THE SPORES OF LYCOPODIUM, PHYLLOGLOSSUM, SELAGINELLA AND ISOETES AND THEIR VALUE IN THE STUDY OF MICROFOSSILS OF PALAEOZOIC AGE.

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ELIZABETH M. KNOX,

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SELAGINELLACEAE

INTRODUCTION.

The LYCOPODIINAE are a ubiquitous race of plants: members are found in many different parts of the world from the tropics to the polar regions, and under a great variety of habitat conditions.

The families with living representatives afford ample evidence of antiquity; and their fossil relatives indicate the abundance of the group during Palaeozoic times. The coals of the Carboniferous Age are to a large extent composed of the carbonised remains of these plants; their spores are found in vast numbers in most coal seams.

The study of fossil spores within the last 25 years has led to their being used as an aid in the correlation of coal seams. Up to the present, the classification of fossil spores has been an arbitrary one; with the increasing use of spores as zonal indices in coalfield work, a more scientific system of nomenclature has been found necessary. A binomial system has been promulgated in America which in all probability will form the basis of future work on classification. Although a general review of the spores of modern Pteridophyta has already been published by the author (Knox, 1938), the lack of any comprehensive survey of the spore morphology of living species of Vascular Cryptogams has proved a considerable handicap in framing a classification of fossil spores; the present study of the spores of modern species of the LYCOPODIINAE has been undertaken with a view to gaining more exact knowledge of spore morphology in this large and important group, both generic and specific, in order to make possible an assessment of relative values for purposes of palaeobotanical taxonomy.

The basis of the following work is furnished by a detailed account of the morphology of the spores of Lycopodium, Phylloglossum, Selaginella and Isoetes, derived from as many of the living species as it has been possible to obtain samples. Most of the material I have examined was obtained from the Herbarium of the British Museum (Natural History), through the courtesy of the Keeper, Dr J. Ramsbottom. Additional material was supplied from the Herbaria of the Royal Botanic Gardens, Kew, through the kindness of Sir Edward Salisbury and from the Royal Botanic Garden, Edinburgh, through the kindness of Sir William Wright Smith. To these gentlemen thanks are gratefully accorded.

The earliest mention of the family Lycopodiaceae was by Dodoneus in the sixteenth century. About 1585 he used the name Lycopodium and gave it to the plant which in all probability is now referred to as Lycopodium Selago. Subsequent to that date members of the family were variously designated as Selago, Selaginoides or Lycopodium. Dillenius in his "Historia Muscorum" (1741) made one of the earliest attempts at classification and distinguished as distinct genera Selago, Selaginoides, Lycopodium and Lycopodiodes. It was not until the following century that homospory, heterospory and the presence or absence of a ligule were recognised as of diagnostic value. That there were two kinds of spores in certain species of Selaginella was known to Dillenius, but the exact nature of the megaspores was in dispute for a long time; not until Lindsay in 1792 germinated the spores of Lycopodium clavatum was the function of the spores in Lycopodium recognised.

Kaulfuss (1824) mentions the tetrahedral nature of the spores and in his "Enumeratio Filices", besides describing many genera and species, he appends an exhaustive bibliography with references going back as far as 1533. The earliest figures of spores are to be found in Hooker and Greville's "Icones Filicum" (1831) and further illustrations are given by Mohl (1833). Later, in 1854, Brackenridge figures a few of the species collected by the U.S. Exploratory Expedition. The figures of all these early writers suffer from the same disadvantage in that they are so small as to be almost valueless. Spring's classic Monograph, published in 1842-1849, marks the beginning of the modern approach to classification. He recognised four genera:- Lycopodium, Selaginella, Tmesipteris and Psilotum. Spring's work was followed by several systematic accounts, notably those of Luerssen (1879), Baker (1887), Pritzel (1901), Herter (1909) and Hirmer (1927). Baker in "Fern Allies" (1887) separates the _Selaginellaceae_ (including Isoetes) from the _Lycopodiaceae_. He leaves Psilotum and Tmesipteris in the latter family. Pritzel (in Naturl. Pflanzenfam, 1902), on the other hand, divides the _Lycopodiales_ into _Eligulatae_ (including _Lycopodiaceae_ and _Psilotaceae_) and _Ligulatae_ (including _Selaginellaceae_, _Isoetaceae_ and three fossil families), whereas Hirmer (1927) removes the living _Psilotaceae_ from the _Lycopodiales_ and places it in a separate order _Psilotales_. In _Lycopodiales_ he includes _Lycopodiaceae_, _Selaginellaceae_, _Isoetaceae_ and five fossil families. This latter arrangement is nearest to the modern one propounded by Eames (1936) who also places Psilotum and Tmesipteris in a separate order _Psilotales_, since as he says "the group is so unlike other vascular plants that it must stand by itself in the order _Psilotales_, an order isolated from the other living orders. In taxonomic and morphologic treatments the family has often been grouped with the _Lycopodiaceae_ but it is evident that such a grouping is unnatural, for not only are the _Psilotaceae_ leafless and rootless and their sporangia cauline and terminal but the sperms are multiciliate and the antheridia superficial". Eames also raises Lycopodium and Selaginella to ordinal rank pointing out that "though remarkable for their strong resemblances and their marked differences they are undoubtedly related but not closely". The Selaginellales have the same type of herbaceous plant body as the Lycopodiales but each of the leaves has a single ligule, also the Selaginellales are heterosporous, with sporophylls in definite strobili. "It is generally believed," writes Eames, "that the differences are great enough to justify ordinal rank forming two small orders Lycopodiales and Selaginellales, which stand more or less together, each containing a single family." Both Hirmer and Eames maintain a separate order Psilophytales for the fossil plants Rhynia, Hornea and their allies. The relationship of these fossils to the Psilotaceae is obscure but, according to Eames, "there can be little doubt but that the Psilotaceae represent surviving remnants of the ancient psilophytalean stock, retaining the major morphological features of the ancestral types. As such they are living examples of the oldest known plants".

So far as is known to the present author no systematic account of the spores of the Lycopodiales, with specific descriptions and figures, has been published, though, scattered through the literature, figures and descriptions of a limited number of types are to be found. The present intention is to make as comprehensive a study of the microspores of the families Lycopodiaceae, Selaginellaceae and Isoetaceae as is possible, having regard to the availability of material for study.

LYCOPODIACEAE.

General Characters and Classification.

In the family Lycopodiaceae the sporophytes are herbaceous with stems bearing small simple leaves. The fertile leaves are usually aggregated in definite cones and the sporangia are homosporous. The family is an ancient one, being known from the Carboniferous, and at the present time is represented by two living genera, Lycopodium and Phylloglossum, a monotypic genus known only from Australia and New Zealand.

In Baker's "Handbook of Fern Allies" (1887) the genus Lycopodium is divided into four sub-genera:-

Sub-genus I. SELAGO. Sporangia placed in the axils of unaltered leaves all down the stem. Leaves multifarious.

Sub-genus II. SUBSELAGO. Sporangia in indistinct terminal spikes. Leaves multifarious.

Sub-genus III. LEPIDOTIS. Sporangia aggregated into distinct terminal spikes. Leaves multifarious.

Sub-genus IV. DIPHASIUM. Sporangia collected into terminal spikes, with small bracts. Leaves distichous and dimorphous.

Pritzel (1901) recognised two sub-genera only, differing in general organisation of the sporophyte and in the exospore morphology:-

Sub-genus I. UROSTACHYA, in which the species have branched or unbranched stems that are erect or pendant; no adventitious roots along the stem; foliage leaves and sporophylls mostly approximate the same size; exospore pitted or granular.

Sub-genus II. RHAPALOSTACHYA, in which the species have prostrate stems with upright branches; adventitious roots borne along the length of the prostrate portion of the creeping stem; sporophylls in well defined strobili, and different from the foliage leaves; exospore reticulate.

Herter (1909), on the other hand, divides the genus into six sub-genera, of which UROSTACHYA (which he raises to generic rank in later papers), contains the largest number of species and is the only sub-genus with which he has dealt systematically. This sub-genus, which is that of Pritzel (1901) with certain emendations, Herter (1909) divides into:- (1) Eurostachys, with leaves and sporophylls alike; (2) Heterostachys, with strobili differentiated from vegetative parts.

The most recent classification, that of Walton and Alston (1938), is a simplification of Herter's, maintaining the six sub-genera of that author, but raising certain of Baker's groups to sub-generic rank. The arrangement of Walton and Alston is as follows:-

Sub-genus I. UROSTACHYS.

Section 1. Selago. Erect terrestrial species. Leaves and sporophylls similar.

Section 2. Sub-Selago. Pendant epiphytes. Leaves and sporophylls similar.

Section 3. Phlegmaria. Strobili strongly different from vegetative parts.

Sub-genus II. CLAVATOSTACHYS, corresponds with Baker's Group of *L. clavatum*.

Sub-genus III. COMPLANATOSTACHYS, corresponds with Baker's sub-genus DIPHASIUM with the addition of *L. casuarinoides*.

Sub-genus IV. CERNUOSTACHYS, corresponds with Baker's Group of *L. cernuum*, excluding *L. casuarinoides*.

Sub-genus V. INUNDATOSTACHYS, corresponds with Baker's Group of *L. inundatum*.

Sub-genus VI. LATERALOSTACHYS, corresponds with Baker's Group of *L. laterale* and includes only two species *L. diffusum* and *L. laterale*.

It has not been found practicable to employ any of the foregoing systems of classification in the account of the spores which follows. Instead, the scheme here adopted is one in which the species are arranged in groups according to spore characters alone, since the purpose of this investigation is to provide a comparative account of spore morphology and not a taxonomic treatment of the genus.

Of the 94 species of Lycopodium enumerated by Baker, I have been able to obtain for examination 91 and a number of varieties. During recent years many previously named varieties have been accorded specific rank, bringing the number of species in Lycopodium to over 300. In the present work it has been considered unnecessary to examine all the varietal forms, and the species enumerated by Baker (1887) have been regarded as adequate for description in most cases. Where varietal forms, now raised to specific rank, have been examined, they have been found to be essentially similar to the species from which they have been segregated.

Method of Treatment and Keys.

A uniform method of treatment and examination has been maintained throughout. The strobili were boiled for one minute in 10% KOH, washed in distilled water and dehydrated in Absolute Alcohol. Two mounts were made from each sample, one in Glycerine Jelly stained with Malachite Green and the other in Euparal-Vert. On each slide not less than 10 spores were measured and the average of the measurements recorded.

For each group of species a key has beem devised. In the preparation of the keys it has been necessary to utilise measurements of minute characters. The description of the microspores is based upon examination under a magnification of 350 diameters.

Key to the Genera Lycopodium, Phylloglossum, Selaginella and Isoetes.

A. Spores ovoid in outline, bi-lateral ... *Isoetes*.

AA. Spores spherical to triangular in outline, tetrahedral.

- B. Exospore without ornamentation ... *Selaginella*.
- BB. Exospore with ornamentation.
  - C. Exospore bearing emergent processes ... ... *Selaginella*.
  - CC. Exospores not bearing emergent processes
    - D. Exospore pitted ... *Lycopodium*.
    - DD. Exospore ridged or reticulate ... *Lycopodium*. *Phylloglossum*.

GENUS I. LYCOPODIUM.

Key to Species Groups in Lycopodium.

A. Spore ornamentation reticulate or with anastomosing ridges ... ... IV. Group *Clavatum*.

AA. Spore ornamentation not as above.

- B. Spore ornamentation pitted.
  - C. Pits round, distinct.
    - D. Sides of spore more or less concave, angles truncate I. Group *Selago*.
    - DD. Sides of spore straight or convex II. Group *Phlegmaria*.
  - CC. Pits coalescent or elongate III. Group *Verticillatum*.
- BB. Spore ornamentation spinose ... *L. densum*.

Exospore Morphology of Lycopodium Species.

GROUP I. Group of L. Selago.

Spores measuring 25μ - 45μ. Sub-triangular in outline in polar view. Sides concave and angles truncate. Exospore ornamented with shallow pits averaging 2 in diameter, spaced 2 - 5 apart.

Key to the species.

A. Spore diameter more than 35μ.

  B. Pits 2μ - 3μ across ... L. Selago fig. 1.

  BB. " 1μ " ... L. fontinaloides fig. 2.

AA. Spore diameter less than 35μ.

  B. Truncate angles pronounced.

    C. Pits 2μ - 3μ across L. serratum fig. 3.

    CC. " 1μ - 2μ " L. miniatum fig. 4.

  BB. Angles flattened ... L. ceylanicum fig. 5.

  L. lucidulum fig. 6.

L. ceylanicum Spring Fig. 5.

Tetrahedral, sub-triangular, 30μ - 35μ. Wall 3μ in thickness. Sides of spore slightly concave and angles truncated. Exospore pitted; pits small, 1μ - 2μ and spaced 2μ - 3μ apart. Spore margin irregular and undulating with indication of pits.

The spores are not mentioned by Spring (1842, p.38), though he remarks upon the affinity of this species with

L. lucidulum (fig. 6). Baker says the species is intermediate between L. lucidulum and L. Selago (fig. 1), and this view is corroborated by the similarity in spore structure of the three species.

L. fontinaloides Spring Fig. 2.

Tetrahedral, sub-triangular, 35μ - 40μ. Wall 3μ - 4μ in thickness. Tetrad scar extending to the margin. Corners of the spore are angular and the sides straight or slightly concave. Exospore finely punctate, the minute, 1μ, pits are regularly disposed, about 2μ - 3μ apart, on all faces.

The spores of this species are mentioned by Spring (1842, p.49).

L. lucidulum Michx. Fig. 6.

Tetrahedral, sub-triangular, 30μ - 40μ. Wall 2μ - 3μ in thickness, Tetrad scar extending to the margin. Sides of spore slightly concave, angles truncate. Exospore pitted; pits small, 1μ - 2μ, spaced 2μ - 3μ apart on the ab-apical side becoming less distinct on the apical face. Margin faintly sinuous.

The spores are described and figured by Wilson (1934, p.275).

L. miniatum Spring Fig. 4.

Tetrahedral, sub-triangular, 30μ - 40μ. Wall 3μ in thickness. Tetrad scar extending almost to the margin. Sides of spore straight or slightly concave, angles truncate.

Exospore pitted; pits small, 1μ - 2μ, spaced 3μ - 5μ apart. On the apical surface the pitting is less well marked and the pits are frequently absent from the concave sides.

The spores of this species are mentioned by Spring (1842, p.28). He remarks that this species "rapproche beaucoup" L. reflexum (fig. 29) of S. America. This similarity is not seen in the spore structure where the resemblance is with L. Selago (fig. 1). Herter (1909) classes L. miniatum with L. Selago, thus recognising their affinity.

L. Selago L. Fig. 1a and 1b.

Tetrahedral, sub-triangular, 35μ - 45μ. Wall 2μ - 3μ in thickness. Tetrad scar 2/3 radius. Sides of spore slightly concave, angles truncate. Exospore pitted; pits distinct, 2μ in diameter, regularly disposed on the ab-apical surface, about 3μ apart, becoming irregular or absent round the apical crest.

Mohl (1833) mentions the spores and gives a minute and inadequate figure. Luerssen (1889) describes the spores as having an irregular network most pronounced on the rounded face; Bruchmann (1910) states they are frequently pitted, 40μ in diameter and figured them with thickened corners. Wilson (1934, p. 275) also describes and figures the spores. Baker (1887) considers L. suberectum Lowe, L. Haleakalae Brack. and L. erubescens Brack. to be forms of Selago. Brackenridge (1854) gives no description of the last two forms and only very inadequate figures. Descriptions and figures are given by Selling (1946, p.11) which show affinities with Selago. Wilson (1934) groups L. Selago together with L. lucidulum (fig. 6) as primitive species, both exhibit characteristic concave sides and papillation.

L. serratum Thumb Fig. 3.

Tetrahedral, sub-triangular, 25μ - 35μ. Wall 2μ in thickness. Tetrad scar extending almost to the margin. Sides of spore slightly concave, angles truncate. Exospore with shallow pits 2μ - 3μ across and 3μ apart on the ab-apical surface; the apical side is almost smooth.

The earliest description of the spores of this species is by Hooker and Greville (1831, tab. 37); their figure with reticulate ornamentation is mis-leading. Spring (1842, p.39) mentions the spores under L. sulcinervium. Selling (1946, p.13) describes and figures the spores.

GROUP II. Group of L. Phlegmaria.

Spores measuring 25μ - 60μ in diameter. Tetrahedral, with sub-triangular outline; sides of spores almost straight to slightly convex. Exospore pitted. Pits small, not exceeding 3μ across, variously spaced from 2μ - 10μ apart.

Key to the species.

The spores within this large group have few features by which they can be easily separated from one another and many are indistinguishable from each other.

A. Pits rather dense and closely arranged, 2μ - 3μ apart.

B. Spore diameter greater than 40μ ...

L. funiforme	
L. robustum	fig. 8
L. Sieboldii	fig. 7
L. strictum	

BB. Spore diameter less than 40μ.

C. Spore diameter 30μ - 40μ

L. aqualipianum	fig. 9
L. callitrichaefolium	fig.10
L. carinatum	fig.11
L. casuarinoides	fig.12
L. cryptomerinum	fig.13
L. Dalhousieanum	fig.14
L. erythraeum	fig.15
L. filiforme	
L. Hamiltonii	fig.16
L. mollicomum	fig.17
L. myrsinites	fig.18
L. Phlegmaria	fig.19
L. sarmentosum	fig.20

CC. Spore diameter 25μ - 30μ.

L. dichotomum	fig.21
L. phlegmarioides	

AA. Pits arranged more than 3μ apart.

B. Pits widely spaced 5μ - 8μ apart.

C. Spore diameter greater than 40μ ...

L. firmum	fig.22
L. Hartwegianum	
L. Lindeni	fig.23
L. megastachyum	fig.24
L. Saururus	fig.25
L. Trencilla	

CC. Spore diameter 35μ - 40μ. ...

L. compactum	fig.26
L. Jamesoni	fig.27
L. obtusifolium	fig.28
L. reflexum	fig.29
L. tetragonum	fig.30

BB. Pits spaced 3μ - 5μ apart.

C. Spore diameter greater than 40μ ...

L. affine	fig.31
L. attenuatum	
L. echinatum	fig.32
L. gnidioides	fig.33
L. myrtuosum	fig.34
L. rigidum	
L. rufescens	fig.35
L. setaceum	fig.36
L. subulatum	fig.37

CC. Spore diameter 30μ - 40μ..

L. apiculatum	
L. Billardieri	fig.38
L. cancellatum	fig.39
L. coralium	
L. dacrydioides	
L. insulare	fig.40
L. linifolium	
L. nummulifolium	fig.41
L. ophioglossoides	
L. Pearcei	fig.42
L. pecten	
L. pinifolium	fig.43
L. squarrosum	
L. varium	
L. Vrieseanum.	

<u>L. affine</u> Hook. & Grev. Fig. 31.

Tetrahedral, sub-triangular, 45μ - 50μ. Walls 5μ in thickness. Tetrad scar extending almost to the margin. Sides of spore convex. Exospore pitted; pits small, 1μ and 3μ - 5μ apart.

Spring (1842, p.21) discusses the affinities of the species but does not mention the spores.

L. apiculatum Spring.

Tetrahedral, sub-triangular, 35μ. Wall thin. Tetrad scar extending to the margin. Sides of spore straight to convex. Exospore pitted; pits small, 1μ deep and regularly spaced 3μ apart.

No mention of the spores of this species has been found in the literature. Baker (1887) states it is nearly allied to L. Phlegmaria (fig. 19); the spores of the two species are similar.

L. aqualipianum Spring Fig. 9.

Tetrahedral, sub-triangular, 30μ - 35μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, regular and spaced 2μ - 3μ apart.

L. attenuatum Spring.

Tetrahedral, sub-triangular, 40μ. Wall 3μ in thickness. Tetrad scar extending to the margin. Sides of spore almost straight or slightly convex. Exospore pitted; pits small, 1μ, spaced 3μ - 5μ apart.

The spores of this species are mentioned by Spring (1842, p.8); he remarks on the close affinity to L. erythraeum (fig. 15).

L. Billardieri Spring   Fig. 38.

Tetrahedral, sub-triangular, 35μ - 40μ. Wall 3μ in thickness. Tetrad scar extending to the margin. Side of spore slightly convex. Exospore pitted; pits 2μ across and varying from 3μ - 7μ apart.

No description of the spores of this species has been found in the literature.

L. callitrichaefolium Mett. fil.   Fig. 10.

Tetrahedral, sub-triangular, 35μ - 40μ . Wall 2μ in thickness. Tetrad scar extending to the margin. Sides of spore convex. Exospore pitted; pits small, deep and regularly arranged 2μ - 3μ apart.

No description of the spores of this species has been found in the literature. Both Baker (1887) and Herter (1909) relate the species to L. Phlegmaria (fig. 19), and the spore sculpturing is similar in the two species.

L. cancellatum Spring   Fig. 39.

Tetrahedral, sub-triangular, 30μ - 35μ . Wall 2μ - 3μ in thickness. Tetrad scar extending to the margin. Sides of spore straight. Exospore pitted; pits small, 1μ - 2μ across, regularly arranged 3μ - 5μ apart.

L. carinatum Desv.   Fig. 11.

Tetrahedral, sub-triangular, 35μ - 40μ. Wall 2μ in thickness. Tetrad scar extending almost to the margin. Sides of spore straight and angles rounded. Exospore pitted; pits small, 1μ, regularly spaced 2μ - 4μ apart.

The spores of this species are mentioned by Hooker and Greville (1831, tab. 181).

<u>L. casuarinoides</u> Spring Fig. 12.

Tetrahedral, sub-triangular, 30μ - 40μ. Wall thin. Tetrad scar extending to the margin. Sides of spore slightly convex. Exospore pitted; pits small, 1μ, spaced 2μ - 3μ apart.

The spores of this species are mentioned by Spring (1842, p.45).

<u>L. compactum</u> Hook Fig. 26.

Tetrahedral, sub-triangular, 35μ - 45μ. Wall 2μ - 3μ in thickness. Tetrad scar extending to the margin. Sides of spore convex. Exospore pitted; pits small, 1μ, spaced 5μ - 8μ apart on all surfaces.

The spores of this species are mentioned by Spring (1842, p. 9).

<u>L. coralium</u> Spring

Tetrahedral, sub-triangular, 30μ - 35μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, regularly spaced 3μ apart.

L. cryptomerinum Maxim. Fig. 13.

Tetrahedral, sub-triangular, 30μ - 40μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits 1μ - 2μ across and regularly spaced 2μ - 3μ apart.

L. dacrydioides Baker

Tetrahedral, sub-triangular, 35μ - 40μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, and spaced 3μ - 5μ apart.

L. Dalhousieanum Spring Fig. 14.

Tetrahedral, sub-triangular, 35μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Sides of spore slightly convex. Exospore pitted; pits small, 1μ, regularly arranged and closely set 2μ apart.

The spores of this species are mentioned by Spring (1842, p. 25).

L. dichotomum Jacq. Fig. 21.

Tetrahedral, sub-triangular, 25μ - 30μ. Wall thin. Tetrad scar extending almost to the margin. Exospore pitted; pits small, 1μ, shallow and closely spaced 2μ apart.

L. echinatum Spring Fig. 32.

Tetrahedral, sub-triangular, 55μ - 60μ. Wall 5μ in thickness. Tetrad scar extending to the margin. Sides of spore convex. Exospore pitted; pits small, 1μ, and spaced 3μ - 5μ apart.

The spores of this species are mentioned by Spring (1842, p. 24).

L. erythraeum Spring Fig. 15.

Tetrahedral, sub-triangular, 30μ - 40μ. Wall 3μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, and 2μ - 3μ apart.

The spores of this species are mentioned by Spring (1842, p. 7).

L. filiforme Roxb.

Tetrahedral, sub-triangular, 30μ - 35μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits 2μ across and regularly spaced 2μ - 3μ apart.

No mention of the spores of this species has been found in the literature. Baker remarks that this species is scarcely more than a slender form of L. Phlegmaria (fig. 19) and the spores of the two are almost indistinguishable from one another.

L. firmum Mett. Fig. 22.

Tetrahedral, sub-triangular, 40μ - 50μ. Wall 5μ - 6μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits minute and spaced 5μ apart.

L. funiforme Cham.

Tetrahedral, sub-triangular, 40μ- 45μ. Wall thin. Tetrad scar extending to the margin. Exospore pitted; pits 2μ- 3μ across on the ab-apical side, closely spaced tending to give a reticulate appearance; the apical surface is smooth.

L. gnidioides Lf. Fig. 33.

Tetrahedral, sub-triangular, 40μ- 45μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, and regularly spaced 3μ- 4μ apart.

The spores of this species are mentioned by Hooker and Greville (1831, tabl. 50) with a small inadequate figure.

L. Hamiltonii Spring Fig. 16.

Tetrahedral, sub-triangular, 30μ. Wall thin. Tetrad scar extending to the margin. Sides of spore convex, angles rounded. Exospore pitted; pits 2μ across and spaced 2μ - 3μ apart, giving a superficial reticulate appearance.

The spores of this species are mentioned by Hooker and Greville (1831, tab. 233) under the specific name L. aloifolium Wall, and by Spring (1842, p. 16).

L. Hartwegianum Spring

Tetrahedral, sub-triangular, 35μ- 45μ. Wall 3μ in thickness. Tetrad scar extending to the margin. Sides of spore almost straight. Exospore pitted; pits small, 1μ, and spaced 5μ - 7μ apart.

The spores of this species are mentioned by Spring (1842, p. 14).

<u>L. insulare</u> Carm. Fig. 40.

Tetrahedral, sub-triangular, 35μ - 40μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Sides of spore almost straight. Exospore pitted; pits small, 1μ, regularly spaced 3μ - 4μ apart.

Baker remarks that this species may be an extreme form of <u>L. Saururus</u> (fig. 25); the spores of both species are very similar.

<u>L. Jamesoni</u> Baker Fig. 27.

Tetrahedral, sub-triangular, 35μ - 40μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Sides of spore almost straight. Exospore pitted; pits small, 1μ, regularly spaced 5μ - 8μ apart.

<u>L. Lindeni</u> Spring Fig. 23.

Tetrahedral, sub-triangular, 40μ - 50μ. Wall 3μ - 4μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits minute, regularly arranged, 5μ - 8μ apart.

The spores of this species are mentioned by Spring (1842, p. 27).

L. linifolium L.

Tetrahedral, sub-triangular, 35μ - 40μ. Wall 3μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, across and spaced 3μ - 5μ apart.

The spores of this species are mentioned by Spring (1842, p. 31).

L. megastachyum Baker Fig. 24.

Tetrahedral, sub-triangular, 40μ - 45μ. Wall 3μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, and irregularly spaced, varying from 3μ - 10μ apart. The surface of the spore appears rugose and the margin minutely sinuous.

L. mollicomum Mart. Fig. 17.

Tetrahedral, sub-triangular, 35μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Sides of spore slightly convex. Exospore pitted; pits 2μ across, regularly spaced 2μ - 3μ apart.

L. myrsinites Lam. Fig. 18.

Tetrahedral, sub-triangular, 35μ. Wall thin. Tetrad scar extending to the margin. Sides of spore convex. Exospore pitted; pits 2μ across, regularly spaced 2μ apart.

The spores of this species are mentioned by Spring (1842, p. 29).

L. myrtuosum Spring Fig. 34.

Tetrahedral, sub-triangular, 40μ - 55μ. Wall 4μ - 5μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits minute and spaced 3μ - 5μ apart.

The spores of this species are mentioned by Spring (1842, p. 10).

L. nummularifolium Blume Fig. 41.

Tetrahedral, sub-triangular, 35μ - 40μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Sides of spore almost straight. Exospore pitted; pits small, 1μ - 2μ across, regularly spaced 3μ - 4μ apart.

The spores of this species are described by Hooker and Greville (1831, tab. 212).

L. obtusifolium Sw. Fig. 28.

Tetrahedral, sub-triangular, 35μ - 40μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Sides of spore almost straight. Exospore pitted; pits minute and spaced 3μ - 8μ apart.

L. ophioglossoides Lam.

Tetrahedral, sub-triangular, 35μ - 40μ. Wall 3μ - 4μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ - 2μ, and regularly spaced 3μ - 5μ apart.

L. pecten Baker

Tetrahedral, sub-triangular, 35μ - 45μ. Wall 3μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, and regularly spaced 3μ - 5μ apart.

L. Pearcei Baker Fig. 42.

Tetrahedral, sub-triangular, 30μ - 35μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, and regularly spaced 3μ - 5μ apart on the ab-apical side; round the apical crest the pits are more scattered.

L. Phlegmaria L. Figs. 19a and 19b.

Tetrahedral, sub-triangular, 30μ - 40μ. Wall less than 2μ in thickness. Tetrad scar extending to the margin. Sides of spore convex. Exospore pitted; pits small, 2μ, regular and spaced 2μ - 3μ apart on the ab-apical surface; round the apical crest the pits are absent.

