones or pori, one at each equatorial end which appear to be joined with a colpus on the distal pole. × 1000.

10. Polar (distal) view of a pollen grain with well-formed colpus (= sulcus). × 1000.

11. A pollen grain showing the two areolate zones included within a broad distal area (=? "sulcus" or enclosed by folds). × 1000.

12. A pollen grain showing its surface and the finger-like appendage (app.) arching over the areolate zone. × 1000.

13. Surface view of the ovary showing longitudinal grooves on the surface. × 4.

14. Slightly oblique cross-section of nearly middle region of a 9-loculed ovary. × 8.

15-16. Cross-section of the middle and sub-apical region of a 9-loculed ovary showing the arrangement of the septa. × 8.

17. Cross-section of sub-apical region of a 9-loculed ovary. × 8.

18. Magnified cross-section of the ovary wall. Note the extent of thickening of the cells, especially of the outer layers. × 500.

19. Longitudinal section of the ovary wall showing the glands (gl.) on the external surface and fibre-like nature of the cells of the wall. × 100.

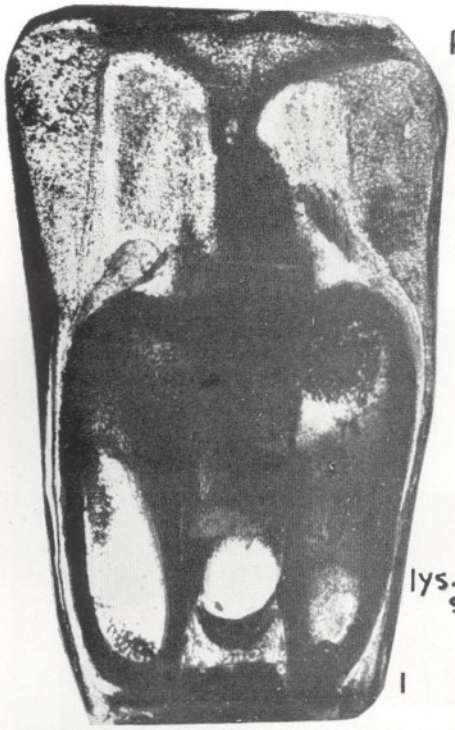
PLATE 3

20. Median longitudinal section of the flower showing tubular perianth tube and the gynaecium. × 16.

21. Longitudinal section of the apex of gynaecium, showing the well formed stylar canal (st. c.) with horizontal septa or the valves (v.). × 34.

22. An oblique cross-section of a flower of 11-loculed ovary passing through the base of the style showing vascular bundles (v.b.) arranged round the stylar canal. × 20.

23. Somewhat magnified view of a cross-section of a style showing six vascular bundles (v.b.) arranged round the stylar canal. × 40.



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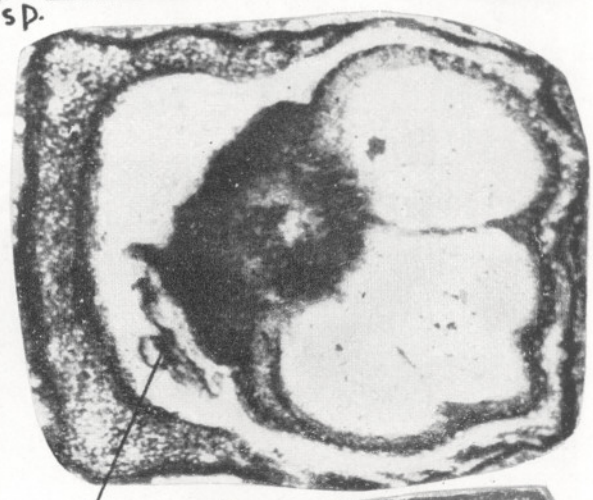

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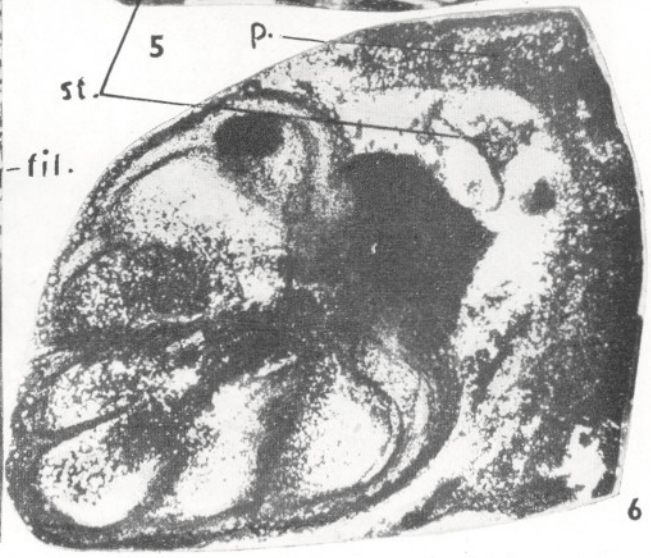

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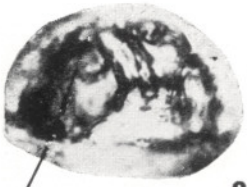

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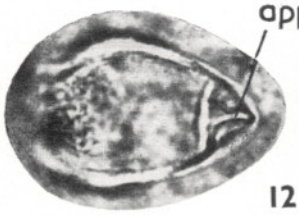

