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PETRIFIED ISOLATED GYMNOSPERMOUS SEEDS FROM THE JURASSIC OF RAJMAHAL HILLS, INDIA

Skamieniałe nasiona roślin nagozalążkowych z jury Rajmahal Hills, India

ABSTRACT. Description is given of five different kinds of petrified, isolated seeds collected from Sonajori, Rajmahal Hills, Bihar. Although the seeds show similarities with various groups of gymnospermous plants, they seem more close to *Podocarpaceae* and *Taxaceae*. Associated vegetative organs are yet to be discovered.

INTRODUCTION

In addition to stems, roots, and fructifications, isolated gymnospermous seeds are also found in the fossiliferous locality of Sonajori near Pakur in the Rajmahal Hills (Sharma 1975; Sharma & Bohra 1976, 1977). The latter are occurring in abudance, so much so, that in some of the specimens hundreds of seeds are present in five centimetre cubic area. These seeds are showing variations in size shape and structure of integument and are grouped thus into five different taxa as given below:
Pakuriospermum pachytestoides gen. et sp. nov.,
Paradoxospermum heterotestoides gen. et sp. nov.,
Taxaliospermum arilloides gen. et sp. nov.,
Sonajorispermum homotestoides gen. et sp. nov.,
Triangulospermum minimum gen. et sp. nov.

The seeds are found embedded in a hard chert in different planes. Slides were prepared by the usual methods of cutting, grinding and polishing processes and mounted in Canada balsam.

SYSTEMATIC DESCRIPTION

Pakuriospermum pachytestoides gen. et sp. nov.

Diagnosis. Seed oval. 5.5 × 4.2 mm in size; erect, solitary, terminal with a pair of opposite bracts at its base. The bracts cover 1/3 of the basal part of the seed; integument 600 μm thick, non-vascularized, differentiated into three

layers i. e. sarcotesta, sclerotesta, endotesta; micropyle short; nucellus parenchymatous, free to base.

Description. The seeds are found isolated and irregularly embedded in the chert adhered with the bract (Pl. I, fig. 1; Pl. III, fig. 1) or without bracts. The bract is 2.6—3.2 × 0.2—0.3 mm in size, curved; apex acute and made up of thick walled cells which are quite distinct from the cells of the integument. The integument is made up of two halves (Pl. I, fig. 2), jointed marginally and is differentiated into three layers (Pl. I, fig. 3). The outer is sarcotesta, 250 to 300 μm thick and consists of large sized, regular, parenchyma with intercellular spaces (Pl. I, fig. 5). Cells look rectangular in surface view while circular in cross section. The epidermis is distinct from the cells of sarcotesta. It is made up of triangular and comparatively thick walled cells. The epidermis may be 1—3 cells thick. The middle layer is 150 do 200 μm wide and consists of thick walled closely placed cells (Pl. I, fig. 5). These cells are elongated in longitudinal section while hexagonal in crossection. This layer forms the micropyle of the seed (Pl. I, fig. 4). The endotesta is thin, 80 to 90 μm wide and consist of thin walled rectangular cells. This layer is generally not found well preserved. The nucellus is free from the integument and is represented generally by a single cell thick layer. Pollen chamber is absent. In some of the seeds endosperm is also seen but its cellular details are not preserved. Two traces enter the base of an ovule (Pl. I, fig. 1; Pl. III, fig. 1).

Comparison. The occurrence of a single erect ovule adaxial to a pair of opposite bracts suggests comparison with the ovules of *Taxaceae* and *Podocarpaceae*. However, an aril is not seen, unlike in the majority of the members of *Taxaceae*. In general plan of construction this seed resembles *Taxospermum* (Sahni 1920, Fig. 1—7). But the presence of two vascular strands brings the present seed close to the *Taxus* ovule (Sahni 1920, Fig. 2). In *Podocarpaceae* some of the genera possess erect ovules e. g. *Pherosphaera*, *Phyllocladus* and *Acmopyle*, while in others the ovules are inverted. Comparison has been made with the former but the present material differs in details e. g. in the absence of epimatium and vascular supply to integument. Rao (1943) and Mittre (1959) described a number of *Podocarpaceous megastrobili* and isolated seeds from the Rajmahal Hills e. g. *Nipaniostrobus*, *Mehtaia* and *Sitholeya*. However, the new material differs from them in size, attachment, structure of integument and the vascular supply.

Type slide No. 183.

Locality. Sonajori (Pakur).

Horizon. Jurassic of Rajmahal Hills, Bihar (India).