The spores of this species or its many varieties have been described by several authors. The earliest mention is by Spring (1842, p.11); Lüstner (1898, p.11) describes the spores of the type Phlegmaria as "tupfelsporen". They are figured by Pritzel (1901, fig.371) to show the pitted exospore. Robinson (1914) discusses the species and the included varieties; one of the varieties, L. Mannii (Hillebr.) Skottsb., raised to specific rank by Skottsberg (1942, p. 132), is figured and described by Selling (1946, p. 16). The spores are similar to those of L. Phlegmaria.

L. phlegmarioides Gaudich.

Tetrahedral, sub-triangular, 25μ - 30μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, regularly spaced 2μ apart.

L. pinifolium Blume Fig. 43.

Tetrahedral, sub-triangular, 30μ - 35μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, and spaced 3μ apart.

The spores of this species are mentioned by Spring (1842, p. 58).

L. reflexum Lam. Fig. 29.

Tetrahedral, sub-triangular, 35μ - 45μ. Wall 4μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits minute and spaced 4μ apart.

L. rigidum Gmel.

Tetrahedral, sub-triangular, 40μ - 45μ. Wall 4μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, spaced 3μ - 4μ apart.

Spring (1842, p. 23) and Baker (1887) both indicate that this species is very near to L. reflexum (fig. 29), and in both species the spore structure is closely similar.

L. robustum Klotzsch   Fig. 8.

Tetrahedral, sub-triangular, 40μ - 45μ. Wall 3μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits 2μ across and spaced 2μ - 3μ apart.

L. rufescens Hook.   Fig. 35.

Tetrahedral, sub-triangular, 40μ - 45μ. Wall 3μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits minute and regularly spaced 3μ - 5μ apart.

L. sarmentosum Spring   Fig. 20.

Tetrahedral, sub-triangular, 35μ - 40μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ - 2μ across and spaced 2μ - 3μ apart giving the appearance of a fine meshed reticulum.

The spores of this species are mentioned by Spring (1842, p. 13).

L. Saururus Lam.   Fig. 25.

Tetrahedral, sub-triangular, 40μ - 45μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, spaced 5μ - 8μ apart.

The spores of this species are described by Hooker and

Greville (1831, tab. 224) under L. crassum; they gave a minute figure showing a tri-radiate mark but no ornamentation.

L. setaceum Hamilt. Fig. 36.

Tetrahedral, sub-triangular, 35μ - 45μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, and regularly spaced 4μ apart. The pitting is most pronounced on the ab-apical side becoming indistinct round the apical crest.

The spores of this species are described by Hooker and Greville (1831, tab. 49); they give minute figures of spores and tetrads. Spring (1842, p. 43) also mentions the spores.

L. Sieboldii Miguel Fig. 7.

Tetrahedral, sub-triangular, 35μ - 45μ. Wall thin. Tetrad scar extending to the margin. Exospore pitted; pits 2μ - 3μ across and closely spaced 2μ apart giving a finely reticulate appearance to the ab-apical surface. The apical side is almost without ornamentation.

L. squarrosum Forst.

Tetrahedral, sub-triangular, 35μ - 40μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, regularly spaced 3μ - 5μ apart.

The spores of this species are described and figured by Hooker and Greville (1831, tab. 185) under the name L. Hookeri;

they are also mentioned by Spring (1842, p. 53).

L. strictum Baker

Tetrahedral, sub-triangular, 40μ - 45μ. Wall 3μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, spaced 2μ - 3μ apart.

L. subulatum Desv. Fig. 37.

Tetrahedral, sub-triangular, 40μ - 45μ. Wall 3μ in thickness. Tetrad scar extending to the margin. Sides of spore convex. Exospore pitted; pits small, 1μ, and spaced 5μ apart.

L. tetragonum Hook. & Grev. Fig. 30.

Tetrahedral, sub-triangular, 35μ - 40μ. Wall 3μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, spaced 5μ - 8μ apart.

The spores of this species are described by Hooker and Greville (1831, tab. 109) and by Spring (1842, p. 12).

L. Trencilla Sodire

Tetrahedral, sub-triangular, 40μ. Wall 3μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, deep and spaced 5μ - 8μ apart.

L. varium R. Br.

Tetrahedral, sub-triangular, 40μ - 45μ. Wall 3μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ, deep and spaced 3μ - 5μ apart. The spore margin is slightly indented, due to the deep pitting.

the spores of this species are described by Hooker and Greville (1831, tab. 112).

L. Vrieseanum Spring

Tetrahedral, sub-triangular, 35μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 1μ deep and regularly spaced 3μ apart.

The spores of this species are mentioned by Spring (1842, p. 33).

GROUP III. Group of L. verticillatum.

Spores measuring 30μ - 45μ Tetrahedral, sub-triangular in outline with slightly convex sides. Exospore rugose and irregularly pitted. The pits tend to coalesce and form channels, separated by short, uneven ridges.

Key to the species.

A. Channels confined to the equatorial margin ... ... L. taxifolium fig. 44

AA. Channels on all surfaces.

B. Channels pronounced.

C. Spore diameter 35μ L. verticillatum fig. 45

CC. " " 30μ L. polytrichoides fig. 46

BB. Small pits between channels.

C. Spore diameter 40μ - 45μ ... L. rubrum fig. 47

CC. Spore diameter 35μ - 40μ ... L. xiphophyllum fig. 48

L. polytrichoides Klf. Fig. 46.

Tetrahedral, sub-triangular to spherical, 30μ. Wall 1μ - 2μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits shallow and close together, sometimes coalescent forming short channels.

The spores of this species are described by Kaulfuss (1824, p. 6); Spring (1849, p. 33) remarks that this "species should be placed with L. verticillatum (fig. 45) with which it is liable to be confounded", and it is noteworthy that the spores are here placed together in the same group. A description and figure are given by Selling (1946, p. 14), who states that the sculpturing recalls the "irregular reticulum of L. cernum"; the resemblance does not seem to be very close.

L. rubrum Cham. Fig. 47.

Tetrahedral, sub-triangular, 40μ - 45μ. Wall 3μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits 2μ across, coalescing to form short channels, giving the surface a rugose appearance.

The spores of this species are mentioned by Spring (1849).

L. taxifolium Sw. Fig. 44.

Tetrahedral, sub-triangular, 40μ - 45μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits small, 2μ across, close together giving the appearance of a fine network; towards the equator the pits coalesce forming short grooves, which are a characteristic feature of the spores when seen in optical section.

<u>L. verticillatum</u> L. Fig. 45.

Tetrahedral, sub-triangular, 35μ. Wall 2μ in thickness. Tetrad scar extending to the margin. Exospore pitted; pits shallow forming irregular short channels between small ridges.

The spores of this species are mentioned by Spring (1842, p. 42).

<u>L. xiphophyllum</u> Baker Fig. 48.

Tetrahedral, sub-triangular, 35μ - 40μ. Wall thin. Tetrad scar extending to the margin. Exospore pitted; pits irregular, about 2μ across, sometimes coalescing to form elongate channels and giving the superficial appearance of a reticulum.

GROUP IV. <u>Group of L. clavatum</u>.

Spores measuring 25μ - 65μ. Sub-triangular to spherical in outline. The exospore is variously ornamented with ridges which either unite to form a reticulum with alveolae of 5μ - 15μ in diameter or remain as irregular broken ridges.

<u>Key to the species</u>.

A. Exospore having a regular mesh structure on the ab-apical hemisphere.

B.	Mesh large, averaging 10μ in diameter.		
C.	Lamellae projecting from the margin about 5μ.		
D.	Spore diameter 30μ - 35μ	L. diaphanum	fig. 49
DD.	" " 35μ - 45μ		
E.	Apical crest smooth	L. contiguum L. Wightianum	fig. 50 fig. 51
EE.	" " ridged	L. vestitum	fig. 53
CC.	Lamellae low, not projecting from the margin more than 2μ.		
D.	Membranous fringe at the equator	L. volubile	fig. 54
E.	Apical crest smooth.		
F.	Mesh 7μ - 15μ	L. annotinum	fig. 55
FF.	" 5μ - 10μ	L. scariosum	fig. 52
EE.	Apical crest not smooth.		
F.	Apical crest channeled.		
G.	Channels deep	L. laterale	fig. 56
GG.	" fine	L. ramulosum	fig. 58
FF.	Apical surface granular or reticulate.		
G.	Granular	L. magellanicum	fig. 57
GG.	Reticulate	L. Sprucei	fig. 59

BB. Mesh averaging less than 10μ in diameter.		
C. Lamellae projecting from the margin 3μ - 5μ.		
D. Apical side with broken ridges	L. clavatum	fig. 61
DD. Apical side with smooth crest.		
E. Tetrad scar 2/3 radius	L. alpinum	fig. 60
EE. " " extending to margin		
F. Mesh 4μ - 5μ..	L. paniculatum	fig. 62
FF. " 7μ ...	L. complanatum	fig. 63
CC. Lamellae not projecting from surface.		
D. Tetrad scar in a furrow, surrounded by a clear area.		
E. Spore diameter 50μ - 55μ	L. adpressum	fig. 64
EE. " " 25μ - 30μ	L. cernuum	fig. 65
DD. Tetrad scar not in a furrow.		
E. Apical crest smooth.		
F. Spore diameter 40μ - 50μ	L. phyllanthum	fig. 66
FF. " 35μ - 40μ.		
G. Mesh 4μ - 5μ, deep	Phylloglossum Drummondii	fig. 67
GG. Mesh 5μ - 7μ, shallow	L. spurium	fig. 68
EE. Apical crest with delicate mesh	L. obscurum	fig. 69

AA. Exospore with irregular ridges on the ab-apical hemisphere.

B. Ab-apical surface with a broken mesh.

C. Tetrad scar in a furrow.

D. Apical side papillate	L. Drummondii	fig. 70
DD. " " with broken mesh ...	L. inundatum	fig. 71
CC. Tetrad scar not in a furrow	L. fastigiatum	fig. 72

BB. Ab-apical surface irregularly ridged.

C. Ridges anastomose ...	L. carolinianum	fig. 74
CC. " do not " ...	L. diffusum	fig. 73

<u>L. adpressum</u> Champ. Fig. 64.

Tetrahedral, almost spherical, 50μ - 55μ. Wall 5μ in thickness. Tetrad scar 2/3 radius, surrounded by a clear unornamented area. Exospore with an irregular reticulate structure on the ab-apical side; the apical surface is papillate, with papillae extending to the furrow.

The spores of this species are mentioned by Spring (1842, p. 75); they are also described and figured by Wilson (1934, p. 276).

<u>L. alpinum</u> L. Fig. 60.

Tetrahedral, almost spherical, 35μ. Wall thin. Tetrad scar 2/3 radius. Exospore regularly reticulate on the ab-apical side; mesh 5μ - 8μ, with thin lamellae, projecting at the margin about 4μ. Surrounding the apical crest ornamentation is absent, but towards the periphery a series of irregular ridges extending inwards for a distance of 15μ are united at the edge by bars of the reticulum.

This species was first mentioned by Mohl (1833) as having reticulate spores. Spring (1842, p. 104) regards it as a varietal form of L. complanatum (fig. 63), also Luerssen (1889) who describes the spores as similar in both species. The spores are described and figured by Wilson (1934) and Erdtman (1943).

L. annotinum L. Fig. 55.

Tetrahedral, almost spherical, 35μ - 40μ. Wall thin. Tetrad scar extending to the margin. Exospore reticulate; mesh 7μ - 15μ across, with thin lamellae, on the ab-apical side; on the apical surface ornamentation is marginal with a few irregular ridges extending about 10μ inwards.

The spores of this species are described by several authors, all of whom remark on the reticulate exospore. The early writers Mohl (1833) and Luerssen (1889) give only short descriptions; illustrations are given by Bruchmann (1910), Wilson (1934) and Erdtman (1943).

L. carolinianum L. Fig. 74.

Tetrahedral, almost spherical, 40μ - 50μ. Wall thin.

Tetrad scar extending to the margin, situated in a furrow bounded by irregular thickenings. Exospore sculptured with irregular sinuous ridges, sometimes giving a sub-reticulate appearance.

The spores of this species are mentioned by Spring (1842, p. 98). Wilson (1934) describes and figures the spores; he also discusses the affinities of the species.

L. cernuum L. Fig. 65.

Tetrahedral, sub-triangular to spherical, 25μ. Wall 2μ - 3μ in thickness. Tetrad scar situated in a furrow, surrounded by a definite margin. Exospore reticulate on the ab-apical side, mesh 5μ. On the apical surface the ornamentation is uneven, rugose, but not reticulate.

This species of Lycopodium is common to many parts of the the world and is mentioned frequently in literature; the spores are described by Hillebrand (1888) and Lüstner (1898), and later by Wilson (1934) who gives a detailed account with figures; Selling (1946) also describes and illustrates the spores.

L. clavatum L. Fig. 61.

Tetrahedral, almost spherical, 30μ. Wall thin. Tetrad scar extending to the margin. Exospore reticulate; mesh 4μ - 7μ, lamellae thin and projecting at the periphery 3μ. On the apical surface the reticulation is broken and irregular.

The spores of this species have been frequently referred to and figured. Mohl (1833) draws attention to the reticulate ornamentation; Hooker and Greville (1931, tab. 113), under the name L. heterophyllum, give a figure showing the reticulate structure; Luerssen (1879) and Lüstner (1898) describe and figure the spores. Wilson (1934) and Erdtman (1943) both describe in detail and illustrate the spores of this species.

L. complanatum L. Fig. 63.

Tetrahedral, sub-triangular, 30μ. Wall thin. Tetrad scar extending to the margin. Exospore reticulate on the ab-apical side; mesh 4μ - 7μ, alveolae deep and lamellae projecting at the periphery about 3μ. The apical crest is smooth and without ornamentation, but towards the equator anastomosing ridges extend inwards for a distance of 15μ.

The spores of this species have been more often described than almost any other member of the genus. Of the earlier authors mention is made by Mohl (1833) and Druce (1882), both giving small diagrams showing reticulation on the wall. Luerssen (1889) describes the spores as similar to those of L. clavatum (fig. 61) but with smaller and more regular reticulum, becoming indistinct or absent round the apical crest. Hegi (1936) gives a figure similar to Luerssen. Erdtman (1943) describes and figures the spores of this species as does Wilson (1934), who also discusses the systematic position of related species, some of which he considers to be ecologically conditioned.

<u>L. contiguum</u> Klotzsch   Fig. 50.

Tetrahedral, sub-triangular, 35μ - 45μ. Wall thin. Tetrad scar extending to the margin. Exospore reticulate; mesh 5μ - 10μ across, with deep alveolae and lamellae thin and projecting at the periphery up to 5μ; around the apical crest ornamentation is absent, but towards the equatorial margin an incomplete reticulation of branching ridges is observable.

The spores of this species are mentioned by Spring (1842, p. 43).

<u>L. diaphanum</u> Sw.   Fig. 49.

Tetrahedral, almost spherical, 30μ - 35μ. Wall thin. Tetrad scar extending to the margin. Exospore reticulate; mesh 5μ - 10μ, lamellae thin and projecting at the periphery from 5μ - 7μ; around the apical crest the ornamentation is absent, but towards the equatorial margin branched ridges are seen as in <u>L. contiguum</u> (fig. 50).

The spores of this species are mentioned and figured by Hooker and Greville (1831, tab. 227).

<u>L. diffusum</u> R. Br.   Fig. 73.

Tetrahedral, almost spherical, 40μ - 45μ. Wall 4μ in thickness. Tetrad scar extending to the margin. Exospore irregularly rugose; low ridges radiate from the apical crest which is itself surrounded by a thickened border.

The spores of this species are mentioned by Spring (1849, p. 39).

<u>L. Drummondii</u> Spring Fig. 70.

Tetrahedral, sub-triangular, 50μ - 55μ. Wall 5μ in thickness. Tetrad scar 2/3 radius. Exospore rugose, with irregular ridges uniting to form a mesh-like structure on the ab-apical side; the apical surface bears short, papillate ridges.

The spores of this species are mentioned by Spring (1849, p. 35).

<u>L. fastigiatum</u> R. Br. Fig. 72.

Tetrahedral, almost spherical, 35μ - 40μ. Wall thin. Tetrad scar 2/3 radius. Exospore irregularly reticulate; on the ab-apical side the ornamentation is a broken reticulum in which the lamellae have a tendency to enlarge at the ends and angles. Ornamentation is absent from the apical surface.

The spores of this species are mentioned by Spring (1849, p. 41).

<u>L. inundatum</u> L. Fig. 71.

Tetrahedral, sub-triangular, 45μ - 50μ. Wall thin.

Tetrad scar 2/3 radius, situated in an unornamented furrow. Exospore reticulate; the reticulation is irregular and the lamellae wavy, particularly on the ab-apical side. On the apical surface the mesh structure is less obvious, decreasing around the furrow.

The spores of this species are described by Luerssen (1889) and figured by Pritzel (1901, fig. 371); they are described and figured by Wilson (1934, p. 276) and by Erdtman (1943).

<u>L. laterale</u> R. Br. Fig. 56.

Tetrahedral, almost spherical, 50μ - 65μ. Wall thin. Tetrad scar 2/3 radius, conspicuous and bounded by a thickened ridge. Exospore, on the ab-apical side, irregularly reticulate, mesh large, 10μ or more, with thin lamellae and shallow lumina. The apical surface is covered with small, thin ridges alternating with elongate pits, giving a delicate veined appearance.

<u>L. magellanicum</u> Sw. Fig. 57.

Tetrahedral, sub-triangular, 45μ - 50μ. Wall thin. Tetrad scar extending to the margin. Exospore reticulate; on the ab-apical side the mesh is irregular, from 5μ - 10μ across and the lamellae 2μ in thickness. Round the apical crest the reticulation is absent and the exospore is finely granular.

<u>L. obscurum</u> L. Fig. 69.

Tetrahedral, almost spherical, 30μ - 35μ. Wall thin. Tetrad scar 2/3 radius. Exospore reticulate on the ab-apical side; mesh 5μ - 8μ across and lamellae 1μ - 2μ in thickness; the apical surface is ornamented with a delicate, inconspicuous reticulum.

The spores of this species are described and figured by Wilson (1934, p. 277).

<u>L. paniculatum</u> Desv. Fig. 62.

Tetrahedral, sub-triangular, 30μ - 35μ. Wall thin. Tetrad scar extending to the margin. Exospore reticulate; mesh 4μ - 5μ, lamellae thin and projecting 3μ from the periphery; the apical surface is without ornamentation.

The spores of this species are mentioned by Spring (1842, p. 95).

<u>L. phyllanthum</u> Hook. & Arn. Fig. 66.

Tetrahedral, sub-triangular, 40μ - 50μ. Wall 3μ in thickness. Tetrad scar extending to the margin. Exospore reticulate; mesh 5μ, irregular with deep lumina and the lamellae uneven and wavy. The reticulation is less marked on the apical surface and absent around the crest.

The spores of this species are figured by Pritzel (1901, fig. 371); they are described and figured by Selling (1946, p. 15).

<u>L. ramulosum</u> Kirk Fig. 58.

Tetrahedral, almost spherical, 50μ. Wall 5μ in thickness. Tetrad scar 2/3 radius. Exospore reticulate on the ab-apical side; mesh 5μ - 12μ; the apical surface is finely channeled and pitted.

<u>L. scariosum</u> Forst. Fig. 52.

Tetrahedral, almost spherical, 30μ. Wall thin. Tetrad scar extending to the margin. Exospore reticulate; mesh 5μ - 10μ, variable in diameter; lamellae thin and lumina shallow; ornamentation is absent from the apical surface.

<u>L. Sprucei</u> Baker Fig. 59.

Tetrahedral, almost spherical, 45μ - 50μ. Wall thin. Tetrad scar 2/3 radius, situated in an unornamented furrow. Exospore reticulate; on the ab-apical side a series of irregular anastomosing ridges form a coarse reticulum; on the apical surface a thin walled delicate mesh structure is developed extending from the crest to the periphery.

<u>L. spurium</u> Willd. Fig. 68.

Tetrahedral, almost spherical, 35μ - 40μ. Wall thin. Tetrad scar extending to the margin. Exospore reticulate; on the ab-apical side the reticulum is irregular, frequently broken, with a mesh of from 5μ - 7μ; ornamentation is absent from the apical surface.

The spores of this species are mentioned by Spring (1849, p. 49).

L. vestitum Desv. Fig. 53.

Tetrahedral, almost spherical, 35µ - 40µ. Wall thin. Tetrad scar 2/3 radius. Exospore reticulate; on the ab-apical side the mesh measures 5µ-10µ across and the thin lamellae project 5µ at the periphery. On the apical surface the ornamentation is of sinuous irregularly shaped ridges.

L. volubile Forst. Fig. 54.

Tetrahedral, sub-triangular, 35µ - 40µ. Wall thin. Tetrad scar extending to the margin. Exospore irregularly reticulate on the ab-apical side; round the apical crest ornamentation is absent. A thin membranous frill, 5µ deep, encircles the spore at the equator.

The spores of this species are mentioned by Hooker and Greville (1831, tab. 170), and a small figure given but showing no ornamentation.

L. Wightianum Wall Fig. 51.

Tetrahedral, almost spherical, 40µ - 45µ. Wall thin. Tetrad scar extending to the margin. Exospore reticulate; mesh 5µ - 10µ, lamellae thin and projecting 5µ from the periphery; ornamentation is absent from the apical furrow, but irregular ridges are developed towards the periphery as in L. contiguum (fig. 50).

Species of Lycopodium with Spinose Exospore.

L. densum Labill. Fig. 75.

Tetrahedral, sub-triangular, 35μ - 40μ. Wall thin. Tetrad scar extending to the margin. Exospore on the ab-apical side covered with spinose processes, 3μ - 5μ long and spaced 5μ - 7μ apart. The apical surface is without ornamentation.

This is the only species of Lycopodium which has been noted to have spinose ornamentation, giving an echinate appearance to the spores.

The spores of this species are figured by Pritzel (1901, fig. 371).

GENUS II. PHYLLOGLOSSUM.

The single species of this genus P. Drummondii is found in Australia and New Zealand. It is a small plant, only a few centimetres high, with a short axis arising from an annually produced tuber. The axis terminates in a strobilus of the Urostachys type. Sporangia homosporous.

P. Drummondii Kunze Fig. 67.

Tetrahedral, sub-triangular, 35μ - 40μ. Wall thin. Tetrad scar extending to the margin. Exospore reticulate; mesh 5μ, of irregular shape, lamellae 2μ in thickness; round the apical crest ornamentation is absent.

The spores of this species are figured by Eames (1936, after Bertrand).

The resemblance of the two genera Lycopodium and Phylloglossum, especially in the structural features of the strobilus, probably indicate a close relationship. Phylloglossum is regarded by Eames (1936) as a "reduced Lycopod", which has become adapted structurally to the "tuberous perennial" habit. "It is not a simple and extremely primitive plant but one whose apparent simplicity is the result of specialisation."

It is of interest to note that the spores of Phylloglossum resemble closely those of Lycopodium phyllanthum (fig. 66), and by reason of the similarity, the species has been included in the key to Group IV of the Lycopodiaceae.

Spore Structure in LYCOPODIACEAE.

From the foregoing account of spore morphology in the LYCOPODIACEAE it becomes of interest to consider to what extent spore characters may contribute to any scheme of classification, and how far the spore types may be correlated with the habit and phytogeography of the species. The most recent systematic arrangement of Walton and Alston (1938), which recognises six subgenera, will be examined from this point of view.

Sub-genus I, UROSTACHYS, which includes the largest number of species (71), is divided into three sections. In Section I, Selago, the species are of the erect, terrestrial type, while Sections 2 and 3, Subselago and Phlegmaria, contain the epiphytic, pendant species. All species of the subgenus UROSTACHYS are characterised by the possession of a pitted exospore. The pits are various in size and shape and the exospore may be finely pitted or exhibit coarse irregular pits. In the majority of species the pits are small and round, averaging 2μ - 3μ in diameter, some closely set together and others widely spaced. But no particular type of pitting is characteristic of any one of the three sections of the subgenus, and it cannot be claimed that the exospore ornamentation bears any relationship either to epiphytism or edaphic conditions. Nor is there any correlation with geographical distribution, since in the subgenus UROSTACHYS tropical, temperate and arctic species are included.

In the six species of the Selago section, however, L. ceylanicum (fig. 5), L. fontinaloides (fig. 2), L. lucidulum (fig. 6), L. miniatum (fig. 4), L. Selago (fig. 1) and L. serratum (fig. 3), the spores have a characteristic shape, exhibiting straight or slightly concave sides and truncate angles. This shape has been noted in no other subgenus of the family and the six species referred to above comprise the Group of L. Selago of the present author.

The remaining five subgenera of Walton and Alston include species which are all terrestrial, with prostrate stems and the species have a wide geographical distribution. Pritzel (1901) united these five subgenera in his subgenus RHAPALOSTACHYS, and, as he recognised, all species included have spores with reticulate ornamentation of the exospore, with one exception, L. densum (fig. 75) in which the spore wall is spinose. The reticulation varies from a small regular mesh with thin lamellae to a large mesh with lamellae of varying thickness. The regular network may be replaced by a pseudoreticulum of irregular, sinuous ridges as in L. carolinianum (fig. 74) and L. diffusum (fig. 73).

In Sub-genus II, CLAVATOSTACHYS, the mesh of the reticulum averages from 5μ - 10μ. The spores are characterised by having an apical surface which is either smooth or finely pitted or with short, irregular ridges which may extend inwards for a short distance from the margin or unite to form an irregular network around the apical crest.

Sub-genus III, COMPLANATOSTACHYS, comprises six species in which the spore morphology lacks uniformity. Four species, L. complanatum (fig. 63), L. scariosum (fig. 52), L. volubile (fig. 54) and L. Wightianum (fig. 51), are typically reticulate on the ab-apical hemisphere, and with sculpturing poorly developed or absent on the apical side.

L. carolinianum (fig. 74), with irregular sinuous ridges uniting in a network, has a characteristic appearance reminiscent of L. inundatum (fig. 71), with which Wilson (1934) suggests the species might justifiably be grouped. L. casuarinoides (fig. 12) is exceptional in having a finely pitted exospore.

Sub-genus IV, CERNUOSTACHYS, includes three species all with differing forms of sculpturing and one is the exceptional spinose spore type of L. densum (fig. 75). The other two species L. cernuum (fig. 65) and L. obscurum (fig. 69) have spores which are reticulate on the ab-apical face, and on the apical surface L. cernuum is papillose while L. obscurum has a delicate mesh.

Sub-genus V, INUNDATOSTACHYS, includes the three species L. inundatum (fig. 71), L. adpressum (fig. 64) and L. Drummondii (fig. 70). All three possess a tetrad scar which lies in a furrow surrounded by a clear unornamented area. The ab-apical surface is irregularly reticulate and on the apical side this network is replaced by uneven papillae or ridges.

Sub-genus VI, LATERALOSTACHYS, contains the two species L. diffusum (fig. 73) and L. laterale (fig. 56) which are quite dissimilar, the former rugose and ridged and the latter exhibiting a wide meshed network on the ab-apical side and on the apical is finely channeled.

It is apparent, therefore, that in LYCOPODIUM the spore morphology adds supporting evidence to the taxonomy of the genus only in a general way. Nevertheless, it should be admitted that Pritzel's division into two subgenera, based on spore characters, is more easily maintained than the division into six subgenera, since the spores fall definitely into two major well defined groups, the pitted and the reticulate. Such characteristic ornamentation easily distinguishes the spores of Lycopodium and Phylloglossum from those of other members of the LYCOPODIINAE, and it has been employed as the basis of division into the groups which have been suggested in the foregoing pages.

There is no apparent connection between spore sculpturing on the one hand and ecological conditions on the other; nor is there any obvious biological signification either in the pitted or reticulate pattern of the exospore.

SELAGINELLACEAE.

General Characters and Classification.

The family Selaginellaceae comprises a single genus with over 600 species. While they exhibit a considerable variety of growth-form, in most species the shoot system is usually creeping and dorsiventral with small leaves arranged in four ranks. The root system is produced from rhizophores, leaves and sporophylls are ligulate, and the sporangia, usually borne in distinct strobili, are of two types, the plants being heterosporous.

The genus has a world wide distribution, but most of the species grow in damp forests of tropical regions and are essentially hygrophilous. Some xerophilous species are able to withstand desiccation for months; the stems curl up when dry and expand when moistened.

One of the earliest classifications of the genus was that of Spring (1849) who distinguished two main groups which he designated:-

Section I, Homoeophylla, species with leaves all alike,

Section II, Heterophylla, species with leaves dimorphous.

The later section, which contains the larger number of species, was sub-divided according to the nature of the strobilus and the morphological character of the stems and leaves.