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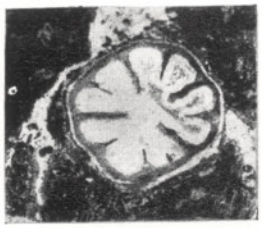

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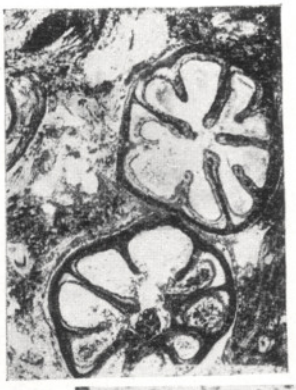

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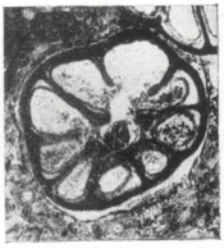

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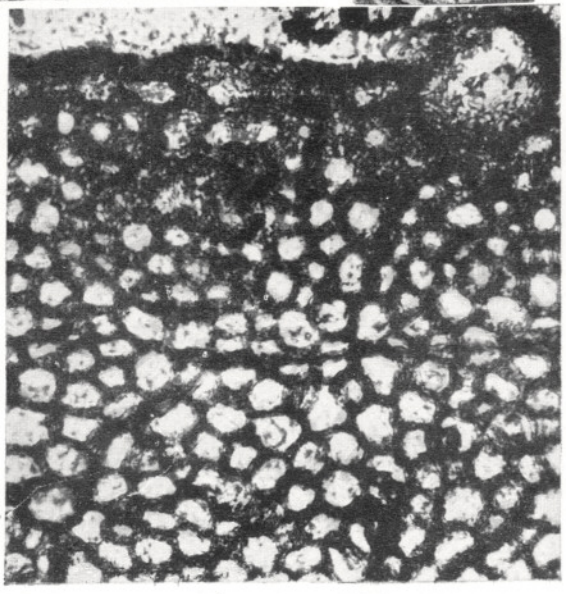

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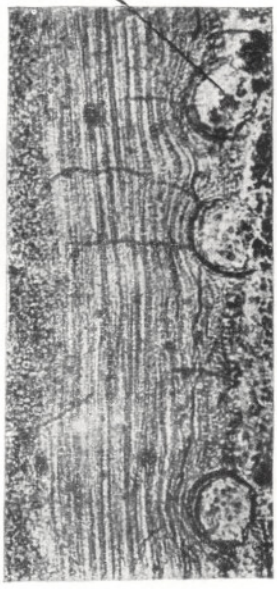

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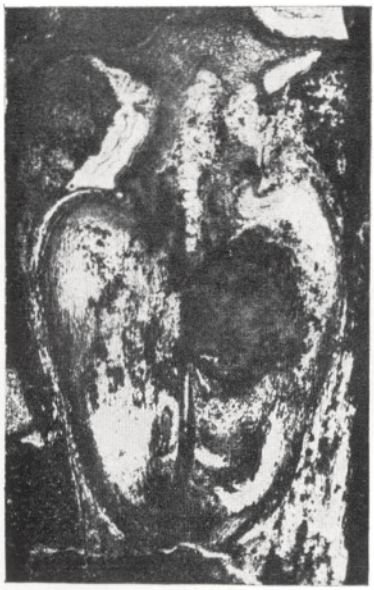

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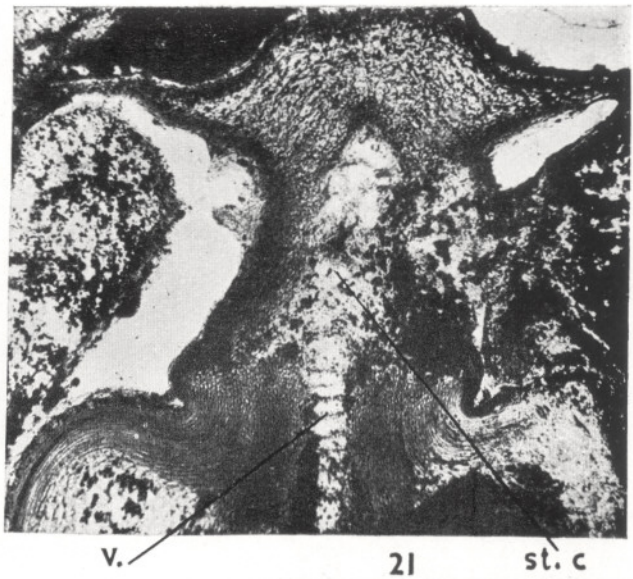

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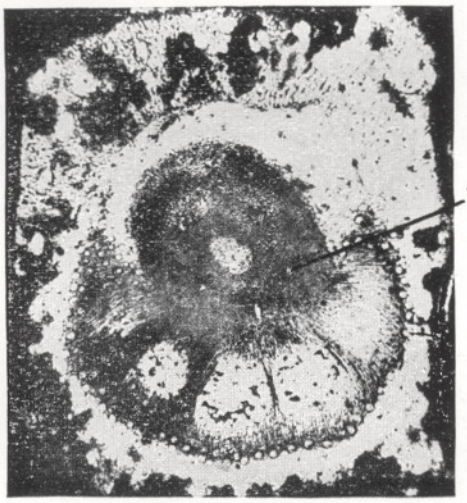

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