Collection. Dr. B. D. Sharma's collection, University of Jodhpur, Jodhpur, India.

Paradoxospermum heterotestoides gen. et sp. nov.

Diagnosis. Seed ovate, 3.2 × 1.8 mm in size, partly platyspermic, scale not adhering, integument 120 to 200 μm thick, non-vascularized, homogeneous

in proximal part and heterogeneous in the distal micropylar portion; micropyle 1.3 to 1.5 mm long; nucellus free to the base.

Description. The type slide No. 24/Raj Pak. is a longitudinal section through the breadth of the seed. It has a rounded basal portion and an elongated narrow micropyle (Pl. III, fig. 2). The integument is parenchymatous in the former while sclerenchymatous in the latter portion of the seed (Pl. I, fig. 6). Surrounding the sclerenchymatous portion of integument there is present a layer of thin walled cells, representing an aril like structure (Pl. I, fig. 7). The platyspermic nature of seed is seen in another section through the width of the seed (Slide No. 24). The nucellus is represented by a layer only one cell thick and it encloses a big megagametophyte cavity.

Comparison. The long micropyle, platyspermic nature and difference in the structure of integument in the proximal and distal parts of the ovule separate out the present material from the other four kinds of isolated seeds described in the paper. It may be compared with the hypothetical Pre-*Torreya* seed (Sahni 1920, Figs 7—9) and *Torreya*. However the attachment of seed and nature of vascular supply is unknown in it. More material is needed for ascertaining the systematic position.

Type slide No. 24.

Locality. Sonajori (Pakur).

Horizon. Jurassic of Rajmahal Hills Bihar (India).

Collection. Dr. B. D. Sharma's collection, University of Jodhpur, Jodhpur, India.

Taxaliospermum arilloides gen. et sp. nov.

Diagnosis. Seed radiospermic, terminal, arillate, elongated, 4.1 × 3.6 mm in size, basal part rounded; integument 86—100 μm thick, covered with an aril like structure. The latter is parenchymatous, 120 to 180 μm thick, covers completely the integument; micropyle narrow, 230 × 28 μm in size; nucellus free; pollen chamber probably present; megagametophyte large.

Description. The type slide No. 121/Raj. Pak. represents a longitudinal section of the seed (Pl. II, fig. 9; Pl. III, fig. 3) but the basal portion is incomplete,while in slide No. SS/199, the entire seed is seen with a thick walled pedicel (Pl. II, fig. 8). The seed is terminal, on the pedicel.

The integument is homogeneous and made up of thin walled cells. It is separated from the aril by a distinct, cutinized epidermis (Pl. II, fig. 9). The micropylar canal opens to the inner side into a deep pollen chamber like structure present in the apical part of nucellus (Pl. II, fig. 10). In slide No 122/Raj. Pak. the pollen chamber is filled with some debris looking like the pollen grains but details of the latter are not clearly visible. The nucellus is represented by a layer one cell thick. It encloses a large megagametophyte which is seen filled with debris (Pl. II, fig. 9).

Comparison. In some of the fossil taxanean seeds an aril covers the entire

surface of ovule e. g. *Palaeotaxus rediviva* Nath., *Marskea (Taxus) jurassica* (Florin) Harris. But in the latter types the aril remains free from integument whereas, in the present seed it is closely adhering.

In *Taxus* and *Torreya* the aril encloses the seed completely and is found closely adhering to the integument like the one seen in the present seed. But in the former the nucellus is adhered with integument and the aril possesses a distinct type of vasculature.

In some members of *Podocarpaceae*, the epimatium is found closely adhering to the integument and covers the seed completely e. g. *Podocarpus* and *Acmopyle*. But these types differ from the present seed in other characters like the nature of integument, free position of nucellus, and presence of the pollen chamber.

Type slide No. 121.

Locality. Sonajori (Pakur).

Horizon. Jurassic of Rajmahal Hills, Bihar (India).

Collection. Dr. B. D. Sharma's Collection, University of Jodhpur, Jodhpur, India.

Sonajorispermum homotestoides gen. et sp. nov.

Diagnosis. Seed oval. 2.3—2.8 × 1.4—1.6 mm in size, partially platyspermic, not adhering to scale; integument bivalved, 80 to 96 μm thick, homogeneous, parenchymatous and nonvascularized; micropyle small; megagametophyte large. The seed possesses a rounded base and a small micropyle (Pl. III, fig. 4). The integument is narrow, without distinct epidermis (Pl. II, fig. 12; Pl. III, fig. 5). The two valves of integument are equally developed with concavity on the inner side (Pl. II, fig. 11). The margins of the valves are comparatively thicker than the middle portion of integument. The nucellar pad is very-well developed (Pl. II, fig. 13). The megagametophyte is large and filled with debris in many seeds.