Spring was followed by Baker (1887) who advanced a more detailed and elaborate arrangement in "Fern Allies" and recognised four sub-genera as follows:-

Sub-genus I. Selaginella proper, with ordinary leaves all alike. This is virtually the same as Spring's Section Homoeophylla.

Sub-genus II. Stachygynandrum, with dimorphous leaves and uniform sporophylls. This sub-genus contains the largest number of species (259), and Baker divides it into six series. The species within the series are classified first, according to habit, and secondly, according to the arrangement of the stems, leaves and rhizophores.

Sub-genus III. Homostachys, with dimorphous leaves and sporophylls.

Sub-genus IV. Heterostachys, with dimorphous leaves and sporophylls; spikes resupinate.

The arrangement adopted by Hieronymous (1901) resembled more closely that of Spring, having the same two sub-genera, Homoeophylla and Heterophylla, the latter being sub-divided on the basis of a complicated system depending mainly on the anatomy of the stems and leaves. The account given by Hieronymous covers some 440 species but only slight reference is made to spore morphology and only a few species are figured.

The most recent classification is that of Walton and Alston (1938) whose treatment of the genus bears a close resemblance to that of Baker, maintaining the four sub-genera of that author, and retaining the six series within the sub-genus Stachygynandrum. The names of the series are altered in some instances and there is also some modification in the serial grouping of the species, but the main variant from Baker's arrangement is in placing together all species with articulate stems in the series Articulatae.

The salient features of the classification put forward by Walton and Alston are as follows:-

Sub-genus I. EUSELAGINELLA. Leaves and sporophylls uniform.

1. Group of *S. Selaginoides*. Sporophylls spirally arranged.

2. Group of *S. pygmaea*. Strobili tetragonous.

3. Group of *S. uliginosa*. Strobili tetragonous. Leaves decussate.

4. Group of *S. rupestris*. Strobili tetragonous. Leaves linear, spirally arranged.

Sub-genus II. STACHYGYNANDRUM. Leaves dimorphous, sporophylls uniform.

Series 1. *Decumbentes*. Prostrate species with main stems rooting throughout.

Series 2. *Ascendentes*. Suberect species, often with a single banded stele.

Series 3. *Sarmentosae*. Suberect, scandent or rarely prostrate, polystelic species.

Series 4. *Caulescentes*. Erect species. The simple erect part of the stem is usually homophyllous and the branched part heterophyllous.

Series 5. *Circinatae*. Xerophilous species.

Series 6. *Articulatae*. Tropical American species with articulate stems.

Sub-genus III. HOMOSTACHYS. Leaves dimorphous. Species with creeping stems and loose strobili.

Sub-genus IV. HETEROSTACHYS. Heterophyllous species with strongly dimorphous sporophylls.

In a genus with such a vast number of species as Selaginella it is obviously difficult if not impossible to devise a wholly satisfactory classification. This has been clearly indicated by Weatherby (1944) in his discussion of the group of Selaginella Oregana where he says that "In any division of Selaginella based on habit, parallel leaf- and spore-variations will be found in different groups. But in any division based on leaf- or spore-characters, parallel variation in habit and other features will be found to quite as great an extent. And as a primary basis for systematic arrangement, habit has very real and practical virtues - so much so, that within the two great homophyllous and heterophyllous sub-genera, it has been used by all taxonomists up to the present time." In the same connection Weatherby draws attention to the usefulness of the characters of both megaspores and microspores in defining a species, but he adds a note of caution, since the appearance of the sculpturing varies with age, although the pattern is constant within the species in mature forms.

No detailed treatment of the megaspores has been attempted here since they are not used extensively in spore analysis of coals, and the primary object of the present study is to elucidate the features of importance in spore morphology which have a bearing on fossil spore classification. It is worthy of note, however, that the megaspores vary in size from $1\frac{1}{2}$ mm. to

5 mm. in diameter, and their sculpturing is of several types - tuberculate, spinose or reticulate. There is no noticeable relationship between the ornamentation of the megaspore and that of the microspore of the same species; for example, a microspore may be furnished with an equatorial flange whereas the megaspore in the same plant may have a coarsely tuberculate exospore.

The following account deals with the microspores only and a short description is given of as many species as it has been possible to obtain the sporangial material, about 350 in all. As in the genus Lycopodium the spores are arranged in groups based on spore characters; the several types of spore sculpturing are illustrated, and under the specific descriptions references are made to the appropriate figures. Where mention of the spores has been made by earlier writers the reference is given; the number after references to Hieronymous (1901) is that which he has given to the particular species under review.

GENUS I. SELAGINELLA.

Key to Species Groups in Selaginella.

A. Spores bearing a membranous wing, flange or annular ring in the equatorial region.

- B. Membrane encircling the spore body and having an equatorial expansion ... I. Group *Sibirica*.
- BB. Membrane not encircling the spore body.
  - C. Spores with an annular ring ... ... IV. Group *Scandens*
  - CC. Spores with membranous equatorial flange.
    - D. Flange notched, 5μ - 10μ wide II. Group *Sanguinolenta*
    - DD. Flange undulate or fimbriate; membrane strutted ... III. Group *Megastachys*

AA. Spores without equatorial wing or flange.

- B. Spore margin entire.
  - C. Exospore smooth, without ornamentation V. Group *Firmula*
  - CC. Exospore granular VI. Group *Helvetica*
- BB. Spore margin uneven.
  - C. Spore margin crenulate ... VII. Group *Cathedrifolia*
  - CC. Spore margin sinuate, toothed or with apparent processes.
    - D. Ornamentation of blunt processes.

E. Processes low, rounded and broader than long.

F. Processes 2μ - 5μ, broad at base.

G. Processes small, closely set, 1μ - 3μ apart — IX. Group <u>Leptophylla</u>

GG. Processes set 2μ - 5μ apart — VIII. Group <u>Radicata</u>

FF. Processes 3μ - 8μ broad at base.

G. Processes irregularly spaced, 2μ - 5μ apart — X. Group <u>Vaginata</u>

GG. Processes flat, close set, separated by channels — XI. Group <u>Repanda</u>

EE. Processes thin, rod-like, longer than broad.

F. Rod-like processes, 2μ - 5μ long.

G. Processes densely packed — XII. Group <u>Stolonifera</u>

GG. Processes sparsely packed — XIII. Group <u>Biformis</u>

FF. Rod-like processes 5μ - 10μ long — XIV. Group <u>Latifrons</u>

DD. Ornamentation of pointed processes.

E. Processes thin, acicular, 3μ - 8μ long, set 5μ - 10μ apart — XVIII. Group <u>Magnifica</u>

EE. Processes with base 2μ or more broad.

F. Stout conical processes, base 5μ or more broad.

- G. Long curved spines — XX. Group Kraussiana
- GG. Straight spines 5μ - 10μ long — XIX. Group Selaginoides

FF. Spinose processes with base 2μ.

- G. Spines widely spaced, 5μ - 8μ apart — XV. Group Sub-arborescens
- GG. Spines densely packed 2μ - 5μ apart.
  - H. Spines short, 1μ - 3μ long — XVI. Group Anceps
  - HH. Spines long, 4μ - 7μ — XVII. Group Uncinata

Exospore Morphology in Selaginella Species.

GROUP I. Group of S. sibirica.

Spores having a central spore body surrounded and enclosed by a thin transparent membrane. The surface of the membrane may be smooth, granular, pitted or setose; it is frequently wrinkled and folded. In optical section the membrane appears as an equatorial wing varying in width from 3μ - 15μ, averaging between 5μ and 10μ.

The Species of Selaginella in which the spores conform to the "Rupestris Type" have been recorded only from the Sub-genus Euselaginella (as defined by Walton and Alston, 1938) excepting their Group I of S. Selaginoides. This is equivalent to the sub-genus <u>Homoeophyllum</u>, Section II, <u>Tetrastachys</u>, of Hieronymous (1901). These authorities both recognise three distinct groups in this section of the sub-genus:-

1. Group of <u>S. pygmaea</u> (syn. <u>S. pumila</u>) with 2 species.
2. Group of <u>S. uliginosa</u> with 2 species.
3. Group of <u>S. rupestris</u> with over 40 species.

The spores of these three groups have been found by the present author to be morphologically similar and are therefore classed together in one and the same group.

<u>Key to species.</u>

A. Spores in which the membrane is inconspicuous or narrow, not exceeding 7μ in width.

  B. Surface of the membrane without ornamentation.

    C. Total spore diameter 35μ - 45μ... ... S. Schmidtii
    S. uliginosa fig. 76

    CC. Total spore diameter 40μ - 55μ .. ... S. rupestris
    S. sibirica fig. 77
    S. Standleyi

  BB. Surface of membrane with ornamentation.

    C. Surface of membrane granular.

      D. Surface finely granular. Average sise 40μ - 50μ ... S. acanthonota
      S. arenicola fig. 78
      S. densa
      S. mutica
      S. Riddellii

S. Underwoodii
S. Watsoni

DD. Surface coarsely granular. Membrane wrinkled and folded. Average size 45μ - 55μ ... S. Bigelowii
S. leucobryoides
S. Parishii
S. scopulorum
S. Sheldoni
S. strutholoides fig. 79

CC. Surface setose ... S. pygmaea fig. 80

AA. Spores in which the membrane projects 7μ - 10μ or more from the spore surface.

B. Surface coarsely granular. Average size 50μ - 60μ ... S. Dregei
S. echinata
S. Hanseni
S. peruviana
S. rupincola
S. Sartorii
S. Wallacei fig. 81
S. Wrightii

BB. Surface pitted ... ... S. Preissiana fig. 82

S. acanthonota Underw.

Sub-triangular to round, total diameter 40μ - 50μ, a few specimens larger. Tri-radiate mark extending to the margin. Central spore body, 30μ - 35μ, surrounded by a thin, granular membrane, projecting from the spore surface 5μ - 7μ.

The spores of this species are mentioned by Clausen (1946).

S. arenicola Underw. Fig. 78.

Sub-triangular, total diameter 35μ - 45μ. Tri-radiate mark extending to the margin. Central spore body, 25μ - 30μ, surrounded by a thin, granular membrane, projecting 5μ - 7μ from the spore surface and with a narrow (2μ) clear translucent border.

The spores of this species are mentioned by Hieronymous (1901, 11) and by Clausen (1946).

S. Bigelowii Underw.

Sub-triangular to spherical, total diameter 50μ - 60μ. Tri-radiate mark extending to the margin. Central spore body, 30μ - 35μ, surrounded by a thin, finely granular membrane, projecting from the spore surface 7μ - 10μ.

The spores of this species are mentioned by Hieronymous (1901, 9).

S. densa Rydb.

Spherical, total diameter 45μ - 60μ. Tri-radiate mark extending to the margin. Central spore body 30μ - 40μ surrounded by a thin, finely granular membrane, projecting from the spore surface 7μ - 10μ.

S. Dregei (Presl.) Hieron.

Almost spherical, total diameter 65μ - 75μ. Tri-radiate mark extending to the margin. Central spore body 45μ - 55μ, surrounded by a thin, coarsely granular, much folded membrane, projecting 10μ - 15μ from the spore surface, and with a translucent border (2μ).

S. echinata Baker

Sub-triangular to spherical, total diameter 50μ - 65μ. Tri-radiate mark extending to the margin. Central spore body, 35μ - 45μ, surrounded by a thin, granular, much folded membrane projecting from the spore surface 7μ- 10μ.

S. Hanseni Hieron.

Sub-triangular to spherical, total diameter 50μ- 60μ. Tri-radiate mark extending to the margin. Central spore body, 30μ- 40μ, surrounded by a thin, coarsely granular membrane projecting from the spore surface 7μ- 10μ.

The spores of this species are mentioned by Hieronymous (1901, 40).

S. leucobryoides Maxon.

Sub-triangular to round, total diameter 40μ- 50μ. Tri-radiate mark extending to the margin. Central spore body 30μ- 40μ, surrounded by a thin, finely granular, much folded membrane projecting from the spore surface 5μ.

S. mutica Eaton

Sub-triangular, total diameter 40μ- 50μ. Tri-radiate mark extending to the margin. Central spore body, 35μ- 45μ, surrounded by a thin, finely granular, much folded membrane projecting 5µ- 7µ from the spore surface.

The spores of this species are mentioned by Hieronymous (1901, 12) and Weatherby (1944).

S. Parishii Underw.

Sub-triangular, total diameter 45µ- 60µ. Tri-radiate mark 1/3 radius. Central spore body, 35µ- 45µ, surrounded by a thin, coarsely granular, wrinkled membrane projecting 5µ- 7µ from the spore surface.

S. peruviana (Milde) Hieron.

Sub-triangular to spherical, total diameter 55µ- 65µ. Tri-radiate mark extending to the margin. Central spore body 35µ- 45µ, surrounded by a thin, coarsely granular, much folded membrane projecting 10µ from the spore surface.

The spores of this species are mentioned by Hieronymous (1901, 34).

S. Priessiana Spring Fig. 82.

Sub-triangular to spherical, total diameter 40µ- 50µ. Tri-radiate mark extends almost to the margin. Central spore body 25µ- 30µ, surrounded by a thin, finely pitted membrane projecting from the spore surface 7µ- 10µ.

The spores of this species are mentioned by Spring (1849, p. 61) and Hieronymous (1901, 5).

<u>S. pygmaea</u> Kaulf. (syn. <u>S. pumila</u> Spring) Fig. 80.

Spherical, total diameter 50μ - 60μ. Tri-radiate mark extending to the margin. Central spore body 35μ - 45μ, surrounded by a thin membrane ornamented with stiff bristles about 3μ long and set 2μ - 3μ apart; the membrane projects 5μ - 7μ from the spore surface. There is a tendency for the spores to remain united in tetrads.

The spores of this species are mentioned by Kaulfuss (1824, p. 9), Spring (1849, p. 60) and Hieronymous (1901, 3).

<u>S. Riddellii</u> van Eseltine

Sub-triangular, total diameter 40μ - 50μ. Tri-radiate mark extends to the margin. Central spore body, 35μ - 45μ, surrounded by a thin, finely granular, much folded membrane projecting 3μ - 5μ from the spore surface.

The spores of this species are mentioned by Clausen (1946).

<u>S. rupestris</u> Spring

Spherical, total diameter, 45μ - 55μ. Tri-radiate mark extends almost to the margin. Central spore body, 30μ - 40μ, surrounded by a thin, nearly smooth, wrinkled membrane, projecting 5μ - 7μ from the surface of the spore body.

The spores of this species are mentioned by Milde (1859, who defines 10 varieties), Hieronymous (1901, 19), Lyon (1901), Reeves (1935, Pl. 380), Knox (1938, fig. 24) and Clausen (1946). Reeves notes the occurrence of "dumb-bell" spores which he figures; these have not been seen by the present author.

S. rupincola Underw.

Sub-triangular, total diameter 45μ - 60μ. Tri-radiate mark extending to the margin. Central spore body 30μ - 40μ, surrounded by a thin, granular membrane projecting 7μ - 10μ from the spore surface and with a narrow, 2μ, translucent rim.

The spores of this species are mentioned by Hieronymous (1901, 8).

S. Sartorii Hieron.

Sub-triangular, total diameter 50μ - 65μ. Tri-radiate mark extends to the margin. Central spore body 30μ - 45μ, surrounded by a thin, coarsely granular, much folded membrane projecting 10μ from the spore surface, with a clear narrow border, 2μ, and an undulating margin due to the irregular folding of the membrane.

The spores of this species are mentioned by Hieronymous (1901, 38).

S. Schmidtii Hieron.

Sub-triangular to spherical, total diameter 35μ - 50μ. Tri-radiate mark extends to the margin. Central spore body 30μ - 40μ, surrounded by a thin, smooth, wrinkled membrane projecting from the spore surface 3μ - 5μ.

The spores of this species are mentioned by Hieronymous (1900, p. 292; 1901, 16).

S. scopulorum Maxon

Almost spherical, total diameter 40μ - 50μ. Tri-radiate mark extending to the margin. Central spore body, 30μ - 40μ, surrounded by a thin, finely granular membrane projecting from the spore surface 5μ.

S. Sheldoni Maxon

Sub-triangular to spherical, total diameter 45μ - 55μ. Tri-radiate mark extending 1/3 to 2/3 radius. Central spore body 30μ - 40μ, surrounded by a thin, granular, much folded membrane projecting 5μ - 7μ from the spore surface.

S. sibirica (Milde) Hieron. Fig. 77.

Sub-triangular, total diameter 45μ - 55μ. Tri-radiate mark 2/3 radius. Central spore body, 35μ - 40μ, surrounded by a thin, smooth, much folded membrane projecting 5μ - 7μ from the spore surface.

The spores of this species are mentioned by Hieronymous (1901, 22).

S. Standleyi Maxon

Sub-triangular to spherical, total diameter 40μ - 50μ. Tri-radiate mark extending to the margin. Central spore body 35μ - 40μ, surrounded by a thin, almost smooth, much folded membrane projecting 3μ - 5μ from the spore surface.

S. strutholoides (Presl.) Underw. Fig. 79.

Sub-triangular, total diameter 50μ - 65μ. Tri-radiate mark extending to the margin. Central spore body, 40μ - 50μ, surrounded by a thin, finely granular, much folded membrane, projecting 5 from the spore surface.

The spores of this species are mentioned by Hieronymous (1901, 42) and by Weatherby (1944).

S. uliginosa Spring Fig. 76.

Spherical, total diameter 35μ - 50μ. Tri-radiate mark extending to the margin. Central spore body, 30μ - 40μ, surrounded by a thin, smooth, much folded membrane projecting 3μ - 5μ from the spore surface.

The spores of this species are mentioned by Hieronymous (1901, 6).

S. Underwoodii Hieron.

Sub-triangular to spherical, total diameter 40μ - 55μ. Tri-radiate mark extending to the margin. Central spore body, 35μ - 40μ, surrounded by a thin, finely granular, much folded membrane projecting 5μ - 7μ from the spore surface.

The spores are mentioned by Hieronymous (1901, 37) and Weatherby (1944).

S. Wallacei Hieron. Fig. 81.

Sub-triangular to spherical, total diameter 55μ - 70μ.

Tri-radiate mark extending almost to the margin. Central spore body, 45μ - 50μ, surrounded by a thin, coarsely granular, membrane projecting 7μ - 10μ from the spore surface.

The spores of this species are mentioned by Hieronymous (1901, 23).

S. Watsoni Underw.

Sub-triangular to spherical total diameter 40μ - 50μ. Tri-radiate mark 2/3 radius. Central spore body 30μ - 40μ, surrounded by a thin, granular folded membrane projecting 5μ - 7μ from the spore surface.

The spores of this species are mentioned by Hieronymous (1901, 14, fig. 402, J.).

S. Wrightii Hieron.

Sub-triangular to spherical, total diameter 45μ - 65μ. Tri-radiate mark 2/3 radius. Central spore body 35μ - 45μ, surrounded by a thin, granular, much folded membrane projecting from the spore surface 10μ. The margin of the membrane is sinous due to folds.

The spores of this species are mentioned by Hieronymous (1901, 24).

GROUP II. Group of S. sanguinolenta.

The spores of this group are characterised by the presence of an equatorial flange which may be almost entire, irregularly notched or serrate, projecting 5μ to 10μ from the surface of the spore body. The ab-apical hemisphere is covered by a thin wrinkled membrane or ornamented with irregular angular elevations. The apical surface may be smooth, granular or scabrid. The size of the spore body varies from 25μ - 50μ in diameter.

Key to the Species.

A. Ab-apical hemisphere with an irregular folded membrane.

B. Total diameter of spore 25μ - 45μ.

C. Total diameter 25μ - 35μ S. laevigata fig. 83
S. Lyallii
S. valdepulosa Fig. 84

CC. " " 35μ - 45μ S. saccharata fig. 85.

BB. Total diameter of spore, 45μ - 60μ

C. Total diamater 45μ - 50μ S. Aitchisonii

CC. " " 50μ - 60μ S. sanguinolenta fig.86

AA. Ab-apical hemisphere with irregular angular elevations.

B. Total diameter 35μ - 45μ; elevations warty ... S. boreale fig. 87
S. Jacquemontii

BB. Total diameter 30μ - 35μ

C. Elevations serrate ... S. pedata fig. 88

CC. " blunt, tuberculate ... S. stenophylla fig. 89

S. Aitchisonii Hieron.

Sub-triangular, spore body 35μ - 45μ, total diameter 45μ - 55μ. Tri-radiate mark extending to the margin. The apical crest is conspicuous and the apical surface is finely granular. The ab-apical hemisphere is covered by a thin wrinkled membrane which forms a notched flange round the equator, 5μ - 7μ in depth.

This species may be a variety of S. sanguinolenta (fig.86), and the spores of the two species are very similar. The spores are described by Hieronymous (1901, 44, and 1902, p.171).

S. boreale Spring Fig. 87.

Tetrahedral, sub-triangular, spore body 30μ - 40μ, total diameter of 35μ - 45μ. Tri-radiate mark extending to the margin. The exospore on the ab-apical surface is ornamented with irregular, warty processes; on the apical side the spore is almost smooth. In the equatorial plane a flange with notched rim is developed.

The spores are mentioned by Kaulfuss (1824, p.18) and Hieronymous (1901, 45).

S. Jacquemontii Spring

Tetrahedral, sub-triangular to spherical, spore body

30μ - 45μ, total diameter of 40μ - 55μ. Tri-radiate mark extending to the margin. Ab-apical hemisphere surrounded by a thin membrane with uneven warty ridges. The membrane projects beyond the spore body and is seen as an equatorial flange with an irregular edge. The spores of this species are very similar to those of S. boreale (fig. 87), and Baker (1887) considers this a synonym and also a close ally to S. sanguinolenta.

The spores of this species are described by Spring (1849, p. 194) and Hieronymous (1901, 45).

S. laevigata Baker Fig. 83.

Sub-triangular, spore body 25μ - 30μ in diameter. Tri-radiate mark extends almost to the margin; apical crest conspicuous and with a narrow flange; apical surface granular. The ab-apical hemisphere is covered with a thin, finely wrinkled membrane which appears at the equator as a transparent wing 5μ in width.

The spores of this species are mentioned by Hieronymous (1901, 372).

S. Lyallii (Hk. & Gr.) Spring

Sub-triangular, spore body 30μ - 35μ in diameter. Tri-radiate mark extends to the margin; apical surface granular. The ab-apical hemisphere is covered by a thin, finely wrinkled membrane, which projects beyond the spore margin 5μ and appears as an equatorial wing. The spores of this species resemble those of S. laevigata (fig. 83) in all essentials. They are described and figured by Hieronymous (1901, 394, fig. 408).

S. pedata Klotzsch Fig. 88.

Sub-triangular, spore body 25µ - 35µ in diameter. Tri-radiate mark extends to the margin; apical surface and crest scabrid. The ab-apical hemisphere bears irregularly serrate, rigid emergences. The equatorial ring is similarly unevenly serrate.

The spores of this species are described by Hieronymous (1901, 408).

S. saccharata A. Br. Fig. 85.

Tetrahedral, sub-triangular, spore body 30µ - 40µ dia-meter of 35µ - 45µ. Tri-radiate mark 2/3 radius. On the apical side the exospore is ornamented with large coarse ir-regular tuberculate processes; the ab-apical surface is covered by a folded membrane which appears at the equator as a trans-parent notched wing-like extension from the spore wall.

The spores are described by Hooker and Greville (1831, II, tab. 177) under the synonym, L. ovalifolium, and also by Hieronymous (1901, 181, and 1902).

S. Parkeri Spring Fig. 101.

Tetrahedral, almost spherical spore, 25µ - 35µ in diameter.

Tri-radiate mark extending to the margin; the apical crest is irregularly toothed. Ths exospore on both apical and ab-apical surfaces is ornamented with coarse, warty processes. The annular ring is 5μ in thickness and has a crenate edge.

The spores of this species are described by Spring (1849, p. 226) and Hieronymous (1901, 144).

<u>S. puberula</u> Spring   Fig. 98.

Tetrahedral, almost spherical spores 30μ - 35μ in diameter. Tri-radiate mark extending to the margin; apical surface finely granular. The ab-apical hemisphere bears irregular warty processes. The annular ring is 7μ-10μ in thickness and with a smooth entire outline.

The spores of this species are mentioned by Hieronymous (1901, 392).

<u>S. sanguinolenta</u> (L.) Spring   Fig. 86.

Sub-triangular to almost spherical, spore body 40μ - 50μ, total diameter of 50μ - 60μ. Tri-radiate furrow frequently open and extending to the margin. The apical crest is conspicuous and the apical surface is smooth to finely granular. The ab-apical hemisphere is covered by a thin, wrinkled membrane which is seen at the equator as an uneven notched flange projecting from 5μ - 10μ from the spore margin.

The spores are mentioned by Spring (1849, p. 57) and Hieronymous (1901, 43).

S. stenophylla A. Br. Fig. 89.

Sub-triangular, spore body 25μ in diameter. Tri-radiate mark extends to the margin; apical surface smooth. The ab-apical hemisphere is ornamented with low, irregular, blunt elevations, 2μ - 3μ across and 3μ - 4μ apart. An uneven notched equatorial ring, 3μ - 4μ in width, is a conspicuous feature of the spores.

The spores of this species are described by Hieronymous (1901, 184).

S. valdepilosa Baker Fig. 84.

Sub-triangular, spore body 20μ - 25μ, total diameter of 25μ - 30μ Tri-radiate mark 2/3 radius. The ab-apical hemisphere is covered by a thin membrane thrown into irregular folds which form a notched flange round the equator. The apical surface is granular.

GROUP III. Group of S. megastachys.

Spores with a spore body 25μ - 40μ in diameter. The ab-apical hemisphere is covered by a thin, transparent membrane, thrown into folds which frequently assume an areolate arrangement, supported by stout strengthening struts. In optical section this membrane projects beyond the spore surface from 5μ - 12μ, and has often a fimbriate margin. The conspicuous apical crest is either serratulate or bears a membranous flange.

The apical surface may be granular or furnished with small, rigid, more or less triangular emergences.

Key to the species.

The spores of this group are very similar and extremely difficult to distinguish from one another; the nature of the apical crest being the only definite feature by which a few species can be segregated.

A. Species in which the apical crest bears a membranous flange.

- B. Spore body 25μ - 30μ in diameter ... ... S. Mayeri fig. 90; S. quatemalensis
- BB. Spore body 35μ - 40μ in diameter ... ... S. tylophora fig. 91

AA. Species in which the apical crest is serratulate.

- B. Spore body 25μ - 30μ in diameter ... ... S. Helferi; S. integerrima fig. 92
- BB. Spore body 30μ - 40μ in diameter ... ... S. asperula fig. 93; S. flaccida fig. 94; S. Lobbii; S. megastachys fig. 96; S. Ostenfeldii; S. pseudo-prolifera; S. Schlechteri; S. semicordata fig. 97; S. Usteri; S. Willdenovii fig. 95

S. asperula vA. vR. Fig. 93.

Sub-triangular, tetrahedral spore body, 30μ - 35μ in diameter. Tri-radiate mark extends almost to the margin; apical crest and apical surface scabriolate. The ab-apical surface is covered by a thin transparent membrane thrown into folds, supported by strengthening struts.

The spores of this species are mentioned by Spring (1849, p. 225) and Hieronymous (1901, 411).

S. flaccida Spring Fig. 94.

Sub-triangular, tetrahedral spore body, 30μ - 35μ in diameter. Tri-radiate mark extends to the margin; apical crest and apical surface are scabrid as in S. asperula (fig. 93). The ab-apical hemisphere is covered by a thin, transparent membrane, folded and strengthened by struts; the membrane projects beyond the spore as a wing at the equator about 10μ and has a fimbriate border.

The spores of this species are mentioned by Hieronymous (1901, 348).

S. Helferi Warb.

Sub-triangular, tetrahedral spore body 25μ - 30μ in diameter. Tri-radiate mark extends to the margin; the apical crest and the apical surface are both furnished with small, irregular, rigid, triangular emergences. On the ab-apical hemisphere the exospore bears stick-like processes 7μ - 10μ long which act as struts for a thin, much folded membrane which covers the surface.

The spores of this species are described by Hieronymous (1901, 373).

S. integerrima Spring   Fig. 92.

Sub-triangular, tetrahedral spore body, 25μ - 30μ in diameter. Tri-radiate mark extends to the margin; apical crest and apical surface scabrid. The ab-apical hemisphere is covered by a thin membrane thrown into folds and with a few supporting struts; the membrane projects about 10μ - 15μ from the surface of the spore.

The spores of this species are mentioned by Spring (1849, p. 41).

S. Lobbii Moore

Sub-triangular, tetrahedral spore body 35μ - 40μ in diameter. Tri-radiate mark extends to the margin; the apical surface is scabriolate. The ab-apical hemisphere is covered by a thin membrane with strengthening struts which assume an areolate form. The spores of this species resemble closely those of S. semicordata (fig. 97); they are described by Hieronymous (1901, 369).

S. Mayeri Hieron.   Fig. 90.

Sub-triangular, tetrahedral spore body 25μ - 30μ in diameter. Tri-radiate mark extends to the margin; the apical crest has a conspicuous wing-like flange. The ab-apical hemisphere is covered by a thin membrane thrown into folds and occasionally strengthened by supporting struts, arranged in a pseudo-reticulate manner.

The spores of this species are described by Hieronymous (1901, 343).

S. megastachys Baker Fig. 96.

Sub-triangular, tetrahedral spore body 30μ - 40μ in diameter. Tri-radiate mark extends to the margin; the apical crest and apical surface are scabrid. The ab-apical hemisphere is covered by a thin membrane, supported by hook-like structures; at the equator the membrane projects beyond the spore as an irregularly dissected wing up to 12μ and has a fimbriate border.

The spores of this species are described by Hieronymous (1901, 361) and figured by Knox (1938, fig. 25).

S. Ostenfeldii Hieron.

Sub-triangular to spherical, spore body 30μ - 40μ in diameter. Tri-radiate mark extending to the margin; apical crest and apical surface scabrid. The ab-apical hemisphere is covered by a thin membrane, irregularly folded and supported by strengthening struts; it projects from the spore surface 10μ, and has a fimbriate border.

S. pseudo-prolØifera Hdl-Mzt.

Sub-triangular to spherical spore body 30μ - 35μ in diameter. Tri-radiate mark extending to the margin; apical crest and apical surface scabrid. The ab-apical hemisphere is covered by a thin membrane thrown into irregular folds, supported by struts and projecting 10μ from the spore surface.

S. quatemalensis Baker

Sub-triangular to spherical spore body, 25μ - 30μ in diameter. Tri-radiate mark extending to the margin; apical crest conspicuous and bearing a flange. The ab-apical hemisphere is covered by a thin membrane supported by struts which unite in an areolate pattern; the membrane projects 5μ - 10μ beyond the spore margin.

The spores of this species are mentioned by Hieronymous (1901, 186).

S. Schlechteri Hieron.

Sub-triangular to spherical, spore body 35μ - 40μ in diameter. Tri-radiate mark extending to the margin; apical crest and apical surface scabrid. The ab-apical hemisphere is covered by a thin, folded membrane supported by struts and projecting 10μ - 12μ from the spore margin.

S. semicordata Spring Fig. 97.

Sub-triangular, tetrahedral, spore body 30μ - 40μ in diameter. Tri-radiate mark extending to the margin; apical crest and apical surface scabrid. The ab-apical hemisphere is covered by a thin, much folded membrane supported by hook-like struts. The edge of the membrane is fimbriate and projects beyond the spore margin from 10μ - 15μ.

The spores of this species are mentioned by Hieronymous (1901, 345).

S. tylophora vA. vR. Fig. 91.

Sub-triangular to spherical spore body 35μ - 40μ in diameter. Tri-radiate mark extends to the margin; it bears a flange and the apical surface is ornamented by small, scattered spines. The ab-apical hemisphere is covered by a thin membrane thrown into folds supported by struts which are arranged in an areolate manner; the membrane has a fimbriate edge and projects 10μ beyond the spore margin.

S. Usteri Hieron.

Sub-triangular spore body, 30μ - 35μ in diameter. Tri-radiate mark extends to the margin; the apical crest and apical surface are scabrid. The ab-apical hemisphere is covered by a thin membrane supported by struts of varying length; the membrane projects beyond the spore margin about 10μ.

S. Willdenovii Baker Fig. 95.

Sub-triangular, spore body 30μ - 35μ in diameter.

Tri-radiate mark extends to the margin. the apical crest and the apical surface are scabrid. The ab-apical hemisphere is covered by a thin membrane thrown into folds and supported by struts which assume a pseudo-reticulate form; the membrane projects beyond the spore margin about 10μ.

The spores of this species are described by Hooker and Greville (1833, I. tab. 57), by Spring (1849, p. 137) and Hieronymous (1901, 372).

GROUP IV. Group of S. scandens.

The spores of this group are distinguished by the presence of a well marked annular ring, varying in width from 5μ - 10μ; the outline of the ring may be smooth and entire or uneven and notched or crenate. The spore size ranges from 25μ - 40μ.

Key to the species.

A. Outline of annular ring entire.

B.	Apical surface granular ...	S. puberula	fig. 98
BB.	" " warty ...	S. scandens	fig. 99

AA. Outline of annular ring notched.

B.	Ring 5μ with a crenate margin	S. Parkeri	fig. 101
BB.	" 7μ - 10μ with a notched margin	S. stellata	fig. 100

S. scandens Spring Fig. 99.

Tetrahedral, almost spherical spores, 35μ - 40μ in diameter. Tri-radiate mark extending to the margin. The exospore has a rugose and warty surface. The annular ring, 5µ - 7µ in thickness, is smooth in outline.

The spores of this species are described by Spring (1849, p. 192) and Hieronymous (1901, 391).

S. stellata Spring Fig. 100.

Tetrahedral, sub-triangular spores 25µ - 30µ in diameter. Tri-radiate mark extending to the margin; apical crest with a conspicuous toothed ridge; apical surface studded with small spinose processes. The ab-apical hemisphere bears large, 5µ, blunt warty elevations. The annular ring is unevenly notched and 7µ - 10µ in thickness.

The spores of this species are described by Hieronymous (1901, 410).

GROUP V. Group of S. firmula.

Spores having a diameter of 15µ - 40µ; exospore smooth and without ornamentation; apical crest generally conspicuous and frequently bearing a thin membranous flange.

Key to the species.

A. Species with a distinct apical crest furnished with a narrow membranous flange.

B. Spore diameter 25µ - 30µ.

C.	Wall 3µ thick ...	S. cordifolia	fig. 102
CC.	Wall thin, less than 2µ	S. firmula	fig. 103
		S. Kurzii	
		S. phanotrichia	

BB. Spore diameter 30μ - 35μ.

C. Wall 2μ or more thick — S. Christii, S. myosuroides, S. Springii, S. Volkensii fig. 104

CC. Wall less than 2μ in thickness .. ... — S. Hochreutineri fig.106, S. leonensis

AA. Species with a conspicuous apical crest, but without a well developed flange; wall thin.

B. Apical crest narrow.

C. Spore diameter 15μ - 20μ — S. Hartwegiana

CC. Spore diameter 25μ - 30μ — S. alutaceae, S. minutifolia, S. Morgani, S. nana fig. 107

BB. Apical crest conspicuous; tri-radiate mark in a furrow between two ridges, which tend to separate.

C. Spore diameter 20μ - 30μ — S. Roxburghii fig. 105, S. sepikensis

CC. Spore diameter 30μ - 40μ.

D. Wall thin, less than 2μ ... — S. Burbidgei fig. 108, S. Menziesii

DD. Wall 3μ ... — S. marginata fig. 109

__S. alutacea__ Spring

Tetrahedral, sub-triangular spores, 25μ - 30μ in diameter. Wall thin. Tri-radiate mark extends to the margin; apical crest conspicuous. Exospore smooth.

The spores of this species are mentioned by Spring (1849, p. 237) and Hieronymous (1901, 287).

S. Burbidgei Baker   Fig. 108.

Tetrahedral, sub-triangular spores, 30μ - 35μ in diameter. Wall thin. Tri-radiate mark extends to the margin and is situated in a furrow between two ridges which have a tendency to separate; apical crest conspicuous. Exospore smooth.

The spores of this species are mentioned by Hieronymous (1901, 251).

S. Christii Hieron.

Tetrahedral, sub-triangular spores, 25μ - 35μ in diameter. Wall 2μ in thickness. Tri-radiate mark extends to the margin; apical crest prominent and bearing a distinct flange. Exospore smooth.

S. cordifolia Spring   Fig. 102.

Tetrahedral, sub-triangular spores, 25μ - 30μ. Wall 3μ in thickness. Tri-radiate mark extends to the margin; apical crest prominent and bearing a pronounced flange. Exospore smooth.

The spores of this species are mentioned by Spring (1849, p. 103) and Hieronymous (1901, 168).

S. firmula A. Br.   Fig. 103.

Tetrahedral, sub-triangular spores, 25μ - 30μ in diameter.

Wall thin. Tri-radiate mark extends to the margin; apical crest prominent and bearing a distinct flange. Exospore smooth.

The spores of this species are mentioned by Hieronymous (1901, 84).

S. Hartwegiana Spring

Tetrahedral, sub-triangular spores 15μ - 20μ in diameter. Wall thin. Tri-radiate mark extends to the margin; apical crest pronounced. Exospore smooth.

The spores of this species are mentioned by Hieronymous (1901, 80).

S. Hochreutineri Hieron. Fig. 106.

Tetrahedral, sub-triangular spores 30μ - 35μ in diameter. Wall thin. Tri-radiate mark extends to the margin; apical crest conspicuous and bearing a distinct flange. Exospore smooth.

S. Kurzii Baker

Tetrahedral, sub-triangular spores, 25μ - 30μ in diameter. Wall thin. Tri-radiate mark extending to the margin; apical crest conspicuous, bearing a distinct flange. Exospore smooth.

The spores of this species are mentioned by Hieronymous (1901, 310).

S. leonensis Hieron.

Tetrahedral, sub-triangular spores, 30μ - 35μ in diameter. Wall thin. Tri-radiate mark extends to the margin; apical crest conspicuous and bearing a flange. Exospore smooth.

The spores of this species are mentioned by Hieronymous (1901, 293).

S. marginata Spring Fig. 109.

Tetrahedral, sub-triangular spores, 35μ in diameter. Wall 3μ in thickness. Tri-radiate mark extends to the margin and is situated in a furrow between ridges; the apical crest is conspicuous. Exospore smooth.

S. Menziesii Spring

Tetrahedral, sub-triangular spores, 30μ - 35μ in diameter. Wall thin. Tri-radiate mark extends to the margin, situated in a furrow; apical crest prominent. Exospore smooth.

The spores of this species are described by Hooker and Greville (1831, II, tab. 200), Spring (1849, p. 185), Hieronymous (1901, 81), Skottsberg (1942), who considers this a variety of S. arbuscula, and figured by Knox (1938, fig. 10).

S. Morgani Zeiller

Tetrahedral, sub-triangular spores 25μ - 30μ in diameter. Wall thin. Tri-radiate mark extends almost to the margin; apical crest pronounced. Exospore smooth.

S. myosuroides (Kaul) Spring

Tetrahedral sub-triangular spores, 30μ - 35μ in diameter. Wall 2μ. Tri-radiate mark extends to the margin; apical crest prominent and bearing a flange. Exospore smooth.

The spores of this species are described by Kaulfuss (1824, p. 19), Brackenridge (1854, p. 339), Spring (1849, p. 236) and Hieronymous (1901, 157).

S. nana (Desv.) Spring Fig. 107.

Tetrahedral, sub-triangular spores, 25μ - 30μ in diameter. Tri-radiate mark extends to the margin; apical crest conspicuous, but without a flange. Exospore smooth.

The spores of this species are mentioned by Brackenridge (1854, p. 336).

S. phanotrichia Baker

Tetrahedral, sub-triangular spores, 25μ - 30μ in diameter. Wall thin. Tri-radiate mark extends to the margin; apical crest well developed and bearing a distinct flange. Exospore smooth.

The spores of this species are mentioned by Hieronymous (1901, 282).

S. Roxburghii (Hk. & Gr.) Spring Fig. 105.

Tetrahedral, sub-triangular spores, 20μ in diameter. Wall thin. Tri-radiate mark extends to the margin; situated in a furrow between two ridges; apical crest conspicuous. Exospore smooth.

S. sepikensis Hieron.

Tetrahedral, sub-triangular spores, 20μ - 30μ in diameter. Wall thin. Tri-radiate mark extends to the margin, situated in a furrow between two ridges; apical crest conspicuous. Exospore smooth.

S. Springii Gaud.

Tetrahedral, sub-triangular spores, 30μ - 35μ in diameter. Wall 2μ in thickness. Tri-radiate mark extends to the margin; apical crest conspicuous and bounded by a flange. Exospore smooth.

The spores of this species are mentioned by Hieronymous (1901, 82).

S. Volkensii Hieron. Fig. 104.

Tetrahedral, sub-triangular spores 30μ - 35μ in diameter. Wall 2μ in thickness. Tri-radiate mark extends to the margin; apical crest well developed and bearing a distinct flange. Exospore smooth.

GROUP VI. Group of S. helvetica.

Spores measuring 20μ - 40μ in diameter; exospore granular; apical crest well-developed and may bear a membranous flange.

Key to the species.

A. Wall 2μ in thickness.

B. Tri-radiate crest with a flange .. .. S. Whitmeei Fig. 110

BB. Tri-radiate crest without a flange.

C. Tri-radiate mark situated in a furrow S. helvetica fig. 111
S. intertexta

CC. Tri-radiate mark with a conspicuous crest ... S. Kernbachii fig. 112

AA. Wall thin, less than 2μ in thickness.

B. Tri-radiate crest with a flange .. .. S. philippina fig. 113
S. reticulata
S. Vaupelii

BB. Tri-radiate crest without a flange, but with a conspicuous ridge.

C. Exospore coarsely granular.

D. Spore diameter 20μ - 25μ ... S. megaphylla fig. 114
S. ramosissima

DD. " 30μ - 35μ .. S. amphirrhizos

CC. Exospore finely granular ... ... S. arbuscula fig. 115
S. Martensii
S. Reineckii
S. revoluta
S. usta

S. amphirrhizos A. Br.

Tetrahedral, sub-triangular, 30μ - 35μ. Wall thin.

Tri-radiate crest conspicuous, extending to the margin. Exospore coarsely granular, as in the spores of S. megaphylla (fig. 114).

The spores of this species are mentioned by Hieronymous (1901, 379).

S. arbuscula Spring Fig. 115.

Tetrahedral, sub-triangular, 25μ - 35μ. Wall thin. Tri-radiate crest well developed and extending to the margin. Exospore smooth to faintly granular.

The spores of this species are mentioned by several authors:- Kaulfuss (1824, p. 20), Hooker and Greville (1831, tab. 200), Spring (1849, p. 183), Brackenridge (1854, p. 333), Hillebrand (1888, p. 648), Hieronymous (1901, 76), Brown and Brown (1931, p. 112), Selling (1946, p. 20, figs. 22, 23).

S. helvetica Link Fig. 111.

Tetrahedral, sub-triangular, 35μ - 40μ. Wall 2μ thick. Tri-radiate mark conspicuous and situated in a narrow furrow bounded on either side by thin ridges and extending almost to the margin. Exospore faintly granular.

The spores of this species are described and figured by Hieronymous (1901, fig. 405) and Hegi (1936, fig. 15).

S. intertexta Spring

Tetrahedral, sub-triangular, 30μ - 40μ. Wall 2μ in thickness. Tri-radiate mark conspicuous and situated in a furrow bounded by narrow ridges, and extending almost to the margin. Exospore smooth to finely granular. The spores of this species are very similar to those of S. helvetica (fig. 111).

S. Kernbachii Hieron. Fig. 112.

Tetrahedral, sub-triangular, 30μ - 35μ. Wall 2μ in thickness. Tri-radiate crest conspicuous and extending to the margin. Exospore granular.

The spores of this species are mentioned by Hieronymous (1901, 335).

S. Martensii Spring

Tetrahedral, sub-triangular, 25μ - 30μ. Wall thin. Tri-radiate mark conspicuous and extending to the margin. Exospore granular.

The spores of this species are mentioned by Hieronymous (1901, 217).

S. megaphylla Baker Fig. 114.

Tetrahedral, sub-triangular, 20μ - 25μ. Wall thin. Tri-radiate mark conspicuous and extending to the margin. Exospore granular.

The spores of this species are described by Hieronymous (1901, 239).

S. philippina Spring Fig. 113.

Tetrahedral, sub-triangular, 30μ - 35μ. Wall thin.

Tri-radiate mark conspicuous with a well developed flange and extending almost to the margin. Exospore smooth to faintly granular.

S. ramosissima Baker

Tetrahedral, sub-triangular, 20μ - 25μ. Wall thin. Tri-radiate mark 2/3 radius, with a conspicuous crest. Exospore coarsely granular.

S. Reineckei Hieron.

Tetrahedral, sub-triangular, 25μ - 35μ. Wall thin. Tri-radiate mark extending to the margin with a well developed crest, particularly prominent at the angles. Exospore faintly granular.

The spores of this species are mentioned by Hieronymous (1901, 83).

S. reticulata (Hk. & Gr.) Spring

Tetrahedral, sub-triangular, 30μ - 40μ. Wall thin. Tri-radiate mark conspicuous with a well developed flange and extending to the margin. Exospore smooth to slightly rough or granular.

S. revoluta Baker

Tetrahedral, sub-triangular, 25μ - 30μ. Wall thin. Tri-radiate crest conspicuous and extending to the margin. Exospore finely granular as in the spores of S. helvetica (fig. 111).

S. usta Viell.

Tetrahedral, sub-triangular, 30μ - 35μ. Wall thin. Tri-radiate mark conspicuous and extending to the margin. Exospore finely granular.

The spores of this species are mentioned by Hieronymous (1901, 334).

S. Vaupelii Hieron.

Tetrahedral, sub-triangular, 30μ - 35μ. Wall thin. Tri-radiate crest with a distinct flange and extending to the margin. Exospore granular.

S. Whitmeei Baker Fig. 110.

Tetrahedral, sub-triangular, 30μ - 35μ. Wall 2μ in thickness. Tri-radiate mark with a conspicuous flange and extending to the margin. Exospore finely granular.

The spores of this species are mentioned by Hieronymous (1901, 88).

GROUP VII. Group of S. cathedrifolia.

Spores, except in S. tamariscina, mostly small, 20μ - 35μ in diameter. Exospore rugose and papillate. The margin of the spore is more or less crenulate.

Key to the species.

A. Spores large, 60μ - 70μ. ... S. tamariscina fig. 116

AA. Spores diameter less than 35 .

B. Spore diameter 20μ - 25μ.

C. Apical crest conspicuous ... S. cathedrifolia fig. 117

CC. Apical crest inconspicuous ... S. producta fig. 118

BB. Spore diameter 25μ - 35μ.

C. Spore diameter 30μ - 35μ S. heterostachys fig.119

CC. Spore diameter 25μ - 30μ.

D. Apical crest conspicuous.

E. Exospore papillate ... S. concinna
S. deliquescens
S. falcata fig. 120

EE. Exospore finely papillate ... S. Savatieri fig. 121

DD. Apical crest inconspicuous ... S. platybasis fig. 122

S. cathedrifolia Spring Fig. 117.

Tetrahedral, sub-triangular, 20μ - 25μ. Wall 1μ- 2μ in thickness. Tri-radiate crest conspicuous and extending almost to the margin. Exospore papillate; margin of spore crenulate.

S. concinna A. Br.

Tetrahedral, sub-triangular, 25μ - 30μ. Wall 1μ- 2μ in thickness. Tri-radiate crest well developed and extending to the margin. Exospore rough and papillate; the sculpturing resembles that in the spores of S. cathedrifolia (fig. 117).

The spores of this species are mentioned by Hieronymous (1901, 384); they are figured by Knox (1938, fig. 15).

S. deliquescens Spring

Tetrahedral, sub-triangular, 25μ- 30μ. Tri-radiate mark extends to the margin and has a prominent apical crest. Exospore rugose and papillate; margin crenulate. The sculpturing of the spores of this species is similar to that of the spores of S. falcata (fig. 120).

The spores of this species are mentioned by Hieronymous (1901, 389).

S. falcata Spring Fig. 120.

Tetrahedral, sub-triangular, 25μ. Tri-radiate mark extending to the margin. Apical crest well developed. Exospore rugose and papillate; margin crenulate.

The spores of this species are mentioned by Hieronymous (1901, 390).

S. heterostachys Baker Fig. 119.

Tetrahedral, sub-triangular, 30μ - 35μ. Wall 2μ in thickness. Tri-radiate mark extending to the margin.

Exospore rugose and papillate; margin crenulate.

S. platybasis Baker Fig. 122.

Tetrahedral, sub-triangular, 25μ - 30μ. Wall thin. Tri-radiate mark extending to the margin. Exospore rugose and papillate; margin crenulate.

The spores of this species are mentioned by Hieronymous (1901, 213).

S. producta Baker Fig. 118.

Tetrahedral, sub-triangular, 20μ. Wall thin. Tri-radiate mark extending to the margin. Exospore rugose and papillate; margin crenulate.

The spores of this species are mentioned by Hieronymous (1901, 255).

S. Savatieri Baker Fig. 121.

Tetrahedral, sub-triangular, 25μ - 30μ. Wall thin. Tri-radiate mark extending almost to the margin; apical crest well developed. Exospore finely papillate; margin minutely crenulate.

S. tamariscina (Beauv.) Spring Fig. 116.

Spores spherical, 60μ - 70μ. Tri-radiate mark 1/2 radius. Exospore rugose and irregularly and coarsely papillate; margin crenulate.

The spores of this species are mentioned by Spring (1849, p. 64) and Hieronymous (1901, 62).

GROUP VIII. Group of S. radicata.

Spores measuring 20μ - 45μ in diameter; ornamented with low, irregularly shaped, warty elevations, varying in breadth from 2μ - 5μ and usually set 2μ - 5μ apart. The elevations are seen on the spore margin which is crenate.

Key to the species.

A. Spore diameter 20μ - 30μ.

B. Spore diameter 20μ - 25μ ... S. Kittyae

BB. " " 25μ - 30μ.

C. Apical crest conspicuous .. S. apus fig. 123
S. Ludoviciana fig. 124
S. caudata

CC. " " not " ... S. velutina fig. 125

AA. Spore diameter 30μ - 45μ.

B. Apical surface papillate.

C. Spore diameter 30μ - 40μ S. dendricola
S. d'Urvillaei

CC. " " 40μ - 45μ S. palidissima fig. 126

BB. Apical surface warty, not papillate.

C. Apical crest conspicuous .. ... S. aristata
S. Balfourii fig. 127

CC. " not conspicuous .. S. abyssinica fig. 128
S. carnea
S. latupana
S. radicata fig. 129
S. sub-diaphana fig. 130
S. temera fig. 131
S. tetragonastachys

S. abyssinica Spring   Fig. 128.

Tetrahedral, sub-triangular, 30μ - 40μ. Tri-radiate mark extending to the margin. Exospore ornamented with low, irregular, warty elevations about 2μ - 5μ across and set 2μ apart; spore margin crenate.

The spores of this species are described by Hieronymous (1901, 158).

S. apus Spring   Fig. 123.

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin, and possessing a well developed crest. Exospore bears low, irregular, warty processes. Spore margin crenate.

The spores of this species are mentioned by Hieronymous (1901, 257) and figured by Lyon (1901).

S. aristata Spring

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin, possessing a well developed crest. Exospore with low, irregular, warty processes, 2μ broad and closely set together.

S. Balfourii Baker   Fig. 127.

Tetrahedral sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin, apical crest prominent. Exospore ornamented on all sides with low, irregular, rounded processes about 2μ - 4μ broad and set 1μ - 2μ apart; spore margin crenate.

The spores of this species are mentioned by Hieronymous (1901, 385).

S. carnea vA. vR.

Tetrahedral, sub-triangular, 30μ - 40μ. Tri-radiate mark extending to the margin, apical crest conspicuous. Exospore rugose, with irregular, low, uneven ridges. Spore margin crenate.

S. caudata (Desv.) Spring

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin, with a conspicuous crest. Exospore rugose with low, irregular, warty processes; margin crenate.

The spores of this species are mentioned by Hieronymous (1901, 346).

S. dendricola Jemm.

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore ornamented with low, irregular, warty processes, 2μ - 5μ broad, becoming smaller towards the apical crest, and closely set together; spore margin crenate.

S. d'Urvillaei (Bory) Al. Br.

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore ornamented with low, irregular, warty processes, 2μ - 4μ broad, closely set together; becoming smaller towards the apical crest.

The spores of this species are mentioned by Hieronymous (1901, 268).

S. Kittyae vA. vR.

Tetrahedral, sub-triangular, 20μ - 25μ. Tri-radiate mark extending to the margin. Exospore rugose with low, irregular, warty processes; spore margin crenate.

S. latupana vA. vR.

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore ornamented with low, irregular, warty processes, 2μ broad and set 2μ apart.

S. Ludoviciana A. Br. Fig. 124.

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin, apical crest conspicuous. Exospore rugose, with a rough warty surface; spore margin crenate.

The spores of this species are mentioned by Hieronymous (1901, 256).

S. palidissima Spring Fig. 126.

Tetrahedral, sub-triangular, 40μ - 45μ. Tri-radiate mark extending almost to the margin. Exospore ornamented with low, irregular, warty processes, 2μ - 4μ broad on the ab-apical side, becoming papillate towards the apical crest; spore margin crenate.

The spores of this species are described by Spring (1849, p. 234) and Hieronymous (1901, 176).

S. radicata (Hk. & Gr.) Spring Fig. 129.

Tetrahedral, sub-triangular, 35μ - 40μ. Tri-radiate mark extending to the margin. Exospore ornamented with low, irregular, warty processes, 2μ - 4μ broad, and set 2μ apart; spore margin crenate.

The spores of this species are described by Spring (1849, p. 114) and Hieronymous (1901, 173).

S. sub-diaphana (Wall) Spring Fig. 130.

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending almost to the margin. Exospore rough with low, irregular, warty processes.

S. tenera (Hk. & Gr.) Spring Fig. 131.

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore bears low, irregular, warty processes, 2μ broad and closely set together; spore margin crenate.

The spores of this species are described by Spring (1849, p. 241) and Hieronymous (1901, 313).

S. tetragonastachys Wall

Tetrahedral, sub-triangular, 30μ - 40μ. Tri-radiate mark extending to the margin. Exospore ornamented with low, irregular, warty processes, 2μ broad and very closely set together; spore margin crenate.

S. velutina Cesati Fig. 125.

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin. Exospore bears low, irregular, warty processes, 2μ broad and closely set together.

GROUP IX. Group of S. leptophylla.

Spores measuring 25μ - 45μ; studded with small, low, rounded processes, 1μ to 2μ long and arranged regularly 1μ to 3μ apart.

Key to the species.

A. Processes 2μ in length.

B. Spore diameter 25μ - 35μ ... S. pentagona fig. 132

BB. Spore diameter 35μ - 45μ ... S. effusa fig. 133

AA. Processes 1μ in length, spore size 30μ - 35μ. ... ... S. Bodinieri
S. boninensis
S. ciliaris fig. 134
S. leptophylla fig. 135

S. Bodinieri Hieron.

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore studded with small rounded processes, 1μ x 1μ, and closely set together.

S. boninensis Baker

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore studded with small rounded processes, 1μ x 1μ, closely set, about 2μ - 3μ apart.

S. ciliaris (Retz) Spring Fig. 134.

Tetrahedral, sub-triangular to round, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore studded with short, 1μ, blunt processes, set about 2μ - 3μ apart.

The spores of this species are described by Spring (1849, p. 233), Brackenridge (1854, p. 337) and Hieronymous (1901, 175).

S. effusa Alston Fig. 133.

Tetrahedral, sub-triangular, 35μ - 45μ. Tri-radiate mark extending to the margin. Exospore studded with small blunt processes, 2μ long and set 1μ to 3μ apart.

S. leptophylla Baker Fig. 135.

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore ornamented with small, low, 1μ, rounded elevations, regularly arranged 2μ - 3μ apart. The processes are seen on the edge of the spore and give it a crenate outline.

S. pentagona Spring   Fig. 132.

Tetrahedral, sub-triangular, 25μ - 35μ. Tri-radiate mark extending to the margin. Exospore studded with small, rounded processes, 2μ x 2μ, and closely set together.

The spores of this species are described by Spring (1849, p. 150) and Hieronymous (1901, 112).

GROUP X.   Group of S. vaginata.

Spores measuring from 25μ - 50μ in diameter; ornamented with irregularly shaped, rounded elevations, ranging from 3μ - 8μ in breadth and variously spaced. The spore margin is uneven and sinuate.

Key to the species.

A.	Spore diameter 40μ - 50μ	...	S. Mettenii	fig. 136
AA.	Spore diameter 25μ - 40μ.			
	B. Spore size 25μ - 30μ	...	S. tenuifolia	fig. 137
	BB. " " 30μ - 40μ	...	S. Hewithii	
			S. involvens	
			S. mongholica	
			S. opaca	fig. 138
			S. sinensis	fig. 139
			S. sub-cordata	
			S. vaginata	fig. 140
			S. yemensis	

S. Hewithii Hieron.

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore bears irregular, warty processes, 5μ - 8μ in diameter, close together and becoming smaller towards the apical crest; spore margin uneven, sinuate.

S. involvens Hieron.

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore studded with irregular, warty processes, varying in diameter from 3μ - 7μ, closely set together; spore margin sinuate.

S. Mettenii A. Br. Fig. 136.

Tetrahedral, sub-triangular, 40μ - 50μ. Tri-radiate mark extending almost to the margin. Exospore ornamented with large, irregularly shaped bosses, 3μ - 8μ across, becoming smaller around the apical crest.