Comparison. In size, shape and structure of nucellus the present seed resembles *Carnoconites laxum* Srivastava (1946) and Sahni (1948), but differs in the structure of integument. In the latter the integument is non-valved and heterogeneous. The seeds are radiospermic or little platyspermic in *Carnoconites* while in the present material it is partly platyspermic.

In the bivalved nature of integument and presence of a distinct nucellar pad, the present material resembles the cordaitalean seed *Mitrospermum florini* Baxter (1971). But it differs in detail and the two seeds come from widely separated geological horizons.

The nucellar basal pad also occurs in some of the Pteridospermous seeds e. g. *Lagenostoma lomaxi* Williamson (Long, 1944; Pl. 2, fig. 23). *Pachytesta berryvillensis* Taylor and Eggert (1969, Pl. II, fig. 1), but the present seed differs from them in the nature of integument, absence of pollen chamber and vascular supply.

Type Slide No 107.

Locality. Sonajori (Pakur).

Horizon. Jurassic of Rajmahal Hills, Bihar (India).

Collection. Dr. B. D. Sharma's Collection, Univ. of Jodhpur, Jodhpur, (India).

Triangulospermum minimum gen. et. sp. nov.

Diagnosis. Seed ovate, 1.8—2.8 × 1.2—1.6 mm in size; solitary, adaxial to the bract, bract vascularized with lateral extensions measuring 0.5 × 0.8 mm in size. Basal part of seed rounded, apex pointed, triangular in cross section, integument thin, non vascularized, heterogeneous, differentiated into three layers, palisade like sarcotesta, sclerotesta and endotesta; nucellus free with a nucellar disc; megagametophyte large.

Description. The scale is seen conical in longitudinal section with narrow lateral extensions (Pl. II, fig. 14). The seed is triangular in cross section (Pl. III, fig. 6). The integument is 70 to 86 μm thick, and differentiated into three layers. The outermost is 40 to 48 μm thick with an epidermis and made up of palisade like cells. The middle layer is 20 to 28 μm thick and consists of thick walled closely placed cells. The innermost layer is thin, 16 to 24 μm wide, parenchymatous and generally poorly preserved. The nucellus possesses a distinct basal pad.

Comparison. The present material differs from the seeds described above in shape, size and structure of integument. Comparison is also made with *Nipaniostrobus* (Rao 1943; Mittre 1959) and other podocarpaceous seeds, but it differs from them in detail e. g. in the structure of integument, micropyle etc.

Type Slide No. 117.

Locality. Sonajori (Pakur).

Horizon. Jurassic of Rajmahal Hills, Bihar (India).

Collection. Dr. B. D. Sharma's Collection, University of Jodhpur, Jodhpur (India).

DISCUSSION

The above described seeds are showing similarities with various groups of gymnospermous plants i. e. *Pteridosperme*, *Pentoxyales*, *Cordaitales*, *Coniferales* and *Taxales*. The relationship with Palaeozoic plants i. e. *Pteridosperme* and *Cordaitales* seems arbitrary as the present material comes from the Jurassic Horizon. Seeds found adhering to the pedicel and bracts e. g. *Pakuriospermum* and *Triangulospermum* were borne terminally as in members of *Taxaceae*. The presence of two vascular strands in pedicel of *Pakuriospermum* further adds support to this view. The presence of an aril-like structure in close adherence with the integument in *Taxaliospermum* certainly shows taxanean nature

of the seed. The presence of heterogeneous integument in the micropylar portion in *Paradoxospermum* relates it with *Torreya* like seeds. The age of *Sonajorispermum* remains unknown. Though in shape, size and presence of nucellar pad, relates it with the seeds of *Carnoconites laxum* Srivastava (1946), but the bivalved, homogeneous integument separates it out from the latter.

Out of the five genera of seeds described in the present paper, *Sonajorispermum homotestoides* possesses more primitive characters (Sahni 1920) than the other types. The integument is bivalved with a single basal ovular strand. The nucellus is provided with a distinct basal pad. On the other hand *Pakuriospermum pachytestoides* shows comparatively advanced characters, e. g. terminal attachment, differentiation of integument into three layers, and presence of two basal vascular strands. A similar situation exists in *Triangulospermum minimum*; the seed is terminal with heterogeneous integument. It may also be considered an advanced type, but the seeds are comparatively small, and the basal vascular supply is indistinct.

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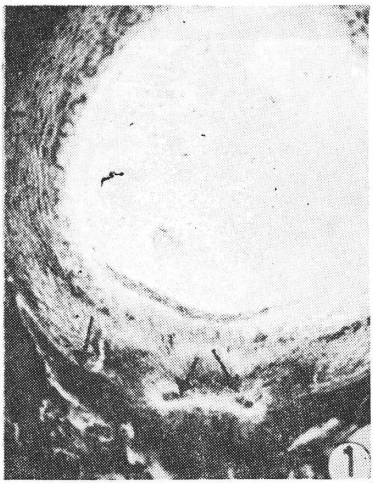
PLATES

Plate I

1. *Pakuriospermum pachytestoides*. L. S. seed with two vascular traces (arrow) and opposite pair of bracts (arrow) in basal portion, × 18
2. Same. Bivalved, heterogeneous integument, × 18
3. Same. Differentiation of integument into sarcotesta, sclerotesta and endotesta, and megagametophyte in the centre, × 18
4. Same L. S. seed showing micropyle, × 24
5. Same. C. S. seed showing differentiation of integument layers, × 60
6. *Paradoxospermum heterotestoides*. L. S. Seed with heterogeneous integument in micropylar portion, × 18
7. Same. Micropyle portion enlarged, × 60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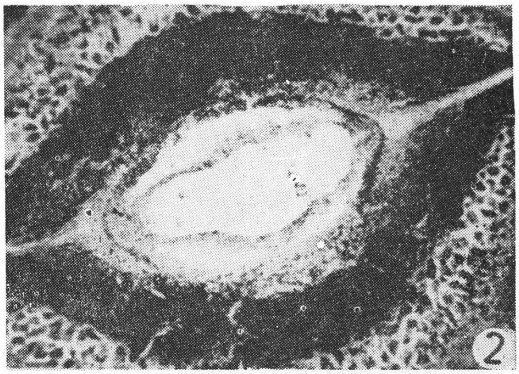
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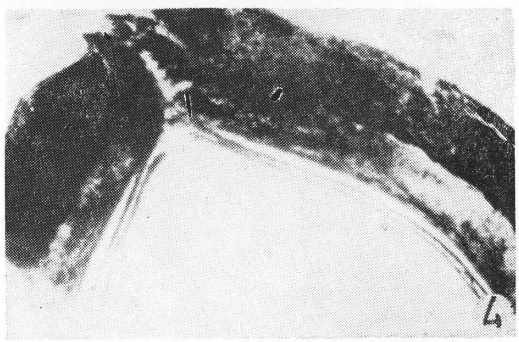
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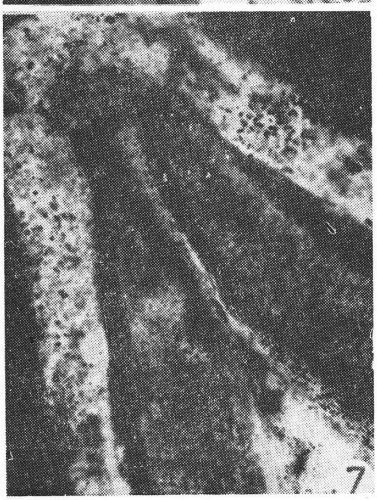
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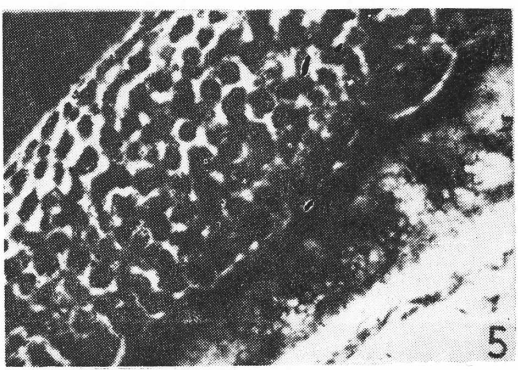
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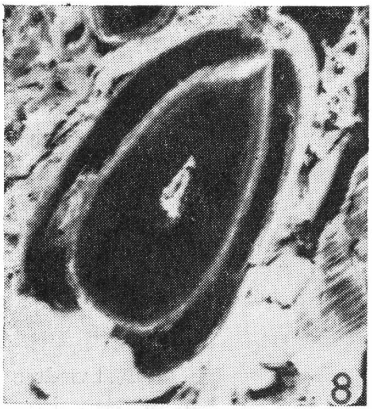
Plate II