S. mongholica Ruprecht

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore ornamented with large, rounded tuberculate processes, 5μ - 8μ broad, closely set together and most conspicuous on the ab-apical surface.

The spores of this species are described by Hieronymous (1901, 49) and figured by Knox (1938, fig. 17). This species is considered synonymous with S. sinensis (Desv.) Spring.

S. opaca Warb. Fig. 138.

Tetrahedral, sub-triangular, 30μ - 40μ. Tri-radiate mark extending to the margin. Exospore ornamented with large warty processes closely set together; on the ab-apical side the processes measure 3μ - 7μ in diameter and towards the apical crest become smaller; spore margin sinuate.

The spores of this species are described by Hieronymous (1901, 248).

S. sinensis (Desv.) Spring Fig. 139.

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore ornamented with large rounded tuberculate processes, 3μ - 7μ broad; spore margin sinuate.

S. sub-cordata A. Br.

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore ornamented with large tuberculate bosses, 3μ - 7μ broad, closely set together. The apical surface is less heavily ornamented than the ab-apical.

S. tenuifolia Spring Fig. 137.

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin. Exospore ornamented with irregular, tuberculate bosses, varying in diameter from 3μ - 6μ and closely set together; spore margin sinuate. The apical surface is rough and with indifferent sculpturing.

The spores of this species are mentioned by Spring (1849, p. 253).

S. vaginata Spring Fig. 140.

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore ornamented with large, irregularly shaped warty processes. On the ab-apical side the tubercles are 3μ - 5μ across, while on the apical surface they become small and towards the apical crest are papillate. The spore margin is sinuate.

The spores of this species are mentioned by Spring (1849, p. 87).

S. yemensis Spring

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears large, irregular warty processes, 3μ - 5μ across; round the apical crest the surface is papillate to almost smooth.

The spores of this species are described by Spring (1849, p. 193) and Hieronymous (1901, 45).

GROUP XI. Group of S. repanda.

Spores measuring from 25μ - 55μ in diameter; ornamented with conspicuous irregularly shaped flattened bosses, varying in diameter from 3μ - 10μ, and separated from one another by winding channels. The spore margin is uneven and sinuate.

Key to the species.

A. Spore diameter 25μ - 35μ ; elevations 3μ - 8μ in breadth ... S. Beccariana fig. 141
S. durinscula

AA. Spore diameter 35μ - 55μ ; elevations 5μ - 10μ in breadth.

B. Spore diameter 30μ - 35μ ... S. calcicola fig. 142

BB. Spore diameter 35μ - 55μ; elevations smaller towards apex.

C. Spore diameter 35μ - 40μ S. d'Armandvillei

CC. " " 50μ - 55μ S. repanda fig. 143

S. Beccariana Baker Fig. 141.

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin. Exospore rough with large, irregular, warty elevations varying in diameter from 3μ - 7μ and separated by winding channels; spore margin sinuate.

S. calcicola Hieron. Fig. 142.

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin situated in a furrow. Exospore ornamented on all surfaces with large irregular, warty elevations, 5μ - 8μ in diameter, separated by winding channels; spore margin sinuate.

S. d'Armandvillei vA. vR.

Tetrahedral, sub-triangular, 35μ - 40μ. Tri-radiate mark extending to the margin. Exospore closely covered on the ab-apical surface with large warty elevations, 5μ - 7μ broad, separated by winding channels. Towards the apical crest the processes become smaller.

S. durinscula Alston

Tetrahedral, sub-triangular, 25μ - 35μ. Tri-radiate mark extending to the margin. Exospore ornamented with irregular, warty elevations varying in diameter from 3μ - 8μ, close together and separated by winding channels. Round the apical crest the processes are smaller and scattered; spore margin sinuate.

S. repanda (Desv.) Spring Fig. 143.

Tetrahedral, sub-triangular, 50μ - 55μ. Tri-radiate mark extending to the margin. Exospore ornamented with large, flat, irregularly shaped elevations, 5μ - 10μ in breadth and separated from one another by winding channels. On the apical surface the processes are smaller; the spore margin is sinuate.

GROUP XII. Group of S. stolonifera.

Spores measuring 20μ - 40μ. Ornamentation of blunt, straight-sided, rod-like processes, 1μ - 2μ in thickness and varying in length from 2μ - 5μ. The processes in most species are regularly arranged, either densely packed or set from 3μ - 5μ apart.

Key to the species.

A. Processes short, less than 3μ long and widely spaced.

B. Spore diameter 20μ - 25μ.

C.	Processes broad at base	S. Hookeri	fig. 144
CC.	" thin " "	S. monospora	fig. 145

BB. Spore diameter 25μ - 35μ ... S. finium
S. permutata fig. 146
S. polystachya fig. 147

AA. Processes more than 3μ long and densely packed.

B. Spore diameter 20μ - 30μ ... S. delicatula
S. picta

BB. " " 25μ - 40μ.

C. Spore diameter 25μ - 35μ S. exaltata
S. inaequifolia fig. 148
S. pennata
S. stipulata
S. stolonifera fig. 149

CC. " " 30μ - 40μ S. conferta fig. 150
S. fulvicaulis
S. Vogelii

S. conferta Moore Fig. 150.

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore studded with short, blunt processes, 3μ - 5μ long and closely set together, 2μ - 3μ apart.

The spores of this species are mentioned by Hieronymous (1901, 166).

S. delicatula (Desv) Alston n. comb.

Tetrahedral, sub-triangular, 20μ - 30μ. Tri-radiate mark extending to the margin. Exospore studded with blunt, rod-like processes, 5μ long and set 2μ apart.

S. exaltata (Kze.) Spring

Tetrahedral, sub-triangular to spherical, 25μ - 35μ. Tri-radiate mark extending to the margin. Exospore ornamented on all faces with blunt, rod-like processes, 3μ - 4μ long and set 2μ - 4μ apart.

The spores of this species are mentioned by Hieronymous (1901, 412).

S. finium vA. vR.

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. On the ab-apical surface the exospore bears blunt processes, 3μ long and set 3μ - 5μ apart; round the apical crest the sculpturing is papillate.

S. fulvicaulis Hieron.

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore studded with blunt processes, 3μ long and set 2μ - 3μ apart. On the apical surface the sculpturing is papillate.

S. Hookeri Baker Fig. 144.

Tetrahedral, sub-triangular, 20μ - 25μ. Tri-radiate mark extending to the margin. Exospore ornamented with short, blunt, tuberculate processes, 2μ long and set 3μ apart.

The spores of this species are mentioned by Hieronymous (1901, 144).

S. inaequifolia (Hk. & Gr.) Spring Fig. 148.

Tetrahedral, sub-triangular, 25μ - 35μ. Tri-radiate mark extending to the margin. Exospore on all faces bears blunt processes, 3μ - 5μ in length and set closely, 2μ - 3μ apart.

The spores of this species are described by Hieronymous (1901, 352).

S. monospora Spring Fig. 145.

Tetrahedral, sub-triangular, 20μ - 25μ. Tri-radiate mark extending to the margin. Exospore studded with blunt processes, 3μ long, very evenly disposed on all surfaces, 3μ apart.

The spores of this species are described by Spring (1849, p. 135) and by Hieronymous (1901, 135).

S. pennata (Don) Spring

Tetrahedral, sub-triangular to almost spherical, 25μ - 35μ.

Tri-radiate mark extending to the margin. Exospore studded with short, blunt processes, 2μ - 3μ in length and set 2μ - 3μ apart.

S. permutata Hieron. Fig. 146.

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin. Exospore bears short, blunt processes, 2μ - 3μ long and set 3μ - 5μ apart.

S. picta A. Br.

Tetrahedral, sub-triangular to spherical, 20μ - 35μ. Tri-radiate mark extending to the margin. Exospore studded with blunt, rod-like processes, 3μ - 4μ long and set 2μ - 3μ apart.

The spores of this species are described by Hieronymous (1901, 349) and figured by Knox (1938, fig. 19).

S. polystachya (Warb.) Hieron. Fig. 147.

Tetrahedral, sub-triangular to spherical, 25μ - 30μ. Tri-radiate mark extending to the margin. Exospore ornamented with thin, blunt processes, 2μ - 3μ long and set 3μ - 5μ apart.

The spores of this species are described by Hieronymous (1901, 362).

S. stipulata Blume

Tetrahedral, sub-triangular to spherical, 25μ - 30μ.

Tri-radiate mark extending to the margin. Exospore studded with blunt processes, 2μ - 3μ long and closely set, 2μ - 3μ apart.

S. stolonifera Spring Fig. 149.

Tetrahedral, sub-triangular to spherical, 25μ - 30μ. Tri-radiate mark extending to the margin. Exospore studded with blunt, rod-like processes, 2μ - 3μ in length and regularly disposed 2μ apart.

The spores of this species are mentioned by Hieronymous (1901, 404).

S. Vogelii Spring

Tetrahedral, sub-triangular, 30μ - 40μ. Tri-radiate mark extending to the margin. Exospore ornamented with blunt, rod-like processes 3μ - 5μ in length and set 3μ apart.

The spores of this species are described by Spring (1849, p. 169) and Heronymous (1901, 72).

GROUP XIII. Group of S. biformis.

Spores measuring 15μ - 35μ; ornamented with blunt, straight-sided, rod-like processes, 1μ - 2μ in thickness and varying in length from 2μ - 5μ. The processes are few in number and widely spaced, in most species more than 5μ apart.

Key to the species.

A. Processes short, 3μ or less in length.

B. Spore diameter 15μ - 20μ ... S. Griffithii
S. intermedia fig. 151

BB. Spore diameter more than 20μ.

C. Spore diameter 20μ - 25μ S. Burkei
S. caulescens fig. 152
S. haematodes fig. 153
S. Jagori
S. Leveriana
S. viticulosa

CC. Spore diameter 25μ - 35μ S. ascendens fig. 154
S. umbrosa

AA. Processes more than 3μ in length, usually 5μ.

B. Spore diameter 15μ - 20μ ... S. aenea
S. frondosa fig. 155
S. poperangensis

BB. Spore diameter more than 20μ.

C. Spore diameter 20μ - 25μ S. bahiensis
S. biformis fig. 156
S. cupra
S. flabellata
S. jungermannioides
S. Mollendorfii
S. Muelleri
S. Neei
S. novae-guineae
S. pallida
S. Paxii
S. pulcherrima

CC. Spore diameter 25μ - 30μ S. ramosii
S. serpens
S. trachyphylla fig. 157

S. aenea Warb.

Tetrahedral, sub-triangular, 15μ - 20μ. Tri-radiate mark extending to the margin. Exospore on the ab-apical side ornamented with thin, straight-sided, blunt processes 5μ long and spaced 5μ - 8μ apart.

S. ascendens vA. vB. Fig. 154.

Tetrahedral, sub-triangular to spherical, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore ornamented on the ab-apical surface with thin, blunt processes 3μ in length and widely spaced, 5μ - 7μ apart.

S. Burkei Hieron.

Tetrahedral, sub-triangular, 25μ. Tri-radiate mark extending to the margin. Exospore on the ab-apical side bears thin, blunt processes 3μ in length and spaced 5μ apart. The apical surface is devoid of ornamentation.

S. bahiensis Spring

Tetrahedral, sub-triangular, 20μ - 25μ. Tri-radiate mark extending to the margin. Exospore on the ab-apical side ornamented with thin, blunt processes, 5μ long and spaced 3μ - 5μ apart.

S. biformis A. Br. Fig. 156.

Tetrahedral, sub-triangular to spherical, 20μ - 25μ. Tri-radiate mark extending to the margin. Exospore studded with thin, blunt processes, 3μ - 5μ long and spaced 3μ - 7μ apart.

The spores of this species are mentioned by Hieronymous (1901, 99).

S. caulescens (Wall) Spring Fig. 152.

Tetrahedral, sub-triangular to spherical, 25μ. Tri-radiate mark extending to the margin. Exospore bears short, blunt processes, 2μ in length and set 5μ apart.

The spores of this species are described by Spring (1849, p. 158) and Hieronymous (1901, 89).

S. cupra Riel.

Tetrahedral, sub-triangular to spherical, 20μ - 25μ. Tri-radiate mark extending to the margin. Exospore on the ab-apical surface bears thin, stick-like processes 5μ long and spaced 5μ - 8μ apart. The apical surface is without ornamentation.

S. flabellata Spring

Tetrahedral, sub-triangular, 25μ. Tri-radiate mark extending to the margin. Exospore studded with thin, blunt processes 3μ - 5μ long and spaced 5μ - 8μ apart. The apical surface is devoid of ornamentation.

The spores of this species are mentioned by Hieronymous (1901, 130).

S. frondosa Warb. Fig. 155.

Tetrahedral, sub-triangular to spherical, 15μ - 20μ.

Tri-radiate mark extending to the margin. Exospore ornamented on the ab-apical side with blunt processes 5μ long and widely spaced, 8μ - 10μ apart. The apical surface is without ornamentation.

The spores of this species are described by Hieronymous (1901, 108).

S. Griffithii Spring

Tetrahedral, sub-triangular to spherical, 15μ - 20μ. Tri-radiate mark extending to the margin. Exospore on the ab-apical side studded with short, blunt processes, 3μ long and set 3μ - 5μ apart.

The spores of this species are described by Hieronymous (1901, 100).

S. haematodes Spring Fig. 153.

Tetrahedral, sub-triangular, 20μ. Tri-radiate mark extending to the margin. Exospore on the ab-apical side bears short, blunt processes 2μ long and set 5μ - 7μ apart. The apical surface is unornamented.

The spores of this species are described by Hieronymous (1901, 125).

S. intermedia (Bl.) Spring Fig. 151.

Tetrahedral, sub-triangular, 15μ - 20μ. Tri-radiate mark extending to the margin. Exospore on the ab-apical surface bears short blunt processes, 2μ - 3μ long and spaced 5μ apart.

S. Jagorii Warb.

Tetrahedral, sub-triangular, 25μ. Tri-radiate mark extending to the margin. Exospore on the ab-apical side bears short, blunt processes, 3μ long and spaced 5μ - 7μ apart. The apical surface is without ornamentation.

The spores of this species are described by Hieronymous (1901, 97).

S. jungermannioides Spring

Tetrahedral, sub-triangular to spherical, 25μ. Tri-radiate mark extending to the margin. Exospore studded with stick-like processes about 5μ in length and 3μ - 5μ apart on the ab-apical side. The apical surface is without ornamentation.

The spores of this species are mentioned by Hieronymous (1901, 203).

S. Leveriana Alston

Tetrahedral, sub-triangular, 20μ - 25μ. Tri-radiate mark extending to the margin. Exospore studded with short, blunt processes 2μ long and widely spaced 5μ - 8μ apart.

S. Mollendorffii Hieron.

Tetrahedral, sub-triangular to spherical, 25μ. Tri-radiate mark extending to the margin. Exospore studded with blunt, stick-like processes 3μ - 5μ in length and set 5μ - 7μ apart.

The spores of this species are described by Hieronymous (1901, 102).

S. Muelleri Baker

Tetrahedral, sub-triangular 25μ. Tri-radiate mark extending to the margin. Exospore ornamented with blunt stick-like processes, 3μ - 5μ long and 5μ or more apart on the ab-apical side; the apical surface is without sculpturing.

S. Neei Hieron.

Tetrahedral, sub-triangular, to spherical, 20μ - 25μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears thin, blunt processes 5μ in length and set 5μ or more apart.

S. novae-guineae Hieron.

Tetrahedral, sub-triangular to spherical, 25μ. Tri-radiate mark extending to the margin. Exospore bears thin, blunt processes, 3μ - 5μ long and set 5μ apart.

The spores of this species are described by Hieronymous (1901, 119).

S. pallida Spring

Tetrahedral, sub-triangular to spherical, 25μ. Tri-radiate mark extending to the margin. Exospore on the ab-apical side bears blunt processes 3μ - 5μ long and set 5μ - 8μ apart. The apical side is without ornamentation.

The spores of this species are mentioned by Spring (1849, p. 116).

S. Paxii Hieron.

Tetrahedral, sub-triangular, 25μ. Tri-radiate mark extending to the margin. On the ab-apical surface the exospore bears thin stick-like blunt processes 5μ long and spaced 5μ - 8μ apart.

S. poperangensis Hieron.

Tetrahedral, sub-triangular to spherical, 20μ. Tri-radiate mark extending to the margin. Exospore studded with blunt processes 5μ long and set 5μ - 8μ apart. The apical surface is devoid of ornamentation.

S. pulcherrima Lieben.

Tetrahedral, sub-triangular to spherical, 25μ. Tri-radiate mark extending to the margin. Exospore studded with blunt processes, 3μ - 5μ long and spaced 5μ - 8μ apart.

The spores of this species are described by Hieronymous (1901, 98).

S. ramosii Hieron.

Tetrahedral, sub-triangular to spherical, 25μ - 30μ.

Tri-radiate mark extending to the margin. Exospore studded with blunt processes, 3μ - 5μ long and set 5μ - 7μ apart.

S. serpens Spring

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin. Exospore studded with straight rod-like processes 5μ long and set 5μ - 8μ apart.

The spores of this species are mentioned by Spring (1849, p. 102) and Hieronymous (1901, 206); they are figured by Knox (1938, fig. 11).

S. trachyphylla A. Br. Fig. 157.

Tetrahedral, sub-triangular, 28μ - 30μ. Tri-radiate mark extending to the margin. Exospore ornamented with blunt rod-like processes, 3μ - 5μ long on the ab-apical side and set 3μ - 5μ apart. The apical surface is without ornamentation.

The spores of this species are mentioned by Hieronymous (1901, 229).

S. umbrosa Lemaire

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears short, blunt processes, 3μ long and set 3μ - 5μ apart. The apical surface is without ornamentation.

The spores of this species are mentioned by Hieronymous (1901, 124).

S. viticulosa Klotzsch

Tetrahedral, sub-triangular, 20μ - 25μ. Tri-radiate mark extending to the margin. Exospore, on the ab-apical side studded with short, blunt processes, 2μ long and set 3μ - 5μ apart. The apical surface is without ornamentation.

The spores of this species are mentioned by Hieronymous (1901, 128).

GROUP XIV. Group of S. latifrons.

Spores measuring from 15μ - 30μ in diameter; the basal hemisphere furnished with thin, straight, blunt, rather widely spaced, rod-like processes, 5μ - 10μ in length and from 3μ - 8μ apart. The apical hemisphere is without ornamentation.

Key to the species.

A. Spore diameter 15μ - 20μ.

B. Processes 8μ - 10μ in length — S. sumatrana fig. 159

BB. " 5μ - 8μ " " — S. atroviridis fig. 158; S. breynioides; S. luzonensis

AA. Spore diameter 20μ - 30μ.

B. Spore diameter 20μ - 25μ; processes set 3μ - 6μ apart — S. longipinna fig. 160; S. trifurcata; S. regularis

BB. Spore diameter 25μ - 30μ; processes set 5μ - 8μ apart.

C.	Processes 5μ in length ...	S. latifrons S. Swartzii	fig. 161
CC.	Processes more than 5μ in length	S. denudata S. halconensis S. rhodospora	fig. 162

S. atroviridis Spring   Fig. 158.

Tetrahedral, sub-triangular, 15μ - 20μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears long, thin, rod-like outgrowths, 5μ - 8μ in length and set 5μ - 8μ apart. The apical hemisphere is without ornamentation.

A description of the species is given by Hooker and Greville (1837, I, tab. 39), under the name Lycopodium atroviridis.

S. breynioides Baker

Tetrahedral, sub-triangular, 15μ - 20μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore is studded with thin, rod-like processes 5μ long and set 5μ - 7μ apart. The apical surface is without ornamentation.

The spores of this species are mentioned by Hieronymous (1901, 86).

S. denudata Spring   Fig. 162.

Tetrahedral, sub-triangular, 25μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore is studded with rod-like processes 5μ - 7μ long and set 5μ - 7μ apart. Around the apical crest the ornamentation is absent.

S. halconensis Hieron.

Tetrahedral, sub-triangular, 25μ. Tri-radiate mark extending to the margin. Exospore, on the ab-apical side, furnished with rod-like processes, 5μ - 7μ long and set 5μ - 8μ apart. The apical surface is without ornamentation.

S. latifrons Warb. Fig. 161.

Tetrahedral, sub-triangular, 25μ. Tri-radiate mark extending to the margin. Exospore on the ab-apical side bears blunt, rod-like processes, 5μ long and set 5μ - 8μ apart. The apical surface is without ornamentation.

The spores of this species are described by Hieronymous (1901, 115).

S. longipinna Warb.

Tetrahedral, sub-triangular, 20μ - 25μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears thin, rod-like processes, 5μ long and spaced 3μ - 5μ apart. The apical surface is without ornamentation.

The spores of this species are described by Hieronymous (1901, 107).

S. luzonensis Hieron.

Tetrahedral, sub-triangular, 15μ - 20μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore is furnished with rod-like processes 5μ long and set 5μ - 8μ apart. The apical surface is without ornamentation.

The spores of this species are described by Hieronymous (1901, 113, and 1902).

S. regularis Baker

Tetrahedral, sub-triangular, 25μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears thin, blunt processes 5μ - 8μ long and set 3μ - 5μ apart. The apical surface is without ornamentation.

S. rhodospora Baker

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears thin, rod-like processes 5μ - 8μ long and set 5μ - 10μ apart. The apical surface is without ornamentation.

S. sumatrana Hieron. Fig. 159.

Tetrahedral, sub-triangular, 15μ - 20μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears rod-like processes 8μ - 10μ long and set 5μ - 8μ apart. The apical surface is without ornamentation.

S. Swartzii Spring

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears rod-like processes 5μ long and set 5μ - 8μ apart. The apical surface is without ornamentation.

S. trifurcata Baker

Tetrahedral, sub-triangular, 20μ - 25μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore is furnished with thin, rod-like processes 5μ long and set 3μ - 6μ apart. The apical surface is without ornamentation.

GROUP XV. Group of S. sub-arborescens.

Spores measuring 15μ - 35μ in diameter; rather sparsely furnished with stout, conical emergences appearing as broad-based spines from 2μ - 5μ in length and in most species 2μ broad at the base; the processes are spaced 2μ - 8μ distant from one another. The apical surface is free from ornamentation.

Key to the species.

A. Spores 15μ - 20μ in diameter ... S. Breynii
S. Jouani
S. sub-arborescens fig.163
S. versicolor

AA. Spores 20μ - 35μ in diameter.

B. Spore diameter 20μ - 25μ.

C. Processes 2μ - 3μ, widely spaced, 5μ - 8μ apart. S. augustiramea
S. confusa
S. Elmeri fig. 164
S. Roland-principis

CC. Processes 3μ - 5μ, spaced 5μ apart ... S. cupressina fig. 165
S. alopecuroides

BB. Spore diameter 25μ - 36μ.

C. Spore diameter 30μ - 35μ S. erectifolia fig. 166
Lycopodium densum fig. 75

CC. " " 25μ - 30μ S. calosticha
S. Davidei
S. Feniscii
S. Kochii
S. peltata fig. 167
S. Plumieri
S. truncata
S. Weberbaueri

S. alopecuroides Baker

Tetrahedral, almost spherical, 20μ - 25μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears thin pointed processes 3μ - 5μ long and spaced 5μ apart. The apical surface is without ornamentation.

The spores of this species are described by Hieronymous (1901, 231).

S. augustiramea Mirell and Bak.

Tetrahedral, sub-triangular, 20μ - 25μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore is studded with short, conical elevations 2μ high and set 5μ - 8μ apart. The apical surface is without ornamentation.

S. Breynii Spring

Tetrahedral, sub-triangular, 15μ - 20μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears short conical processes, 3μ long and set 3μ - 5μ apart. The apical surface is without ornamentation.

The spores of this species are recorded by Spring (1849, p. 119) and Hieronymous (1901, 210).

S. calosticha Spring

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears short, conical processes set 2μ - 5μ apart. The apical surface is without ornamentation.

The spores of this species are mentioned by Hieronymous (1901, 209).

S. cupressina A. Br. Fig. 165.

Tetrahedral, sub-triangular, 20μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore is furnished with thin, pointed processes, 3μ - 5μ long and set 3μ - 6μ apart. The apical surface is without ornamentation.

The spores of this species are mentioned by Spring (1849, p. 113), Brackenridge (1854, p. 337) and Hieronymous (1901, 104).

S. Davidei Franchet

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears stout, conical processes, up to 5μ in length and set 3μ - 6μ apart. The apical surface is without ornamentation.

S. Elmeri Hieron. Fig. 164.

Tetrahedral, sub-triangular, 20μ - 30μ. Tri-radiate mark extending to the margin. The exospore on the ab-apical side studded with conical processes 3μ long and set 5μ - 8μ apart. The apical surface is without ornamentation.

S. erectifolia Spring Fig. 166.

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. The apical surface is devoid of ornamentation and the exospore on the ab-apical side is studded with stout conical processes, 5μ in length and 2μ broad at the base; set 5μ - 8μ apart.

S. Feniscii Hieron.

Tetrahedral, sub-triangular, 25μ. Tri-radiate mark extending to the margin. The exospore bears conical processes

3μ - 4μ long and set 3μ - 5μ apart on the ab-apical side; round the apical crest the surface is smooth or papillate.

S. Jouani Hieron.

Tetrahedral, sub-triangular, 15μ - 20μ. Tri-radiate mark extending to the margin. On the ab-apical side the exo-spore bears conical processes 3μ - 4μ long and set 3μ - 5μ apart. The apical surface is without ornamentation.

The spores of this species are mentioned by Hieronymous (1901, 110).

S. Kochii Hieron.

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin. On the ab-apical side the exo-spore bears stout conical processes 3μ long and set 3μ - 5μ apart. The apical surface is without ornamentation.

S. peltata Presl. Fig. 167.

Tetrahedral, sub-triangular, 25μ. Tri-radiate mark extending to the margin. On the ab-apical surface the exo-spore bears stout conical processes 2μ long and set 5μ - 8μ apart. The apical surface is without ornamentation.

S. Plumieri Hieron.

Tetrahedral, sub-triangular, 25μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore is studded with short, stout conical processes 3μ long and set 3μ - 5μ apart. The apical surface is without ornamentation.

S. Roland-principis Alston

Tetrahedral, sub-triangular, 20μ - 25μ. Tri-radiate mark extending to the margin. The exospore is studded with short, stout, conical processes, 2μ - 3μ long and set 5μ - 8μ apart; the apical surface is without ornamentation.

S. sub-arborescens Hook. Fig. 163.

Tetrahedral, sub-triangular, 15μ - 20μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore is studded with short, stout, conical processes, 2μ - 3μ long and set 3μ - 5μ apart. The apical surface is without ornamentation.

The spores of this species are mentioned by Hieronymous (1901, 406).

S. truncata A. Br.

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears stout conical processes 2μ long and set 2μ - 3μ apart. The apical surface is without ornamentation.

The spores of this species are described by Hieronymous (1901, 205).

S. versicolor Spring

Tetrahedral, sub-triangular, 15μ - 20μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears short, stout conical processes 2μ - 3μ long and set 3μ - 5μ apart. The apical surface is without ornamentation.

The spores of this species are mentioned by Hieronymous (1901, 155).

S. Weberbaueri Hieron.

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears stout, conical processes, 3μ - 4μ long and set 3μ - 5μ apart. The apical surface is without ornamentation.

GROUP XVI. Group of S. anceps.

Spores measuring 20μ - 35μ in diameter, ornamented with short, conical, pointed emergences, densely packed together. The processes are small, from 1μ - 3μ in length and set 2μ - 5μ apart.

Key to the species.

A. Spore diameter 30μ - 35μ	...	S. Wallichii	fig. 168
AA. " " 20μ - 30μ.			
B. Processes acicular	...	S. anceps	fig. 169
		S. erythropus	fig. 170
BB. Processes stout and conical		S. blepharostachys	fig. 171
		S. Mayerhoffii	fig. 172

<u>S. anceps</u> Presl. Fig. 169.

Tetrahedral, sub-triangular, 20μ - 25μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears minute acicular processes, 1μ - 2μ long and set 2μ - 3μ apart; the spore margin has a denticulate appearance. The apical surface is without ornamentation.

The spores of this species are mentioned by Hieronymous (1901, 105).

<u>S. blepharostachys</u> Alston Fig. 171.

Tetrahedral, sub-triangular, 20μ - 30μ. Tri-radiate mark extending to the margin and with a conspicuous crest. The exospore is ornamented with small, conical, spinose processes, 2μ long, numerous and closely set, 2μ apart. On the apical side the emergences are sparse and absent from the apical crest.

<u>S. erythropus</u> (Mart.) Spring Fig. 170.

Tetrahedral, sub-triangular, 20μ - 25μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore is ornamented with fine acicular processes, 2μ - 3μ long and set 3μ - 5μ apart. The apical surface is without emergences.

The spores of this species are described by Hieronymous (1901, 123).