8. *Taxaliospermum arilloides*. L. S. seed showing aril covering the integument, × 18
9. Same. Attachment of seed to the axis, × 12
10. Same. A pollen chamber like structure (arrow) filled with debris, × 60
11. *Sonajorispermum homotestoides*. Bivalved, homogeneous integument. Nucellus free and filled with debris, × 36
12. Same. Integument hemogeneous and parenchymatous, × 48
13. Same. L. S. Seed showing nucellar pad and free nucellus, × 36
14. *Triangulospermum minimum*. L. S. Ovules showing heterogeneous integument, × 24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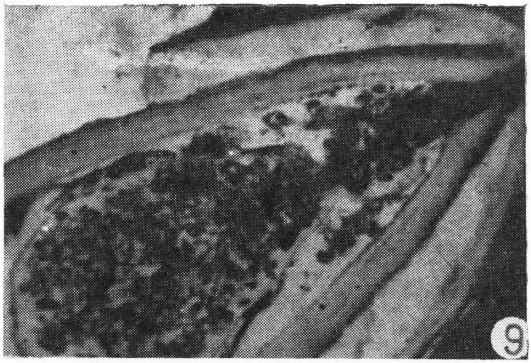
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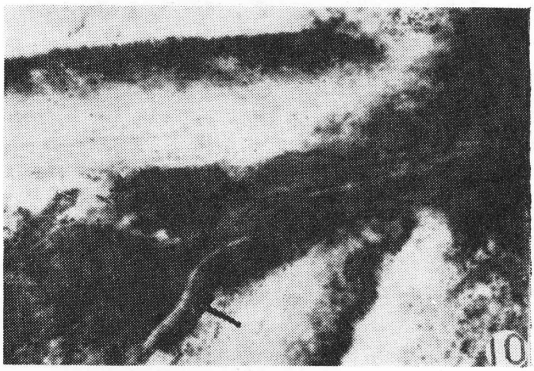
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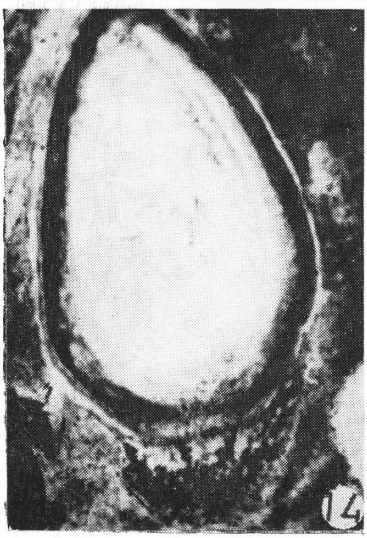
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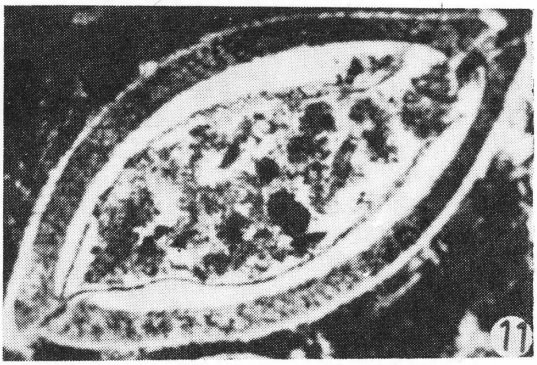
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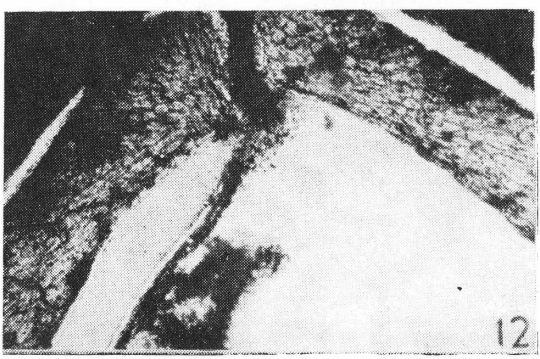
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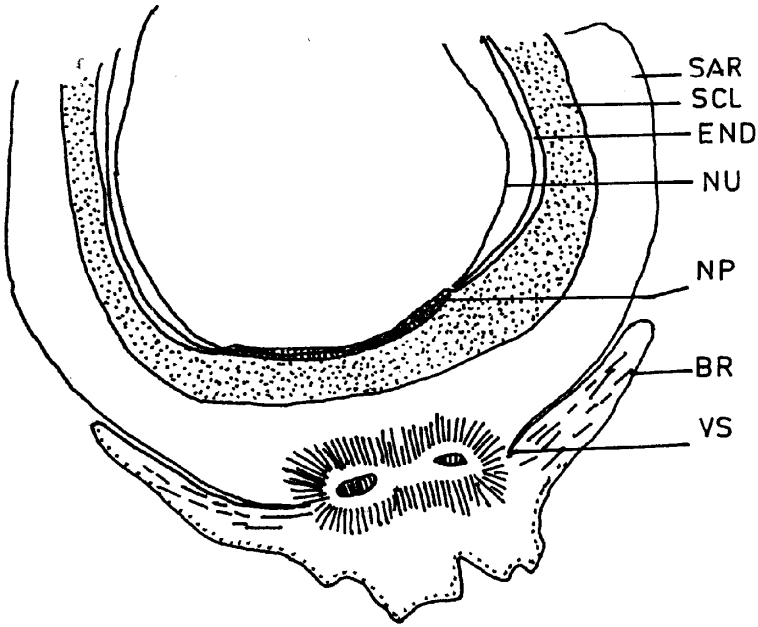
Plate III

1. *Pakuriospermum pachytestoides* L. S. Seed showing bracts, two vascular strands and thick, heterogeneous integument, ×72
2. *Paradoxospermum heterotestoides* L. S. Seed showing free nucellus and heterogenous integument in micropylar portion, ×12
3. *Taxaliospermum arilloides* L. S. Seed, integument covered with an aril nucellus free, ×12
4. *Sonajorispermum homotestoides* L. S. Seed showing shape and free nucellus, ×12
5. Same. Homogeneous integument, ×72
6. *Triangulospermum minimum* C. S. Seed, triangular shape and heterogeneous integument, ×48

SAR — Sarcotesta, SCL — sclerotesta, END — endotesta, NU — nucellus, BR — bract, VS — vascular strand, INT — integument, MI — micropyle, AR — aril, EN — endosperm.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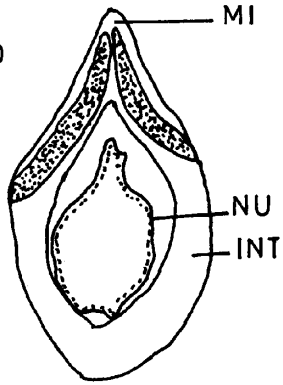
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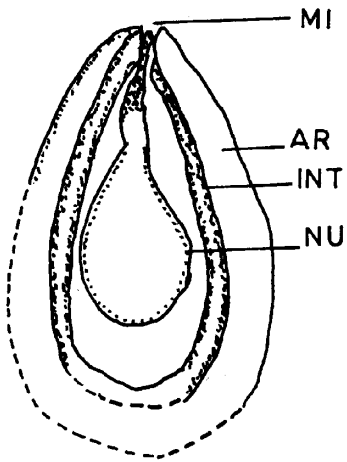
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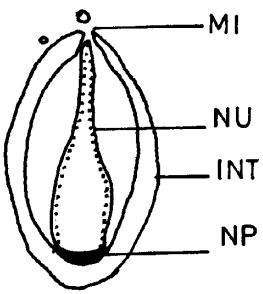
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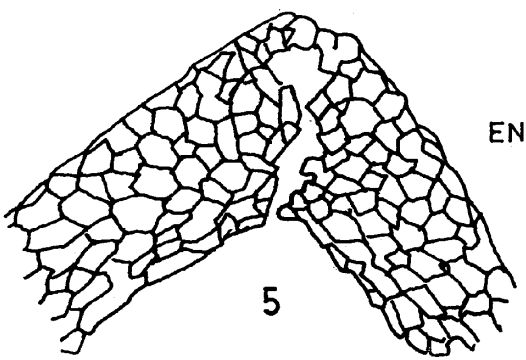

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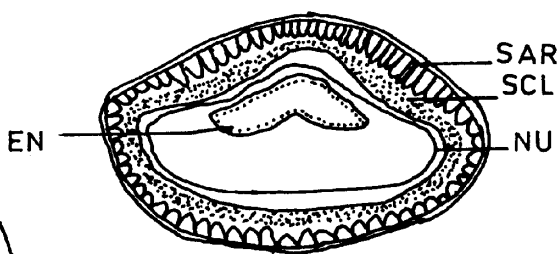
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