S. Mayerhoffii Hieron. Fig. 172.

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears stout, conical processes, 2μ long and set 3μ - 5μ apart. The apical surface is without ornamentation.

S. Wallichii Spring Fig. 168.

Tetrahedral, sub-triangular to spherical, 30μ - 35μ. Tri-radiate mark extending to the margin. Exospore bears short, stout, conical processes, 2μ long, sometimes coalescing at the base, closely arranged 2μ - 3μ apart.

The spores of this species are described by Hieronymous (1901, 357).

GROUP XVII. Group of S. uncinata.

Spores measuring 20μ - 35μ in diameter; furnished with long spinose processes, densely packed together. The spines vary in length from 4μ - 7μ and have a base of 1μ - 3μ broad; the spines are irregularly arranged and spaced 2μ - 5μ apart.

Key to the species.

A. Spinose processes long, up to 7μ.

B. Spines stout, with a base 3μ broad .. .. S. Eggersii fig. 173
S. eurynota
S. intacta fig. 174
S. lingulata
S. polycephala
S. pubescens

BB. Spines thin with a narrow base.

C. Spore diameter 20μ - 25μ	S. articulata	fig. 175
	S. bombycina	fig. 176
	S. caudorhiza	
CC. " " 25μ - 35μ	S. epirrhizos	
	S. horizontalis	
	S. Lindigii	
	S. mnioiodes	
	S. uncinata	fig. 177

AA. Spinose processes less than 5μ.

B. Spore diameter 20μ - 25μ ...	S. chilensis	fig. 178
	S. geniculata	fig. 179
BB. " " 25μ - 35μ ...	S. Galleotei	
	S. Poeppigiana	fig. 180
	S. sulcata	
	S. trisulcata	

<u>S. articulata</u> Spring Fig. 175.

Tetrahedral, sub-triangular to spherical, 20μ - 25μ. Tri-radiate mark extending to margin. Exospore bears spinose processes on all faces; on the ab-apical side they are long up to 7μ, set 3μ - 4μ apart. Those on the apical side are shorter.

The spores of this species are mentioned by Hieronymous (1901, 427).

<u>S. bombycina</u> Spring Fig. 176.

Tetrahedral, sub-triangular to spherical, 20μ - 30μ. Tri-radiate mark extending to the margin. Exospore densely covered with sharp spines, 4μ - 6μ long and about 3μ apart on the ab-apical side; on the apical surface the processes are shorter.

The spores of this species are mentioned by Spring (1849, p. 191).

S. caudorhiza Baker

Tetrahedral, sub-triangular to spherical, 20μ - 30μ. Tri-radiate mark extending to the margin. Exospore ornamented on all faces with sharp, spinose processes, 5μ - 7μ long and densely set together, 3μ - 5μ apart.

S. chilensis Spring   Fig. 178.

Tetrahedral, sub-triangular, 20μ - 25μ. Tri-radiate mark extending to the margin. Exospore ornamented on all faces with sharp spines up to 5μ in length and irregularly arranged about 3μ apart.

The spores of this species are mentioned by Hieronymous (1901, 365).

S. Eggersii Sodiro   Fig. 173.

Tetrahedral, sub-triangular to spherical, 25μ - 35μ. Tri-radiate mark extending to the margin. The exospore bears stout spinose processes, 7μ long and 3μ broad at the base; they are densely packed together, set about 3μ apart.

The spores of this species are mentioned by Hieronymous (1901, 433).

S. epirrhizos Spring

Tetrahedral, sub-triangular to spherical, 25µ - 30µ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore is ornamented with sharp spinose processes, 5µ - 8µ long and 2µ at base, densely packed 3µ - 5µ apart. Round the apical crest the spines are shorter and less densely arranged.

The spores of this species are mentioned by Hieronymous (1901, 426).

S. eurynota A. Br.

Tetrahedral, sub-triangular to spherical, 25µ - 35µ. Tri-radiate mark extending to the margin. Exospore covered with stout spines, 5µ - 8µ long, 3 broad at the base and densely packed together 3µ - 5µ apart.

The spores of this species are mentioned by Hieronymous (1901, 414).

S. Galeottei Spring

Tetrahedral, sub-triangular to spherical, 25µ - 35µ. Tri-radiate mark extending to the margin. The exospore is ornamented with sharp spines about 5µ in length and set 3µ - 5µ apart.

The spores of this species are mentioned by Hieronymous (1901, 435) and figured by Knox (1938, fig. 13).

S. *geniculata* Spring Fig. 179.

Tetrahedral, sub-triangular, 20μ - 30μ. Tri-radiate mark extending to the margin. Exospore ornamented on all faces with sharp spines 5μ long and set 3μ - 5μ apart.

The spores of this species are described by Spring (1849, p. 227) and Hieronymous (1901, 406).

S. *horizontalis* (Presl.) Spring

Tetrahedral, sub-triangular to spherical, 25μ - 35μ. Tri-radiate mark extending to the margin. Exospore ornamented on all faces with sharp spines 5μ - 7μ long and set 3μ - 5μ apart.

The spores of this species are mentioned by Hieronymous (1901, 415).

S. *intacta* Baker Fig. 174.

Tetrahedral, sub-triangular to spherical, 25μ - 30μ. Tri-radiate mark extending to the margin. The exospore is ornamented with stout spinose processes, 7μ long, 3μ broad at the base and densely set 3μ - 5μ apart. On the apical side the processes are short and less closely packed.

The spores of this species are mentioned by Hieronymous (1901, 398).

S. *Lindigii* A. Br.

Tetrahedral, sub-triangular to spherical, 25μ - 30μ.

Tri-radiate mark extending to the margin. The exospore is ornamented with spinose processes, 5μ - 7μ long, closely packed together, 3μ - 5μ apart. Round the apical crest the spines are short and scattered.

The spores of this species are mentioned by Hieronymous (1901, 432).

S. lingulata Spring

Tetrahedral, sub-triangular, 25μ - 35μ. Tri-radiate mark extending to the margin. Exospore on the ab-apical side studded with stout spines, 7μ long and 3μ broad at the base; spines arranged irregularly about 5μ apart. On the apical surface the spines are short and scattered.

The spores of this species are mentioned by Hieronymous (1901, 424).

S. mnioides A. Br.

Tetrahedral, sub-triangular to spherical, 25μ - 35μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore is ornamented with sharp spinose processes, 7μ long and closely packed together 2μ - 4μ apart. On the apical surface the spines are short and scattered.

The spores of this species are mentioned by Hieronymous (1901, 436).

S. Poeppigiana Spring Fig. 180.

Tetrahedral, sub-triangular to spherical, 25μ - 35μ.

Tri-radiate mark extending to the margin. Exospore is ornamented with sharp spines 5μ long, densely packed together 2μ - 4μ apart.

The spores of this species are mentioned by Hieronymous (1901, 423).

S. polycephala Baker

Tetrahedral, sub-triangular to spherical, 25μ - 35μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears stout spinose processes, 7μ long and 3μ broad at the base; the processes are set 3μ - 5μ apart. On the apical surface the spines are small and scattered.

S. pubescens (Wall) Spring

Tetrahedral, sub-triangular to spherical, 25μ - 35μ. Tri-radiate mark extending to the margin. Exospore ornamented with stout, spinose processes, 7μ long and 3μ broad at the base; the spines are irregularly arranged and set 2μ - 4μ apart.

The spores of this species are described by Spring (1849, p. 173) and Hieronymous (1901, 73).

S. sulcata Spring

Tetrahedral, sub-triangular to spherical, 25μ - 35μ. Tri-radiate mark extending to the margin. Exospore bears sharp, spinose processes 5μ long, irregularly disposed 2μ - 4μ apart.

The spores of this species are mentioned by Spring (1849,

p. 214) and Hieronymous (1901, 413).

S. trisulcata Asph.

Tetrahedral, sub-triangular to spherical, 25μ - 35μ. Tri-radiate mark extending to the margin. Exospore ornamented with sharp spines 5μ long and set 3μ - 5μ apart.

S. uncinata Spring   Fig. 177.

Tetrahedral, sub-triangular to spherical, 25μ - 35μ. Tri-radiate mark extending to the margin. Exospore bears spinose processes 5μ - 7μ long and set 3μ - 4μ apart. On the apical side the spines are smaller and scattered.

The spores of this species are described by Hieronymous (1901, 341).

GROUP XVIII.   Group of S. magnifica.

Spores measuring 20μ - 35μ in diameter; ornamented on the ab-apical hemisphere with slender, pointed, acicular processes, widely spaced. The acicles vary in length from 3μ - 8μ and are regularly arranged from 5μ - 10μ apart. The apical surface is smooth.

Key to the species.

A. Acicular processes less than 5μ in length ... ... S. cagayensis fig. 181
S. longissima
S. pilosula

AA. Acicular processes more than 5μ. in length

B. Acicles thin and up to 8μ long.

C.	Spore diameter 20μ - 25μ	S. Spanielema	fig. 182
		S. speciosa	
CC.	" " 25μ - 35μ	S. Brooksii	fig. 183
		S. contigua	
		S. tomentosa	

BB. Acicles 5μ long.

C.	Spore diameter 20μ - 25μ	S. alopecuroides	
		S. Keistingii	
		S. latifolia	
		S. magnifica	fig. 184
		S. Wariensis	
CC.	" " 25μ - 35μ	S. adligans	fig. 185
		S. ambigua	
		S. Copelandii	
		S. flabellata	

<u>S. adligans</u> Hieron. Fig. 185.

Tetrahedral, sub-triangular, 25μ - 35μ. Tri-radiate mark extending to the margin. Exospore ornamented with sharp acicular processes 5μ long and 5μ - 10μ apart. On the apical surface the acicles are absent.

<u>S. alopecuroides</u> Baker

Tetrahedral, sub-triangular to spherical, 20μ - 25μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears thin acicular processes 3μ - 5μ long and 5μ apart. The apical surface is smooth.

The spores of this species are described by Hieronymous (1901, 231).

S. ambigua A. Br.

Tetrahedral, sub-triangular to spherical, 25μ - 30μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears acicular processes 5μ long and set 5μ - 10μ apart. The apical surface is smooth.

The spores of this species are mentioned by Hieronymous (1901, 165).

S. Brooksii Hieron. Fig. 183.

Tetrahedral, sub-triangular to spherical, 25μ - 30μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore is ornamented with thin acicular processes, 5μ - 7μ long, sometimes curved and set 5μ - 6μ apart. The apical surface is smooth.

S. cagayanensis Hieron. Fig. 181.

Tetrahedral, sub-triangular to spherical, 25μ - 30μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears fine acicular processes, 3μ long and widely spaced 5μ - 10μ apart. The apical surface is smooth.

S. contigua Baker

Tetrahedral, sub-triangular, 30μ - 35μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears acicular spines 5μ - 7μ long and set 5μ - 10μ apart. The apical surface is without ornamentation.

The spores of this species are mentioned by Hieronymous (1901, 234).

S. Copelandii Hieron.

Tetrahedral, sub-triangular, 25μ - 30μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears thin, acicular spines, 5μ long and set 5μ - 8μ apart. The apical surface is without ornamentation.

S. flabellata Spring

Tetrahedral, sub-triangular, 25μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears acicular processes, 5μ long and set 5μ - 8μ apart.

The spores of this species are mentioned by Hieronymous (1901, 130).

S. Keistingii Hieron.

Tetrahedral, sub-triangular, 20μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears acicular processes, 5μ long and set 5μ - 8μ apart. The apical surface is without ornamentation.

S. latifolia Spring

Tetrahedral, sub-triangular, 20μ - 25μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears fine acicular processes, 5μ long and set 5μ - 8μ apart. The apical surface is smooth.

The spores of this species are described by Spring (1849, p. 168) and Hieronymous (1901, 141).

S. longissima Baker

Tetrahedral, sub-triangular, 25µ - 30µ. Tri-radiate mark extending to the margin. Exospore bears acicular processes, 3µ long and set 3µ - 5µ apart. On the apical surface the acicles are few and scattered.

The spores of this species are mentioned by Hieronymous (1901, 497).

S. magnifica Warb. Fig. 184.

Tetrahedral, sub-triangular, 20µ - 25µ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore is ornamented with fine acicular processes, 5µ long and set 5µ - 8µ apart. On the apical surface the processes are absent.

The spores of this species are mentioned by Hieronymous (1901, 137).

S. pilosula vA. vR.

Tetrahedral, sub-triangular to spherical, 25µ - 30µ. Tri-radiate mark extending to the margin. The exospore is ornamented with fine acicular processes, 3µ - 5µ long and set 5µ apart. On the apical surface the acicles are absent.

S. Spanielema Alston   Fig. 182.

Tetrahedral, sub-triangular, 20μ - 25μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears acicular processes, up to 8μ long and set 5μ - 8μ apart. The apical surface is without ornamentation.

S. speciosa A. Br.

Tetrahedral, sub-triangular, 20μ - 25μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore is ornamented with fine acicular processes 5μ - 7μ long and set 5μ apart. The apical surface is smooth.

The spores of this species are mentioned by Hieronymous (1901, 138).

S. tomentosa Spring

Tetrahedral, sub-triangular to spherical, 25μ - 30μ. Tri-radiate mark extending to the margin. The exospore bears long acicular processes, 5μ - 7μ, and set 5μ apart. The apical surface is without ornamentation.

The spores of this species are mentioned by Hieronymous (1901, 442).

S. Wariensis Hieron.

Tetrahedral, sub-triangular, 20μ - 25μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears short, acicular processes, 5μ long and set 5μ apart. The apical surface is without ornamentation.

GROUP XIX. Group of S. Selaginoides.

Spores measuring 25μ - 40μ in diameter; furnished with stout, coarse, conical processes having a spreading base 5μ broad. The spines vary in length from 5μ - 12μ, tapering to a point and arranged irregularly and widely spaced.

Key to the species.

A.	Processes set more than 10μ apart	S. Selaginoides	fig. 186
AA.	" " less " 10μ "	S. atirrensis	fig. 187

S. atirrensis Hieron. Fig. 187

Tetrahedral, sub-triangular to spherical, 25μ - 35μ. Tri-radiate mark extending to the margin. Apical surface papillate. Exospore on ab-apical side studded with coarse spinose processes, 3μ broad at the base, with blunt or straight ends, about 5μ - 8μ long, irregularly arranged and widely spaced, 5μ - 8μ apart.

The spores of this species are mentioned by Hieronymous (1901, 438).

S. Selaginoides Link Fig. 186.

Tetrahedral, sub-triangular to spherical, 35μ - 40μ. Tri-radiate mark extending to the margin, apical crest prominent. On the ab-apical surface the exospore is ornamented with coarse, stout, blunt spinose processes, 5μ - 8μ long, spreading at the base to 5μ and widely spaced 10μ - 15μ apart.

The apical side is finely granular.

The microspores of this familiar species are described by several authors:- Link (1842), Milde (1859), Braun (1860), Luerssen (1889), Hieronymous (1901, fig. 401), Hegi (1936, taf. I, fig. 51), Reeve (1935, pl. 380), Erdtman (1943, figs. 487, 488).

GROUP XX. Group of S. Kraussiana.

Spores measuring 30μ - 55μ in diameter; furnished with long, stout, curved spines. The spines measure up to 12μ in length and have a base varying from 3μ - 7μ and are irregularly arranged.

Key to the species.

A.	Spines widely spaced	S. Kraussiana	fig. 188
AA.	" closely "	S. Kunzeana	fig. 189

S. Kraussiana A. Br. Fig. 188.

Tetrahedral, sub-triangular to spherical, 50μ - 55μ. Tri-radiate mark 2/3 radius and frequently seen to be open. On the ab-apical side the exospore bears long, stout, curved spines, up to 12μ long and widely spaced 10μ or more apart. Surrounding the apical slit the spines are short and broad at the base.

The spores of this species are mentioned by Hieronymous (1901, 420), and are figured by Slagg (1932).

S. Kunzeana A. Br. Fig. 189.

Tetrahedral, sub-triangular to spherical, 30μ - 50μ. Tri-radiate mark extending to the margin. On the ab-apical side the exospore bears stout, curved spines 8μ - 12μ long with a spreading base up to 7μ broad. The spines are closely set on the ab-apical surface but on the apical side they are short and scattered.

The spores of this species are mentioned by Hieronymous (1901, 429).

Spore Structure in SELAGINELLACEAE.

The genus Selaginella comprises some 600 species, and of these about 350 have been examined, representative of all the sub-genera and series as formulated by Walton and Alston (1938).

The microspores are relatively small, ranging from 15μ - 50μ with a few species of 60μ in diameter. In the majority of cases the spore size varies from 20μ - 40μ. This is in contrast to the spores of the genus Lycopodium where they are most frequently 40μ to 50μ in diameter.

The spore shape throughout the genus Selaginella is sphaerico-tetrahedral. The ornamentation usually takes the form of protuberances or outgrowths of the wall which are of three main types; the spinose, tuberculate and rod-like. All may be regarded as having been derived from a smooth walled form as seen in S. firmula (fig. 103), slight deviations from which are illustrated in the granular appearance of S. helvitica (fig. 111) or the finely papillate form of S. cathedrifolia (fig. 117). An increasing degree of spinosity is observed in such species as S. sub-arborescens (fig. 163), S. uncinata (fig. 177) and S. Kraussiana (fig. 188); a series with acicular outgrowths is exemplified in S. cagayanensis (fig. 181), S. magnifica (fig. 184) and S. Spanielema (fig. 182), in the latter of which the acicles attain a length of 8 μ. The tuberculate type includes spores whose walls have rounded, warty elevations as in S. radicata (fig. 129); where the excrescences become more pronounced the coarsely tuberculate type is reached as in S. vaginata (fig. 140) and S. sinensis (fig. 139). The third series comprises spores characterised by the presence of thin, parallel-sided, rod-like outgrowths as seen in S. stolonifera (fig. 148), S. biformis (fig. 156), S. latifrons (fig. 161), culminating in S. sumatrana (fig. 159) with the processes 10 μ in length.

In addition to the three more common types referred to, some species of Selaginella are distinguished by the possession of a membranous growth; this membrane may encircle the entire spore body as in S. sibirica (fig. 77), or may be confined to the ab-apical hemisphere as wing-like outgrowths, supported by strengthening struts as seen in S. megastachys (fig. 96) and S. integerrima (fig. 92), or be reduced to an equatorial flange as in S. sanguinolenta (fig. 86).

Finally, a type, infrequent in occurrence, is distinguished by the presence of an annular equatorial ring as seen in S. scandens (fig. 99).

No single type of sculpturing has been found to be characteristic of any one of the four sub-genera of Selaginella, as defined by Walton and Alston, nor of any single series within a sub-genus. Thus it cannot be maintained that the spore sculpturing accords with the classification in Selaginella, and in fact, there is no noticeable relationship between spore morphology and any of the taxonomic arrangements suggested. This is in contrast to the genus Lycopodium where the spore morphology has been shown to bear some relationship to classification, if only in a general way. In neither genus, however, can any connection be traced between spore morphology and ecological conditions.

It can, however, be stated that the spores of Selaginella, so far examined by the author or described by Hieronymous (1901), do differ materially in sculpturing and external morphology from those of Lycopodium, and the spores of the two genera would not be likely to be confused with one another. Whereas in Lycopodium the exospore is pitted or reticulate, in Selaginella the ornamentation exhibits some form of outgrowth from the spore wall, either spinose or tuberculate processes or a membranous wing; no such excrescences are featured amongst the spores of Lycopodium, with the one exception of L. densum (fig. 75).

ISOETACEAE.

General Characters and Classification.

The family Isoetaceae comprises three genera: Isoetes, with over 60 species, and the fossil genera Nathorstiana and Pleuromeia. The family is characterised by a short, erect axis with crowded acicular leaves, all of which may be fertile. The base of the axis forms a swollen meristem which produces dichotomously forked roots in regular succession.

Members of the genus Isoetes are relatively small, herbaceous plants, occupying diverse habitats. Some are essentially lacustrine, submersed in water, others are xerophytic forms occurring on dry hillsides. They are inhabitants chiefly of cool, climatic regions, rare or absent in the tropics. All the leaves may be fertile and the plants are heterosporous.

The name was first mentioned by Linnaeus in 1751, and two years later he established the genus. Delile in 1827 was the first to give a detailed account of the development of Isoetes, based on an examination of Isoetacea. Interest in the genus was further stimulated through the work of Braun (1864) and by 1867 Milde was able to refer to 15 species. A synopsis of the genus was published by Baker in 1880, which was later incorporated in his "Fern Allies" (1887). In this synopsis 46 species are brought together and the primary divisions of the genus are based upon the geographical distribution of the species. Following Baker's work, Motelay and Vendryès (1883) published a monograph of the genus. They recognised 47 species and give figures of several spore forms. Other systematic accounts dealing mainly with N. American forms were published, but no outstanding addition to our knowledge of the genus was made until 1922 when Pfeiffer published her "Monograph of the Isoetaceae". This work contains a useful account of the history, morphology and ecological relationships of Isoetes, together with a classification based upon the sculpturing of the megaspores. Recently, Williams (1943) gives a morphological account of a new species from Western Australia.

Pfeiffer recognises four Sections: Tuberculatae, Echinatae, Cristatae and Reticulatae, characterised by megaspores possessing tuberculate, spiny, crested or reticulate exospores respectively. Sixty-four species are described in detail and in the majority of cases mention is made of the microspores, though these have not been found to be of much diagnostic value.

The present account describes the microspores of 40 species of Isoetes. Following the procedure adopted in Lycopodiaceae and Selaginellaceae the microspores are segregated into groups with similar spore ornamentation.

On this basis three groups of microspore types are recognised: Group I, in which the exospore is smooth or granular; Group II, with papillate ornamentation and Group III, bearing setose processes. A key is given to the groups as well as keys to series of species within each group. The number after references to Pfeiffer (1922) is that which she has given to the particular species under review.

GENUS I. ISOETES.

Key to Species Groups.

A. Exospore smooth to finely granular; margin entire I. Group of *I. echinospora*

AA. Exospore rugose, papillate or setose; margin not entire.

B. Exospore rugose or papillate ... II. Group of *I. adspersa*

BB. Exospore setose ... III. Group of *I. Hystrix*

Exospore Morphology in Isoetes Species.

Group I. Group of *I. echinospora*.

Spores ovoid; 25μ - 40μ in length, about 20μ in breadth. The exospore is smooth to granular; margin entire.

Key to the species

In this group there are few distinguishing characters; the spores vary little in size and being practically devoid of sculpturing they are difficult, in fact almost impossible, to distinguish from one another.

A.	Spore length 30μ or more	...	I. Drummondii fig. 190 I. Piperi I. Pringlei I. riparia I. Savatieri
AA.	Spore length 30μ or less	...	I. boliviensis I. echinospora fig. 191 I. Ekmani I. foveolata I. Howellii I. lacustris I. mexicana I. saccharata I. setacea I. Tuckermani I. Tuerckheimii

I. boliviensis Weber

Spores 30μ x 20μ. Ovoid in outline. Exospore smooth to finely granular; margin entire.

No mention of the spores of this species has been found in the literature.

I. Drummondii A. Br. Fig. 190.

Spores 30μ - 35μ x 20μ. Ovoid in outline with a well developed apical crest. Exospore coarsely granular; margin entire.

Spores of this species described by Motelay and Vendryès (1883) and by Pfeiffer (1922, 20).

I. echinospora Dur. Fig. 191.

Spores 30μ x 20μ . Ovoid in outline. Exospore smooth to granular; margin entire.

The spores of this species are described by Motelay and Vendryès (1883) and by Baker (1887) and Pfeiffer (1922, 40).

I. Ekmani Weber

Spores 30μ x 20μ. Ovoid in outline. Exospore smooth to granular; margin entire.

No mention of the spores of this species has been found in the literature.

I. foveolata var. plenospora Alston

Spores 25μ - 30μ x 20μ. Ovoid in outline with a well developed apical ridge. Exospore granular; margin entire.

The spores of this species are described by Pfeiffer (1922, 56).

I. Howellii Engelm.

Spores 25μ - 30μ x 20μ. Ovoid in outline with a well developed apical crest. Exospore smooth to faintly granular; margin entire.

The spores of this species are described by Pfeiffer (1922, 34).

I. lacustris L.

Spores 30μ x 20μ. Ovoid in outline. Exospore almost smooth; margin entire.

The spores of this species are described by Motelay and Vendryès (1883) and by Baker (1887) and Pfeiffer (1922, 51).

I. mexicana Und.

Spores 30µ x 20µ. Ovoid in outline with a well developed apical ridge. Exospore smooth to granular; margin entire.

The spores of this species are described by Pfeiffer (1922, 37).

I. Piperi Eaton

Spores 30µ x 20µ. Ovoid in outline. Exospore faintly granular; margin entire.

The spores of this species are described by Pfeiffer (1922, 53).

I. Pringlei Und.

Spores 35µ x 25µ. Ovoid in outline with a well developed apical crest. Exospore granular; margin entire.

The spores of this species are described by Pfeiffer (1922, 49).

I. riparia Engelm.

Spores 30µ - 35µ x 20µ - 25µ. Ovoid in outline. Exospore smooth to granular; margin entire.

The spores of this species are described by Motelay and Vendryès and by Pfeiffer (1922, 48).

I. saccharata var. Amesii Eaton

Spores 30μ x 15μ. Ovoid in outline. Exospore smooth to finely granular; margin entire.

The spores of this species are described by Pfeiffer (1922, 47).

I. Savatieri Franchet

Spores 30μ - 40μ x 20μ - 25μ. Ovoid in outline with a well developed apical crest. Exospore granular; margin entire.

The spores of this species are described by Motelay and Vendryès and by Pfeiffer (1922, 45).

I. setacea Bosc.

Spores 30μ x 20μ. Ovoid in outline. Exospore granular; margin entire.

The spores of this species are described by Motelay and Vendryès and by Baker (1887) and Pfeiffer (1922, 6).

I. Tuckermani A. Br.

Spores 30μ x 20μ. Ovoid in outline. Exospore granular to rugose; margin entire.

The spores of this species are described by Motelay and

Vendryès and by Baker (1887) and Pfeiffer (1922, 55).

I. Tuerckheimii Brause

Spores 25μ - 30μ x 15μ - 20μ. Ovoid in outline. Exospore smooth to minutely papillate; margin entire.

The spores of this species are described by Pfeiffer (1922, 36).

Group II. Group of I. adspersa

Spores ovoid, measuring 20μ - 40μ in length and 15μ - 20μ in breadth. The exospore is papillate or faintly reticulate with an uneven margin, usually crenulate.

Key to the species

A. Spores 30μ or more in length.

B. Exospore faintly reticulate I. ovata fig. 192

BB. Exospore papillate ... I. amazonica
I. azorica
I. Gardneriana fig. 193

AA. Spores less than 30μ in length; exospore papillate ... ... I. adspersa fig. 194
I. Braunii
I. capensis
I. coromandelina
I. flaccida
I. Nuttallii
I. Schweinfurthii
I. Stephansenii

I. adspersa A. Br. Fig. 194.

Spores measure 30μ x 20μ. Ovoid in outline with a well developed apical crest. Exospore granular to papillate;

margin finely crenulate.

The spores of this species are described by Motelay and Vendryès (1883) and by Baker (1887) and Pfeiffer (1922, 10).

I. amazonica A. Br.

Spores 30μ - 35μ x 20μ. Ovoid in outline with a well developed apical crest. Exospore granular to finely tuberculate; margin faintly crenulate.

The spores of this species are described by Pfeiffer (1922, 21).

I. azorica Dur.

Spores 35μ - 40μ x 20μ - 25μ. Ovoid in outline with a conspicuous apical ridge. Exospore papillate; margin crenulate.

The spores of this species are described by Motelay and Vendryès (1883) and by Baker (1887) and Pfeiffer (1922, 59).

I. Braunii Dur.

Spores 30μ x 20μ. Ovoid in outline. Exospore papillate; margin crenulate.

The spores of this species are described by Baker (1887) and Pfeiffer (1922, 42).

I. capensis A. Duthie

Spores 25μ - 30μ x 20μ. Ovoid in outline with a well developed apical ridge. Exospore rugose to papillate; margin crenulate.

No mention of the spores of this species has been found in the literature.

I. coromandelina L. fil.

Spores 20μ - 30μ x 15μ - 20μ. Ovoid in outline with a well developed apical ridge. Exospore rugose to papillate; margin crenulate.

The spores of this species are described by Pfeiffer (1922, 5).

I. flaccida Shuttlew.

Spores 20μ - 30μ x 15μ - 20μ. Ovoid in outline with a well developed apical ridge. Exospore papillate; margin crenulate.

The spores of this species are described by Motelay and Vendryès (1883) and by Baker (1887) and Pfeiffer (1922, 31).

I. Gardneriana Kze. Fig. 193.

Spores 30μ - 35μ x 20μ - 25μ. Ovoid in outline with a conspicuous apical ridge. Exospore rugose to papillate; margin crenulate.

The spores of this species are described by Motelay and Vendryès (1883) and by Baker (1887) and Pfeiffer (1922, 22).

I. Nuttallii A. Br.

Spores 25μ - 30μ x 15μ - 20μ. Ovoid in outline with a well developed apical ridge. Exospore papillate; margin crenulate.

The spores of this species are described by Motelay and Vendryès (1883) and by Baker (1887) and Pfeiffer (1922, 26).

I. ovata Pfeiffer Fig. 192.

Spores 30μ - 35μ x 20μ. Ovoid in outline. Exospore lightly reticulate with ridges spine-like in silhouette; margin finely crenulate.

The spores of this species are described by Pfeiffer (1922, 3,5).

I. Schweinfurthii A. Br.

Spores 30μ x 20μ. Ovoid in outline. Exospore minutely papillate; margin finely crenulate.

The spores of this species are described by Pfeiffer (1922, 3).

I. Stephansenii A. Duthie

Spores 25μ - 30μ x 15μ - 20μ. Ovoid in outline. Exospore papillose; margin crenulate.

No mention of the spores of this species has been found in the literature.

Group III. Group of I. Hystrix.

Spores ovoid, measuring 20μ - 40μ in length and 15μ - 25μ in breadth. The exospore is ornamented with fine, setose processes, varying in length from 2μ - 5μ and set about 3μ - 5μ apart. The apical crest is well developed in all species.

Key to the species

A. Setae more than 3μ in length.

- B. Spores more than 30μ in length ... ... I. habbemensis fig. 195; I. stellenborisiensis; I. Stuartii
- BB. Spores 30μ or less in length ... ... I. alpina; I. Hookeri; I. Hystrix fig. 197; I. Lechleri

AA. Setae less than 3μ in length.

- B. Spores 30μ in length ... I. Baetica; I. velata
- BB. Spores less than 30μ in length ... ... I. Boryana; I. japonica fig. 196; I. tenuissima

I. alpina Kirk

Spores 25μ - 30μ x 15μ - 20μ. Ovoid in outline with conspicuous ridges. Exospore bears stout bristles, 3μ - 5μ long and spaced about 5μ apart.

The spores of this species are described by Motelay and Vendryès (1883) and by Baker (1887) and Pfeiffer (1922, 17).

I. Baetica Willk.

Spores 30μ x 20μ. Ovoid in outline with well developed apical crest. Exospore minutely setose; setae 2μ - 3μ long and 3μ - 5μ apart.

No mention of the spores of this species has been found in the literature.

I. Boryana Dur.

Spores 20μ - 25μ x 15μ. Ovoid in outline with conspicuous apical ridge. Exospore setose; setae 2μ long and about 3μ - 5μ apart.

The spores of this species are described by Motelay and Vendryès, and by Baker (1887) and Pfeiffer (1922, 14).

I. habbemensis Alston Fig. 195.

Spores 35μ - 40μ x 20μ - 25μ. Ovoid in outline with well developed apical ridge. Exospore echinate; ornamentation of fine stiff bristles 5μ long and 5μ apart.

No mention of the spores of this species has been found.

I. Hookeri A. Br.

Spores 30μ x 20μ. Ovoid in outline with well developed apical ridge. Exospore finely setose; setae 3μ - 4μ long and 3μ - 4μ apart.

The spores of this species are described by Motelay and Vendryès and by Pfeiffer (1922, 28).

<u>I. Hystrix</u> Dur. Fig.

Spores 30μ x 20μ. Ovoid in outline with well developed apical ridge. Exospore echinate; ornamented with spinules 3μ - 4μ long and about 5μ apart.

The spores of this species are described by Motelay and Vendryès and by Baker (1887) and Pfeiffer (1922, 25).

<u>I. japonica</u> A.Br. Fig. 196.

Spores 20μ - 25μ x 15μ. Ovoid in outline with well developed apical ridge. Exospore finely setose; bristles 2μ long and about 5μ apart.

The spores of this species are described by Motelay and Vendryès (1883) and by Baker (1887) and Pfeiffer (1922, 60).

<u>I. Lechleri</u> Mett.

Spores 30μ x 20μ. Ovoid in outline with a well developed apical ridge. Exospore spinulose; processes 3μ - 5μ long and 3μ - 5μ apart.

The spores of this species are described by Motelay and Vendryès (1883) and by Baker (1887) and Pfeiffer (1922, 32).

<u>I. stellenborisiensis</u> A. Duthie

Spore 35μ x 20μ. Ovoid in outline with well developed apical ridge. Exospore setose; ornamentation of stout bristles 3μ - 4μ long and 3μ - 5μ apart.

No mention of the spores of this species has been found in the literature.

I. Stuartii A. Br.

Spores 30µ - 40µ x 25µ - 30µ. Ovoid in outline with well developed apical ridge. Exospore setose; bristles 3µ long, closely set about 3µ apart.

The spores of this species are described by Baker (1887) and Pfeiffer (1922, 28).

I. tenuissima Bor.

Spores 20µ - 25µ x 20µ. Ovoid in outline with well developed apical ridge. Exospore setose; setae 2µ - 3µ long and about 3µ apart.

The spores of this species are described by Motelay and Vendryès (1883) and by Baker (1887) and Pfeiffer (1922, 12).

I. velata A. Br.

Spores 30µ x 20µ. Ovoid in outline with well developed apical ridge. Exospore finely setose; setae 2µ - 3µ long and 3µ - 5µ apart.

The spores of this species are described by Motelay and Vendryès and by Baker (1887) and Pfeiffer (1922, 15).

Spore Structure in Isoetaceae.

The microspores of Isoetes are remarkably uniform in shape and size; they are ovoid in outline, frequently with a conspicuous apical ridge and rarely exceed 40µ x 30µ. In the majority of species they are of small dimensions. The microspore tetrad may show bi-lateral or tetrahedral arrangement; the freeing of the spores, however, soon allows a change of shape and rounding of the sharp angles. The ornamentation of the exospore is granular, papillose, spinulose or setose; occasionally a wing-like extension or crest may be present on the apical side.

The three groups in which the microspore types have been arranged for present comparative purposes, bear no apparent relationship to the four sections defined by Pfeiffer according to megaspore structure. Among the species which are included, for example, in Group I, in which the exospore is smooth or granular, are representatives of all four sections and types of megaspore recognised by Pfeiffer. There seems to be no valid correlation between type of ornamentation in the microspore and the form of sculpturing in the megaspore of the same species. Within the genus variations in morphological characters are so small that a natural grouping of the species is a matter of difficulty. Such classifications as have been suggested are mainly useful as aids to identification. It might be argued that the microspores could be used equally as well as megaspores; their small size and the consequent difficulty of examination, however, lessens the value of microspores for systematic diagnosis; they can be of use as additional evidence, and as such they are employed very occasionally by

Pfeiffer. Moreover, no obvious connection exists between the spore structure and the varied ecological conditions in which the plants live.

Of the two fossil genera, spores are known only for Pleuromeia, the microspores of which conform to the Isoetes type and are reniform in shape. Since both the fossil genera are Mesozoic members of the Isoetaceae, their spores, if they occur in the older Palaeozoic rocks, might be expected to appear only occasionally. It may be significant that similar ovoid spores have been recorded from the Carboniferous strata but the plants from which they originated are indeterminate.

PALAEOZOIC FOSSIL SPORES.

Following the study of the microspores of living representatives of the LYCOPODIINAE an evaluation may now be made of the several characters of spore morphology most likely to be of use for specific and generic diagnosis, and suggestions advanced as to the features least subject to change and variation during geologic time, and therefore of greatest taxonomic significance.

All pteridophytic spores are formed in essentially the same manner as the result of a tetrad division of the spore mother cell; the shape of each individual member of the tetrad is either tetrahedral or bi-lateral, depending upon the plane of division. Likewise the scar formed at the point of attachment of a spore to other members of the tetrad is either a tri-radiate or longitudinal slit. In the genera Lycopodium and Selaginella the tetrahedral form of spore is the normal one, and the tri-radiate mark is characteristic of both genera. A few unusual examples with bi-lateral, bean-shaped spores have been recorded for Lycopodium (Selling, 1946), but their occurrence is rare; in Isoetes, however, the microspores are ovoid in outline. The symmetry in exospore ornamentation is also influenced by the tetrad formation, though it may be slightly modified after the spores are set free from one another (Knox, 1949).

It has been shown in the preceding pages that in Lycopodium, two types of exospore ornamentation only, are represented, namely, the pitted and the reticulate, with the one exception of L. densum (fig. 75). In Selaginella and Isoetes, however, neither pitted nor reticulate types have been noted by the present author. On the contrary, the exospore exhibits great diversity of ornamentation in the form of outgrowth or protuberance - acicular, spinose, warty, tuberculate or rod-like, of varying length and breadth. These different types of excrescence account for the appearance of the majority of the microspores of Selaginella; the remaining few have membranous extensions of the wall which may appear as equatorial wings or as encircling bladder-like structures. It is of considerable interest that these several types of spore are all recognisable amongst the spores found in coals of Carboniferous age, but, as Schopf (1944) has pointed out, "It is important that many specific features of spores of different geological age can be matched because of evolutionary convergence as well as because of community of derivation. Consequently, unless there exists some corroborative evidence based upon spore forms actually present in contemporaneous fossils whose relationship can be established, all that seems warrantable is to direct attention to the similarity of the spores of different geologic age, recognising that the similarities may or may not have phyletic implications." It is necessary, therefore, to consider briefly the record of the rocks.

PALAEOZOIC PLANT RECORD AND CLASSIFICATION.

The earliest records of land plants of which we can be reasonably certain are from rocks of Silurian age. Impressions have been found in such rocks from different parts of the world, and the records, though scanty, indicate that by the close of the Silurian period, the invasion of the land by primitive plants had begun and thus paved the way for the evolution of a land flora.

During early Devonian times land plants show evidence of evolutionary trends along different lines. "With the discovery of the Rhynie Flora and the recognition of the order Psilophytales, the common ancestry of all vascular plants became a matter within the bounds of proper speculation" (Darrah, 1939). The Psilophytales, which include the Rhyniaceae, are defined as dichotomous, leafless and rootless plants, with terminal homosporous sporangia. This complex group, though somewhat unnatural, provides sufficient variety in form, from which different types may be derived, and from which, it is reasonable to suppose that lycopsid, sphenopsid and pteropsid lines may have evolved, though probably each along an independent path, traceable back to the algae.

Already in Middle Devonian times in Asteroxylon a habit simulating that found in Lycopodium is encountered; but the true strobiloid lycopods did not make their appearance until the Upper Devonian. During the Carboniferous period the Lepidodendrales, belonging to the lycopsid group, become dominant and reach a climax of development, then rapidly die out and only a few forms persist into the Permian. Most members were arborescent, though a few were herbaceous, and they all show great diversity of form, structure and method of attachment of the cone. Five families are recognised as follows:-

I. LEPIDODENDRACEAE (Carboniferous).

The strobili (Lepidostrobus) resemble closely those of

Selaginella, being ligulate, but larger in proportion. Some species produced strobili with one kind of spore only and others with both megaspores and microspores in the same cone.

II. LEPIDOCARPACEAE (Carboniferous).

Represented by one genus which bears cones with seed like structures.

III. MIADESMIACEAE (Carboniferous).

Also monotypic; a small, possibly herbaceous plant with seed-like sporophyll.

IV. BOTHRODENDRACEAE (Carboniferous).

Having the general habit of Lepidodendron, and the strobili (Bothrodendrostrobus) likewise similar to those of Selaginella.

V. SIGILLARIACEAE (Carboniferous and Permian).

Trees with unbranched axes and cones borne on special peduncles grouped in zones on the trunk and branches. Strobili heterosporous.

The only known fossil genus of the Lycopodiaceae is Spencerites, occurring in the Carboniferous. It bears a peltate sporophyll with a leaf-like umbo and spores of 140μ in diameter, with an equatorial wing.

Among Palaeozoic fossils are a few herbaceous plants which in habit resemble Lycopodium or Selaginella and are placed in the genera Lycopodites and Selaginellites respectively, the former apparently homosporous and the latter heterosporous. The presence or absence of a ligule is in most cases indeterminate, hence the assignment is uncertain.

The strobili of the extinct families were like those of living Lycopodiales, but in most cases of large size. Some forms were probably homosporous, but the majority were certainly heterosporous. The sporangia were radially elongated in contrast to the short type found in Lycopodium and Selaginella. In the megasporangia the number of spores was greater than in Selaginella. The spores resemble those of living heterosporous genera, though some were apparently very large and with prominent and complex ornamentation.

From the Devonian up to the present day we have evidence of the existence of land plants with jointed stems, and leaves borne in whorls at the nodes. In some the sporangia are borne on sporophylls while in others they are borne on stalked sporangiophores. These plants, united in the phyllum ARTICULATALES, include the orders:-

I. PROTOARTICULATINEAE.

Plants with bifurcate leaves and pendulous naked sporangia.

II. SPHENOPHYLLINEAE.

Herbaceous creeping plants, with slender articulate stems bearing whorls of wedge-shaped leaves. The strobili are built up of a series of whorls of leaf-like bracts, fused together for about half their length so that each whorl forms a cup round the axis of the strobilus. Attached to the axis immediately above the bracts in each whorl is a whorl of slender pedicels, each terminated in a sporangium. The spores are all of one kind, about 90μ in diameter and bear spines connected by ridges on their surfaces (Knox, 1939, fig. 120).

III. EQUISETINEAE.

Included with Equisetum are a large number of extinct forms with striking resemblances to the living genus. Commonest amongst the fossils of this order are the members of the family Calamitaceae. The characteristic sporangium bearing organ is the sporangiophore. The spores were produced in tetrads and fully formed spores are smooth and usually all about the same size, though in some species (e.g. C. casheana) abortive spores are found with larger ones in the same sporangium (Hirmer, 1927).

The third division of vascular plants which differentiated from the psilophytalean complex was the FILICALES, characterised by large leaves and as a rule with sporangia borne upon abaxial surfaces. The spores of these plants are somewhat diverse and are found in considerable numbers in coal seams. The FILICALES are, however, outwith the scope of the present survey and the classification of the group does not concern us here.

These several great phyla, LYCOPODIALES, ARTICULATALES and FILICALES, represent the dominant inhabitants of the Palaeozoic swamps; it is the remains of this vegetation which has gone in large measure to the formation of coal.

In recent years the application of the study of palaeobotany has become of increasing value in correlation of coal seams, particularly in relation to the search for coal and oil. The plant remains, including microfossils, of a given stratum may not only help to determine its age and mode of deposition but also the climate and physiographic environment under which the plants lived.

Coal may be studied from many angles: physical, chemical or biological; the biological alone concerns us here. One of the most recent developments in the microscopic study of coal has been the correlation of seams by means of spores and other microfossils. Continental workers for some time have used megaspores for this purpose with considerable success (Zerndt, 1934, 1937, and Dijkstra, 1946, 1949). In Great Britain microspore analysis has been more frequently employed; it is with the microspores that we are concerned at present. Various kinds of coal, particularly cannels and dull coals, contain vast numbers of spores, of which the cutinised spore coat is usually well preserved. It is seldom possible to determine the parent plant from which the spores or detached fragments came, though various methods have been devised for determining the parentage of some types of spores. Hartung (1933) has published a careful study of the spores from macerated calamarian cones which can be compared with spores isolated from coals. The peel method has also been used successfully upon fern sporangia (Radforth, 1938).

The typical accumulations of coal with which the geologists in this country are most familiar are chiefly of Carboniferous age. Carbonaceous sediments composed to a large extent of plant material are found also in other parts of the world in Devonian sediments; the earliest recorded occurrence of spores with the tetrad scar is from a kerosene shale of Sweden, of Upper Cambrian age, but the botanical affinity is unknown.

The immense number and variety of microspores found in coals is an indication of the richness of the vegetation in Palaeozoic times. The flora of the Carboniferous period was particularly luxuriant; and a definite sequence and evolution of plant types can be traced with a gradual shift in the dominance of various groups. In the Lower Carboniferous the chief components of the vegetation belong to the Sphenophyllales, Lepidodendrales and Coenopterid ferns; while later, the Cordaitales begin to diversify and become conspicuous.

The Upper Carboniferous is marked by a great development of ferns and pteridosperms, and the extinction of the older forms of Lepidodendron, Sigillaria, Calamites and Neuropteris.

It might therefore be expected that in the Lower Carboniferous the greatest number of spores with definite Lycopodalean affinity would occur, with a small admixture of spores of filicinean origin; this is recognised to be the case.

In Great Britain most of the work on spore analysis of coal has been confined to the Middle Coal Measures, and save for a short paper on the microspores of the Limestone Coal Group in Scotland by the present author (1948), little account has been taken of the spores of the Lower Carboniferous strata; thus a representation of the relative proportions of spore types during different periods can only be roughly estimated at present for this country.

An interesting summary has been given, however, by Naumova (1937), for coals of the U.S.S.R. His conclusions are in agreement with the facts so far recorded of the spore content of the coals of the Carboniferous in Scotland. Naumova records a total of 400 forms of spores and pollen from the coal basins and deposits of the U.S.S.R. of different ages from the Devonian to the Tertiary. The number described from the Palaeozoic is 190, from the Mesozoic 154, and from the Cenozoic 65. In the Palaeozoic era spores with a tri-radiate slit, which he terms Triletes Rimales, are predominantly developed up to 89 per cent., with 5 per cent. Monoletes and 2 per cent. Aletes; pollen appears towards the close of the era to the extent of 4 per cent. In the Mesozoic, although spores of the Triletes Rimales group continue to predominate, accounting for 60 per cent., an increasingly greater part is played by pollen of the Aporosa class (i.e., pollen without pores). An interesting point with regard to size is also mentioned - the forms with largest diameter, averaging 50μ-70μ, are developed principally in the Palaeozoic strata, whereas in the Mesozoic the average diameter is 40μ- 50μ. In the Devonian of the U.S.S.R., Naumova states that the complex of spores consists solely of forms of the Triletes group, and the exine usually has sculpturing in the form of tubercles, spines or hooks; many of the types are similar to those found in the Lower Carboniferous. Here again only Trilete spores are encountered, among which forms with thickened margin, probably Lepidodendroid, are prevalent up to 75 per cent. The Upper Carboniferous complex consists mostly of forms of the Triletes group but with a small proportion of Monoletes appearing; the latter with sculpturing of a coniferous type. Among the Triletes, spores with reticulate ornamentation appear and those with a thickened border become rare. The Permian assemblage is similar to that of the Upper Carboniferous;

the main distinction being in less diversity of form and the appearance of coniferous pollen with two air-sacs.

It is significant that in the Devonian and Lower Carboniferous only spores of the Trilete group have been recorded from the U.S.S.R., a fact which pertains also in Scotland and which tends to strengthen the supposition that the vegetation at that time consisted mainly of Lepidodendrales, Equisetales and Sphenophyllales. The ferns in which some genera have monolete spores, and gymnospermic plants apparently did not gain ascendency until Upper Carboniferous times. The microspore content of the Productive Coal Measures in Scotland (Knox, 1942, 1946) is similar to that recorded for the coals of the Middle Coal Measures in England (Raistrick, 1933, 1934; Millott, 1939) and the spore types recorded from both resemble in general the types from corresponding measures in the U.S.S.R. In the early work on microfossils of coal in this country, spores were classified according to an artificial system, different groups being referred to by letters, and different types by numbers, A1 --- B1 --- etc. In the Coal Measures of the Upper Carboniferous of Great Britain the monolete, bilateral, smooth spores, designated B1, becomes a common constituent. This is a type which recurs amongst living ferns in widely separated genera, and the frequency of its occurrence in Upper Carboniferous strata is probably due to prevalence at that time of ferns in the vegetation of the coal swamps. This spore, Bl, is not the same as that mentioned by Naumova as occurring in the Upper Carboniferous of the U.S.S.R.; he stresses monolete spores with exospore of the coniferous type. Similar gymnospermic forms are recorded from Britain, but they are not common.

The spores of only a small number of fossil plants are known with certainty; of these, the microspores of Lepidostrobus Jacksoni or Lepidostrobus Oldhamii (Kidston, 1923) are amongst the most easily recognised, and they are indistinguishable from the type Dl of Raistrick (1933). Other known spores are those of plants belonging to the Calamitaceae (Hartung, 1933; Walton, 1948), a smooth, round type; those of Mazocarpon oedipternum (Schopf, 1941) with a papillate exospore; the granular spores of Crosstheca Hughesiana and Crosstheca Hoeninghausia (Kidston, 1923); the small triangular spores of the pteridosperm Renaultia gracilis and the large spherical spinose variety Sphenophyllum Dawsoni (Knox, 1938, figs. 118 and 120).

CLASSIFICATION OF FOSSIL SPORES.

A natural classification of fossil spores is at present practically impossible, since few of the spores so far described have been found in organic connection with the parent plant. It is thus necessary to formulate an artificial system using the various morphological features which have been found to be of diagnostic value.

Several systems have been proposed from time to time by different authors; these schemes are fundamentally the same and employ as their primary division the form of dehiscence slit, i.e., whether tri-radiate or longitudinal. Wodehouse (1935, p. 135) is of the opinion that the "form and character of the germinal furrows are generally strictly phyletic, tending to be constant throughout families and other groups".

Schopf (1944) says that "The classification of spores admittedly presents many difficulties. When attempt is made to classify spores in accordance with the standard taxonomy apparently inconsistent situations arise. In part this is because taxonomy of higher plants is almost entirely based on structures of the sporophyte, whereas spores belong to the gametophyte generation. The fact that Palaeozoic plant genera are extinct further complicates the problem so that their treatment must necessarily be different from that used by students of Cenozoic and Recent spores or pollen". Another point is that in the vegetable kingdom, from time to time in quite diverse families differences in spores and pollen reached a maximum, irrespective of the stage in the evolutionary process reached by the family. The Pteridophytes are frequently strongly differentiated in many parts of the plant body, and during Palaeozoic times when they represented the most important forms of plant life, many diverse types are recognised which had adapted themselves to several ecological situations which are now largely occupied by so-called higher plants. It is a striking fact that the spores of these Palaeozoic plants were already highly organised and varied.

The classification of Potonie (1932) was one of the first to be used for stratigraphical purposes. He gave the generic name of Sporonites to all spores and added a descriptive prefix to designate a genus, as for example Laevigato-sporonites. The earlier method of dividing the trilete spores into Laevigato-, Apiculati- and Zonales, Potonie asserted required revision.

Raistrick (1934) in England, employed the same distinguishing characters, but formulated a simpler nomenclature, using a letter and number as A1, B3, etc.; the letter being indicative of a generic form and the number of a specific character. In all he recognised seven genera, A to G, and some seventy species.

The Russian scheme of Naumova (1937) approaches more closely to the German, giving prominence, first to the form of dehiscence slit and second to the sculpturing.

The most recent and comprehensive system of the American authors Schopf, Wilson and Bentall (1944) incorporates, as far as possible, all previously published work, and in their Annotated Synopsis of Palaeozoic Fossil Spores (1944) the guiding principles on which they base their classification are stated. It is pointed out by them that "the species classified under the same generic name must possess significant characteristics in common" and that "the essential validity of any classification depends on the relative significance that attaches to the various bio-characters". The system promulgated by these three authors recognises 15 genera for microspores. The genera are distinguished by differences in symmetry, sculpturing and to some extent, size, and each spore is given a generic and specific name, e.g., Punctatisporites punctatus. This system can easily be extended, the number of species added to, or the number of genera increased, as occasion demands.

In Great Britain, the classification of Raistrick, useful as it was in the beginning, is now found to be inadequate; it has been felt for some time that a binomial nomenclature should be adopted, thus enabling comparison to be made of work in this country, America and Europe. A universally recognised system also has the advantage that correlation on a wider scale can be effected and problems of plant distribution and migration during Palaeozoic times can be viewed more satisfactorily.

The study of the microspores of living representatives of the LYCOPODIALES and their arrangement into groups having closely similar spores can now serve as a basis for the classification of fossil spores. The application of this principle to fossil spores suggest the advisable limits which should be set for any group or artificial genus, as regards size and variety of ornamentation. It has been proved elsewhere (Knox, 1949) that in archegoniate plants, even during development, the nature of the ornamentation, or the variety of the processes with which the spores will ultimately be adorned, remains constant. A pointed, conical excrescence does not change during growth to a tuberculate or rod-like elevation; thus in any arbitrary classification it is safe to place all the spores with spinose ornamentation in the same group, since by so doing even a juvenile spore with spines will be included with the fully developed adult. Recognition of this fact will necessitate a wider range of size in a genus, so as to include the immature with the mature spores of the same species. In order to segregate those spores possessing the same type of process and external morphology, some of the larger "genera" proposed by Schopf, Wilson and Bentall will require to be sub-divided and altered. This applies particularly to the genera Punctati-sporites and Granulati-sporites, which include spores with several different types of ornamentation. As regards the division into monolete and trilete, the former, which are oval and bean-shaped spores, have been kept in a genus by themselves, following Schopf, Wilson and Bentall, so long as the longitudinal slit is clearly visible and the exospore is smooth, granular or finely punctate.

In the following pages these emendations, re-arrangements and sub-divisions are set out as suggestions. Four new genera have been proposed to accommodate the spore species which do not easily fit into the existing scheme. These genera have been named _Spinoso-sporites_, _Plani-sporites_, _Verrucoso-sporites_ and _Microreticulati-sporites_; they contain species with spinose, smooth, tuberculate and reticulate exospores respectively. Besides the spores referred to the new genera, two others have been transferred to different genera; they are _Punctati-sporites auriculaferens_ placed in _Triquitrites_ (fig. 273) and _Cirratriradites zonalis_ placed in _Endosporites_ (fig. 295). The generic names used by Schopf, Wilson and Bentall have been maintained when their definition has not been altered. The individual spores are listed with the specific name recognised by these authors, with the exception of the new genera and the two forms mentioned above. The descriptions and figures given by Ibrahim, Loose and others have been copied from the original publications, although in some cases these descriptions and figures are inadequate. Additional types from Great Britain are appended in their appropriate group, and references to the original publication given with each type. For these it is necessary, until fuller comparative study can be made, to retain the artificial nomenclature, i.e., letter and number, e.g., E 5 Raistrick; 17 K, etc.

KEY TO GENERA OF PALAEOZOIC MICROSPORES.

(Adapted from the key of L. R. Wilson in Pollen Analysis Circular, No. 8.)

A. Spores with bi-lateral symmetry; monolete suture.

B. Vesicular appendages lacking ... ... VII. Laevigato-sporites

BB. Vesicular appendages one or two.

C. Vesicular appendages two, attached opposite on central body ... ... XII. Ali-sporites

CC. " one, annulate ... XVII. Florinites

AA. Spores with tri-radial symmetry; trilete sutures.

B. Vesicular appendages present.

C. Vesicular appendages single .. ... XIII. Endosporites

CC. " trimerous .. VI. Alati-sporites

BB. Vesicular appendages not present.

C. Spores spherical; wall thin; ornamentation absent or very slight XIV. _Calamospora_

CC. Spores spherical or triangular; ornamentation conspicuous.

D. Equatorial region fimbriate, flanged, thickened or auriculate.

E. Auriculate thickenings at radial angles .. IX. _Triquitrites_

EE. " absent at angles.

F. Fimbriate flanges longer between radii than at angles ... XV. _Reinschospora_

FF. Flange not as above.

G. Equatorial region thickened VIII. _Densosporites_

GG. " not thickened.

H. Flange broad and membranous XI. _Cirratriradites_

HH. " narrow, uniform width ... X. _Lycospora_

DD. Equatorial region without flange or thickening.

E. Wall thickening reticulate.

F. Alveolae less than 6 μ across IV. _Microreticulati-sporites_

FF. " more than 6 μ across V. _Reticulati-sporites_

EE. Wall thickening not reticulate.

F. Ornamentation absent or granular. Spore margin entire or nearly so ... II. Plani-sporites

FF. Ornamentation of variously shaped processes clearly visible on margin ...

G. Ornamentation of sharp pointed processes .. ... I. Spinoso-sporites

GG. " not as above.

H. Ornamentation of blunt, straight-sided partate processes ... Raistrickia

HH. Ornamentation of rounded, warty or tuberculate processes ... III. Verrucoso-sporites

Exospore Morphology of Fossil Spores.

GENUS I. SPINOSO-SPORITES Knox, gen. nov.

Spores tetrahedral, trilete, triangular to spherical; 25µ - 75µ in diameter. Ornamentation of sharp, pointed, conical processes, variable in length, breadth and distance apart.

Spinoso-sporites aculeatus (Loose) Knox, comb. nov. Fig. 198.
Punctati-sporites aculeatus (Ibr.) S. W. & B., comb. nov. *

Spherical to ovate, 48µ - 53µ. Tri-radiate mark 2/3 radius. Wall 2µ. Spines 3µ in length, 1µ broad at base; set 2µ - 4µ apart.

Probably equivalent to E5 (Raistrick).

Spinoso-sporites globosus (Loose) Knox, comb. nov. Fig. 199.
Punctati-sporites globosus (Loose) S. W. & B., comb. nov.

Spherical to elliptical, 44μ - 60μ. Tri-radiate mark 2/3 radius. Spines small, 1μ; margin with fine prickles.

Probably equivalent to B6 (Raistrick).

Spinoso-sporites latigranifer (Loose) Knox, comb. nov. Fig. 200.
Punctati-sporites latigranifer (Loose) S. W. & B., comb. nov.

Ovoid, 55μ - 78μ. Ornamentation faintly spinose, spines 1μ. Exospore with very fine prickles appearing granular.

Spinoso-sporites spinosus (Loose) Knox, comb. nov. Fig. 201.
Punctati-sporites spinosus (Loose) S. W. & B., comb. nov.

Spherical, 36μ - 41μ. Spiney to faintly verrucose; prickles 1.5μ broad; margin shows broad, blunt prickles.

Spinoso-sporites spinulastratus (Loose) Knox, comb. nov. Fig.202.
Punctati-sporites spinulastratus (Loose) S. W. & B., comb. nov.

Ovoid to round, 54μ - 72μ. Tri-radiate mark 2/3 radius. Surface covered with fine spines ("hedgehog-prickles").

Probably equivalent to B4 (Raistrick).

Spinoso-sporites microsaetosus (Loose) Knox, comb. nov. Fig. 203.
Granulati-sporites microsaetosus (Loose) S. W. & B., comb. nov.

Traingular, 26μ - 39μ. Tri-radiate mark 2/3 radius. Saetose, bristles 2μ - 2.5μ; margin bristly to prickly.

Probably equivalent to D8 (Raistrick).

Spinoso-sporites microspinosus (Ibr.) Knox, comb. nov. Fig. 204.
Granulati-sporites microspinosus (Ibr.) S. W. & B., comb. nov.

Triangular, 34μ - 39μ. Tri-radiate mark 2/3 radius. Spinose, spines 3μ - 4μ long and 2μ broad.

Probably equivalent to 17K (Knox, 1948).

E 1. (Raistrick) Fig. 206.

Spherical, 35μ - 50μ. Tri-radiate mark 2/3 radius. Surface varying from finely punctate to granular, usually with fine hair-like processes easily seen on periphery.

E 2. (Raistrick) Fig. 207.

Spherical, 30μ - 45μ. Tri-radiate mark faintly visible or absent. Surface punctate to finely toothed; teeth seen on the margin.

E sp. Fig. 208.

Spherical, 25μ. Tri-radiate mark 1/3 radius. Surface with acicles 5μ - 8μ long and spaced about 5μ apart.

18 K. (Knox, 1948) Fig. 205.

Triangular, 55μ. Tri-radiate mark extending to the margin. Surface with spinose processes, 5μ - 7μ long, straight or curved and spaced 3μ - 5μ apart.

* For further synonymy see the paper by Schopf, Wilson and Bentall (1944).

GENUS II. PLANI-SPORITES Knox, gen. nov.

Spores tetrahedral, trilete, spherical to rounded-triangular; 25μ - 130μ in diameter. Ornamentation absent or granular to punctate or finely papillate. Margin of spore entire or very nearly so.

<u>Plani-sporites aureus</u> (Loose) Knox, comb. nov. Fig. 209.
<u>Punctati-sporites aureus</u> (Loose) S. W. & B., comb. nov.

Oval to round; 45μ - 75μ. Tri-radiate mark 1/3 radius. Surface faintly reticulate to punctate; margin very finely notched.

<u>Plani-sporites granifer</u> (Ibr.) Knox, comb. mov. Fig. 210.
<u>Punctati-sporites granifer</u> (Ibr.) S. W & B., comb. nov.

Triangular to spherical, 70μ - 95μ. Tri-radiate mark 2/3 radius. Wall 2μ - 3μ; surface granular; at margin granules 3μ - 4μ apart.

<u>Plani-sporites microtuberosus</u> (Loose) Knox, comb. nov. Fig. 211.
<u>Punctati-sporites microtuberosus</u> (Loose) S. W. & B., comb. nov.

Ovoid to spherical; 58μ - 84μ. Tri-radiate mark 2/3 radius. Exospore covered with fine, small tubercles (1μ), closely set; margin finely granular.

<u>Plani-sporites parvipunctatus</u> (Kosanke) Knox, comb. nov. Fig. 212.
<u>Punctati-sporites parvipunctatus</u> Kosanke.

Almost spherical, 32μ - 38μ. Wall about 2μ. Exospore finely punctate.

Probably equivalent to <u>E2</u> (Raistrick).

<u>Plani-sporites punctatus</u> (Ibr.) Knox, comb. nov. Fig. 213.
<u>Punctati-sporites punctatus</u> Ibr.

Round to triangular, 50μ - 77μ. Tri-radiate mark extending to the margin. Surface punctate; margin smooth or slightly rough.

Probably equivalent to <u>B5</u> (Raistrick).

Plani-sporites sphaerotriangulatus (Loose) Knox, comb. nov. Fig. 214.
Punctati-sporites sphaerotriangulatus (Loose) S. W. & B.

Triangular, 40μ - 57μ. Tri-radiate mark 2/3 radius. Surface smooth to faintly punctate; margin smooth: wall 1.5μ thick.

Plani-sporites deltiformis (S. W. & B.) Knox, comb. nov. Fig.215.
Granulati-sporites deltiformis S. W. & B.

Tri-radial, side concave; 26μ - 30μ. Surface smooth, without ornamentation.

Plani-sporites deltoides (Ibr.) Knox, comb. nov. Fig. 216.
Granulati-sporites deltoides (Ibr.) S. W. & B., comb. nov.

Triangular, 65μ - 77μ. Tri-radiate mark extending to the margin. Surface smooth to faintly punctate. Margin smooth.

Plani-sporites granulatus (Ibr.) Knox, comb. nov. Fig. 217.
Granulati-sporites granulatus Ibr.

Triangular, 25μ - 34μ. Tri-radiate mark 2/3 radius. Surface granulate; margin rough.

Plani-sporites microgranifer (Ibr.) Knox, comb. nov. Fig. 218.
Granulati-sporites microgranifer Ibr.

Triangular, 31μ - 35μ. Tri-radiate mark extending to the margin; surface granular.

Plani-sporites piroformis (Loose) Knox, comb. nov. Fig. 219.
Granulati-sporites piroformis Loose.

Triangular, 26μ - 40μ. Tri-radiate mark extending to the margin. Surface faintly granular.

Probably equivalent to D4 (Raistrick).

Plani-sporites priddyi (Berry) Knox, comb. nov. Fig. 220.
Granulati-sporites priddyi (Berry) S. W. & B., comb. nov.

Triangular, 35μ. Tri-radiate mark 2/3 radius. Wall thin, often slightly convex; surface smooth.

Plani-sporites verrucosus (Wilson and Coe) Knox, comb. nov. Fig. 221.
Granulati-sporites verrucosus (Wilson & Coe) S. W. & B., comb. nov.

Tri-radial, sides concave; 23μ - 26μ. Exine papillate.

6K. (Knox, 1942) Fig. 222.

Oval; 80μ - 150μ long. Tri-radiate mark 1/3 radius, frequently open. Surface very finely granular.

11 K. (Knox, 1948) Fig. 223.

Triangular, 65μ - 80μ. Tri-radiate mark 2/3 radius, surrounded by a translucent area. Wall 3μ thick; surface smooth.

GENUS III. VERRUCOSO-SPORITES Knox, gen. nov.

Spores tetrahedral, trilete; spherical to triangular; 25μ - 120μ in diameter. Ornamentation rounded, warty or tuberculate processes; visible as rounded elevations at the margin.

Verrucoso-sporites bucculentus (Loose) Knox, comb. nov. Fig. 224.
Punctati-sporites bucculentus (Loose) S. W. & B., comb. nov.

Ovoid, 38μ - 55μ. Tri-radiate mark extending to the margin. Surface verrucose; tubercles 3μ - 5μ; margin with small tubercles visible.

Probably equivalent to E4 (Raistrick).

Verrucoso-sporites firmus (Loose) Knox, comb. nov. Fig. 225.
Punctati-sporites firmus (Loose) S. W. & B., comb. nov.

Round to triangular, 57μ - 62μ. Tri-radiate mark 2/3 radius. Surface verrucose, tubercles 3μ - 6μ; on the margin elevations appear 3μ - 4μ long.

Probably equivalent to D3 (Raistrick).

Verrucoso-sporites grandiverrucosus (Kosanke) Knox, comb. nov.
Punctati-sporites grandiverrucosus Kosanke

Spherical, 73μ - 92μ. Wall 1μ - 3μ. Ornamentation characteristically verrucose; margin irregular.

Verrucoso-sporites grumosus (Ibr.) Knox, comb. nov. Fig. 226.
Punctati-sporites grumosus (Ibr.) S. W. & B., comb. nov.

Triangular to spherical; 54μ - 85μ. Tri-radiate mark 2/3 radius. Surface verrucose.

Verrucoso-sporites insignitis (Ibr.) Knox, comb. nov. Fig. 227.
Punctati-sporites insignitis (Ibr.) S. W. & B.

Round to triangular, 50μ - 78μ. Surface bearing granules, sometimes small spines, 3μ - 4μ long. At the margin these processes appear as warty protuberances.

Verrucoso-sporites microverrucosus (Ibr.) Knox, comb. nov. Fig.228.
Punctati-sporites microverrucosus (Ibr.) S. W. & B., comb. nov.

Ovate to spherical, 38μ - 74μ. Tri-radiate mark extending to the margin. Surface tuberculate; tubercles 3μ - 7μ long. Margin faintly wavy.

Verucoso-sporites papillosus (Ibr.) Knox, comb. nov. Fig. 229.
Punctati-sporites papillosus (Ibr.) S. W. & B., comb. nov.

Triangular to round, 74μ - 98μ. Tri-radiate mark 2/3 radius. Surface tuberculate; tubercles 7μ - 12μ long and 4μ - 8μ broad; warts mainly flattened and various shapes.

Verrucoso-sporites verrucosus (Ibr.) Knox, comb. nov. Fig. 230.
Punctati-sporites verrucosus (Ibr.) S. W. & B., comb. nov.

Ovoid to round, 65μ - 108μ. Tri-radiate mark 2/3 radius. Surface warty; warts 2μ - 4μ.

Verrucoso-sporites tuberculatus (Berry) Knox, comb. nov. Fig.231.
Laevigato-sporites tuberculatus (Berry) S. W. & B., comb. nov.

Oval, 54μ by 39μ. Wall thin. Surface tuberculate; tubercles not visible at the edge of the spore.

Verrucoso-sporites gibbosus (Ibr.) Knox, comb. nov. Fig. 232.
Granulati-sporites gibbosus (Ibr.) S. W. & B., comb. nov.

Triangular, 42μ - 46μ. Tri-radiate mark 2/3 radius. Surface tuberculate; tubercles 2μ - 3μ broad and 2μ - 3μ long.

Verrucoso-sporites triquetris (Ibr.) Knox, comb. nov. Fig. 233.
Granulati-sporites triquetris (Ibr.) S. W. & B., comb. nov.

Triangular, 38μ - 58μ. Tri-radiate mark extending to the margin. Surface tuberculate; tubercles round to flattened warts, 3μ - 4μ long.

Raistrickia abditus (Loose) S. W. & B., comb. nov.

Oval, 63μ - 78μ. Exospore 5μ. Tri-radiate mark very faint. Surface tuberculate; tubercles 6μ - 10μ.

16 K. (Knox, 1948). Fig. 234.

Triangular with sides concave; 40μ - 45μ. Tri-radiate mark extending almost to the margin. Surface ornamented with small tuberculate processes, 2μ long and widely spaced, 4μ - 5μ apart.

20 K. (Knox, 1948). Fig. 235.

Spherical, 70μ - 80μ. Tri-radiate mark 1/3 radius. Surface closely covered with short (2μ - 3μ) tuberculate processes.

21 K. (Knox, 1948).. Fig. 236.

Spherical to ovate; about 100μ in diameter. Tri-radiate mark 1/3 radius. Surface ornamented with rounded processes 6μ - 8μ long, 3μ - 4μ broad and spaced 5μ - 7μ apart.

23 K. (Knox, 1948). Fig. 237.

Spherical, 100μ - 120μ. Tri-radiate mark 1/3 radius. Surface ornamented with small papillae, visible as slight elevations at the margin, and regularly arranged 5μ apart; between the papillae the surface is finely granular.

GENUS IV. MICRORETICULATI-SPORITES Knox, gen. nov.

Spores tetrahedral, trilete or bi-lateral, monolete; spherical to triangular or oval; 14μ - 70μ in diameter. Ornamentation reticulate with mesh not more than 6μ across or broken ridges, irregular in shape and disposition.

Microreticulati-sporites corrugatus (Ibr.) Knox, comb. nov.
Fig. 238.
Punctati-sporites corrugatus Ibr.

Spherical, 42μ - 46μ. Tri-radiate mark 2/3 radius. Surface reticulate to wrinkled; reticulum more or less broken up into separate irregular ridges.

Microreticulati-sporites cusus (Loose) Knox, comb. nov. Fig. 239.
Punctati-sporites cusus Loose.

Ovoid to round, 47μ - 57μ. Tri-radiate mark extending to the margin. Surface reticulate; reticulum of sunken mesh, 4μ - 6μ; outline slightly wavy; wall 2μ - 3μ.

Probably equivalent to D6 (Raistrick).

Microreticulati-sporites lacunosus (Ibr.) Knox, comb. nov. Fig.240.

Punctati-sporites lacunosus (Ibr.) S. W. & B., comb. nov.

Triangular, 49μ. Tri-radiate mark 2/3 radius. Surface faintly microreticulate; reticulum 2μ - 3μ across.

Microreticulati-sporites maculatus (Ibr.) Knox, comb. nov. Fig.241.
Punctati-sporites maculatus (Ibr.) S. W. & B., comb. nov.

Polygonal to circular, 46μ - 69μ. Tri-radiate mark 2/3 radius. Surface reticulate; mesh 5μ - 6μ; margin coarsely toothed.

Probably equivalent to F3 (Raistrick).

Microreticulati-sporites nobilis (Wicher) Knox, comb. nov. Fig.242.
Punctati-sporites nobilis (Wicher) S. W. & B., comb. nov.

Triangular, 30μ - 40μ. Tri-radiate mark 2/3 radius. Surface reticulate; mesh 1μ - 3μ; an irregular network covers the spore body; the bars of the mesh are relatively thick and rounded above; margin notched.

Microreticulati reticulocingulum (Loose) Knox, comb. nov. Fig.243.
Punctati-sporites reticulocingulum (Loose) S. W. & B., comb. nov.

Spherical to ovoid; 35μ - 56μ. Tri-radiate mark faint. Surface reticulate; mesh 4μ - 5μ; bars up to 2μ broad and extending over the margin.

Probably equivalent to F1 (Raistrick).

Microreticulati-sporites trigonoreticulatus (Loose) Knox, comb. nov. Fig. 244.
Punctati-sporites trigonoreticulatus (Loose) S. W. & B., comb. nov.

Triangular, 49μ - 54μ. Tri-radiate mark extending to the margin. Surface reticulate; mesh 1μ.

Microreticulati-sporites velatus (Loose) Knox, comb. nov. Fig.245.
Punctati-sporites velatus (Loose) S. W. & B., comb. nov.

Elliptical, 41μ - 57μ. Surface reticulate to rugose.

Microreticulati-sporites fistulosus (Ibr.) Knox, comb. nov. Fig. 246.
Granulati-sporites fistulosus (Ibr.) S. W. & B., comb. nov.

Triangular, 38μ - 46μ. Tri-radiate mark extending to the margin. Surface finely reticulate; mesh 2μ; margin toothed.

Microreticulati-sporites parvus (Ibr.) Knox, comb. nov. Fig.247.
Granulati-sporites parvus (Ibr.) S. W. & B., comb. nov.

Triangular; 23μ - 32μ. Tri-radiate mark 2/3 radius. Surface reticulate; reticulum fine, 1μ; margin faintly rough.

Microreticulati-sporites torquifer (Loose) Knox, comb. nov. Fig. 248.
Granulati-sporites torquifer (Loose) S. W. & B., comb. nov.

Triangular to polygonal, 29µ - 42µ. Tri-radiate mark 2/3 radius. Surfaces rugose and irregularly ridged; margin finely notched; Wall 2µ - 3µ thick.

Microreticulati-sporites trigonus (Ibr.) Knox, comb. nov. Fig.249.
Granulati-sporites trigonus (Ibr.) S. W. & B., comb. nov.

Triangular, 27µ - 46µ. Tri-radiate mark 2/3 radius. Surface reticulate; mesh 4µ - 6µ across; margin wavy.

Microreticulati-sporites Theissenii (Kosanke) Knox, comb. nov. Fig. 250.
Laevigato-sporites Theissenii Kosanke.

Bi-lateral, monolete; oval, elongate; 14µ - 24µ; Wall 1µ - 2µ. Surface loosely to sharply verrucose, forming intermittent ridges and valleys.

Belonging to this series are a large number of reticulate spores ranging in diameter from 20µ to 70µ, with mesh from 3µ to 6µ. Some of these are illustrated as Group F microspores from the Limestone Coal Group in Scotland (Knox, 1948) and numbered 25K., 26K, 27K, 28K, 31K, 32K, 33K, 34K, 35K, 36K, 37K.

GENUS V. RETICULATI-SPORITES (Ibrahim, 1933) emend., S. W. & B.

Spores radially symmetrical; spherical or moderately oblate; size ranges from 40μ - 100μ in diameter. Ornamentation coarsely and often irregularly reticulate; mesh more than 6μ across.

Reticulati-sporites corporeus Loose Fig. 251.

Oval to polygonal; 60μ - 65μ. Tri-radiate mark 2/3 radius. Surface reticulate; mesh 18μ - 23μ across; the margins of the mesh structure appear frilled; they extend over the spore margin.

Reticulati-sporites facetus (Ibr.) S. W. & B., comb. nov. Fig.252.

Circular; 42μ - 55μ. Surface reticulate; mesh 5μ - 8μ across with bars 2μ - 3μ thick.

Reticulati-sporites mediareticulatus Ibr. Fig. 253.

Polygonal to ovate; 58μ - 65μ. Tri-radiate mark 2/3 radius. Surface reticulate; mesh 7μ - 14μ, bars 2μ thick; margin smooth.

Probably equivalent to F2 (Raistrick).

Reticulati-sporites ornatus (Ibr.) S. W. & B., comb. nov. Fig.254.

Oblate to polygonal; 70μ - 108μ. Tri-radiate mark 2/3 radius. Surface reticulate; mesh 15μ - 23μ with warty bars 4μ - 7μ thick.

Reticulati-sporites polygonalis (Ibr.) S. W. & B., comb. nov. Fig. 255.

Polygonal to round; 88μ - 108μ. Tri-radiate mark 2/3 radius. Darker ring inside periphery; strong, large mesh with bars 6μ - 8μ thick, arranged with polygon over centre and radial ribs from the angles to the periphery. Probably equivalent to <u>C3</u> (Raistrick).

<u>Reticulati-sporites reticulatus</u> (Ibr.) S. W. & B., comb. nov.

Polygonal to round; 73μ - 100μ. Tri-radiate mark 2/3 radius. Surface reticulate; mesh 15μ - 23μ; ridges of mesh winding to frilly and 3μ - 4μ thick; mesh 4- to 5-sided with a smaller network connecting them 7μ - 9μ across. Round the spore is a lighter membrane 2μ - 4μ wide.

<u>Reticulati-sporites reticuliformis</u> Ibr. Fig. 256.

Polygonal to circular; 72μ - 94μ. Tri-radiate mark extending to the margin. Surface reticulate; mesh 13μ-17μ; bars 3μ - 5μ thick; a thin membrane seen round the margin 5μ - 7μ broad.

<u>5K</u> (Knox, 1942) Fig. 257.

Spherical; 80μ - 100μ. Spore ornamented with prominent ridges forming deep hexagonal alveoli; the large-meshed network has membranous flanges which appear at the margin of the spore as a transparent wing.

<u>GENUS VI</u>. <u>ALATI-SPORITES</u> Ibrahim, 1933.

Spores radial, trilete; sub-triangular, with wings present. Ornamentation of the spore body may be punctate or finely reticulate. The spore coat consists of two distinct membranes; the outer membrane is thin and expanded to form bladders in trimerous pattern.

Alati-sporites pustulatus (Ibr.) Fig. 258.

Triangular to round; spore body 49μ - 55μ in diameter. Tri-radiate mark extending to the margin. Surface of spore very finely reticulate; wings, 16μ - 24μ broad, punctate.

Probably equivalent to D5 (Raistrick).

GENUS VII. LAEVIGATO-SPORITES (Ibrahim, 1933) emend., S. W. & B.

Spores bi-lateral, monolete; oval to bean-shaped. Spores range in size from 20μ- over 130μ in their long dimension. Ornamentation smooth to finely punctate.

Laevigato-sporites bilateralis (Loose) S. W. & B., comb. nov. Fig. 259.

Oval, monolete; 41μ- 58μ. Surface finely reticulate; outline notched; wall 3μ - 5μ thick.

Laevigato-sporites desmoinensis (Wilson & Coe) S. W. & B., comb. nov. Fig. 260.

Bi-lateral, bean-shaped; monolete; 60μ - 75μ long and 39μ - 42μ wide. Wall transparent and unornamented.

Laevigato-sporites minimus (Wilson & Coe) S. W. & B., comb. nov. Fig. 261.

As above; 21μ - 29μ long and 17μ - 20μ wide.

These two spore types are probably equivalent to B1 (Raistrick).

<u>Laevigato-sporites minutus</u> (Ibr.) S. W. & B., comb. nov.
Fig. 262.

Ovate, monolete; 16μ - 25μ. Surface punctate; margin rough.

Probably equivalent to <u>B8</u> (Raistrick).

<u>Laevigato-sporites pennovalis</u> Berry Fig. 263.

Ovate; 46μ long and 31μ broad; wall thicker at ends than sides. Surface sparingly covered with small papillae, evenly spaced but not visible at margin.

<u>Laevigato-sporites vulgaris</u> Ibr. Figs. 264a& 264b.

Oval to bean-shaped; 42μ - 85μ. Surface smooth to faintly punctate.

<u>GENUS VIII</u>. <u>DENSO-SPORITES</u> (Berry, 1937) emend., S. W. & B.

Spores radially symmetrical, trilete; round to sub-triangular; size 35μ - 100μ in diameter. Ornamentation smooth to apiculate and rugose. The spore coat is characterised by great differences in thickness, being thin and membranous on the proximal and distal walls and thick in the equatorial region. Round the equator there may be a dense ring or a flange.

<u>Denso-sporites annulatus</u> (Loose) S. W. & B., comb. nov. Fig.265.

Oval to triangular; 25μ - 45μ. Tri-radiate mark extending to the margin. Spore surface smooth to finely punctate.

Probably equivalent to <u>A1</u> (Raistrick).

Denso-sporites covensis Berry

Oval; 58μ long and 50μ broad. Wall very thick, about 1/3 diameter, dark and opaque, smooth and even; central portion clear and trapezoidal in shape, margins clearly marked, no apparent connection between inside and outside.

Denso-sporites indignabundus (Loose) S. W. & B., comb. nov. Fig. 266.

Round, oval or polygonal; Tri-radiate mark extending to the margin; 40μ - 75μ. Surface and margin with closely spaced spines about 1μ - 2μ long. In polar view a faint brownish equatorial rim runs concentrically and is up to 6μ broad.

Probably equivalent to A5 (Raistrick).

9K (Knox, 1948) Fig. 267.

Sub-triangular; 50μ - 75μ. Tri-radiate mark extending to the margin. Surface of spore finely spinose; equatorial wing, fringed and irregularly and coarsely toothed.

GENUS IX. TRIQUITRITES Wilson and Coe, 1940.

Spores trilete, radial; oval to elliptical in vertical plane; in equatorial plane triangular in outline with rounded or truncate corners; sides convex to strongly concave. Size 35μ - 70μ. Surface smooth to granular or verrucose.

Triquitrites arculatus Wilson & Coe Fig. 268.

Triangular, tri-radial with concave sides and an equatorial flange conspicuously wider at the corners; 40μ - 49μ.

Tri-radiate mark 2/3 radius. Surface without ornamentation.

Triquitrites spinosus Kosanke. Fig. 269.

Radial, trilete; triangular in outline with corners truncate and thickened; 45μ - 55μ. Tri-radiate mark 2/3 radius. Ornamentation smooth to slightly warty.

Probably equivalent to 16K (Knox, 1948, fig. 13).

Triquitrites tribullatus (Ibr.) S. W. & B., comb. nov. Fig.270.

Triangular; 42μ - 62μ Tri-radiate mark 2/3 radius.

Exospore 1μ thick increased at the corners to 12μ broad.

Probably equivalent to D7 (Raistrick).

Triquitrites trigonappendix (Loose) S. W. & B., comb. nov. Fig. 271.

Triangular; 40μ - 42μ. Tri-radiate 1/3 radius. Bell shaped outline, with appendages resembling ears at the corners, which are rolled inwards. Surface smooth.

Triquitrites triturgidus (Loose) S. W. & B., comb. nov. Fig.272.

Triangular, trefoil shaped; 45μ - 65μ. Tri-radiate mark 2/3 radius. Corners 10μ thick; exospore smooth.

Probably equivalent to D10 (Raistrick).

Triquitrites auriculaferens (Loose) Knox, comb. nov. Fig.273.
Punctati-sporites auriculaferens (Loose) S. W. & B., comb. nov.

Triangular, 43μ - 53μ. Tri-radiate mark 2/3 radius. Exospore 1μ thick with thickened corners; surface sporadically dotted with small warts.

GENUS X. LYCOSPORA S. W. and B.

Spores radial, trilete; circular or broadly triangular in transverse plane; lenticular in lateral profile, equator marked by a thick tapering ridge. Size 18μ - 45μ. Ornamentation smooth to granular or rugose.

Lycospora micropapillatus (Wilson & Coe) S. W. &. B., comb. nov. Fig. 274.

Tri-radial, with equatorial flange. Body triangular, 15μ - 16μ. Tri-radiate mark crosses the equatorial flange. Exine micro-papillate.

Lycospora minutus (Wilson & Coe) S. W. & B., comb. nov. Fig.275.

Tri-radial, with equatorial flange; 20μ - 26μ. Inner edge of flange with a somewhat irregular layer; embedded in this is a series of blunt rods at right angles and surrounding the body of the microspore. Surface papillate.

Lycospora pellucidus (Wicher) S. W. & B., comb. nov. Fig.276.

Round to oval, with equatorial flange; 30μ - 40μ. Tri-radiate mark with ridges. Equatorial wing 6μ wide. Surface micro-reticulate to punctate.

Lycospora pusillus (Ibr.) S. W. & B., comb. nov. Fig. 277.

Round to oval; 30μ - 40μ. Tri-radiate mark extending to the margin. Equatorial flange 3μ - 4μ wide; exospore granular to finely reticulate.

Probably equivalent to D1 (Raistrick).

GENUS XI. CIRRATRIRADITES Wilson and Coe, 1940.

Spores trilete, radially symmetrical; round to triangular, with a strongly projecting equatorial flange. Size 30μ to 120μ. Ornamentation may be granular or punctate; the flange may be radially striated and in addition may develop one or two concentric bands of irregular thickening.

Cirratriradites argutus (Ibr.) S. W. & B., comb. nov. Fig. 278.

Circular with an equatorial wing; 46μ. Tri-radiate mark extending to the margin of the spore body. Surface smooth to punctate.

Cirratriradites cicatricosus (Ibr.) S. W. & B., comb. nov. Fig. 279.

Spherical with an equatorial flange; 62μ - 73μ. Tri-radiate mark extending to the margin. Surface ornamented with irregular ridges, partly toothed; flange 3μ - 4μ broad with notched margin.

Cirratriradites faunus (Ibr.) S. W. & B., comb. nov. Fig. 280.

Spherical with an equatorial flange; 38μ - 54μ. Tri-radiate mark 2/3 radius or extending to the margin. Surface punctate or faintly reticulate; flange darker than the centre, 6μ - 8μ broad, appears faintly reticulate.

Cirratriradites formosus (Ibr.) S. W. & B., comb. nov. Fig. 281.

Round to triangular, with an equatorial flange; 90μ - 95μ. Tri-radiate mark extending to the margin. Surface faintly reticulate to punctate.

Cirratriradites maculatus Wilson & Coe. Fig. 282.

Tri-radial, triangular; 87μ - 89μ. Tri-radiate ridges cross the equatorial flange.

Probably equivalent to C5 (Raistrick).

Cirratriradites peacocki Berry. Fig. 283.

Roundly triangular; 31μ. Tri-radiate mark 2/3 radius. Surface rough or slightly reticulate; central part surrounded by a clear wing, narrow at the angle, wider at sides.

Cirratriradites penningtonensis (Berry) S. W. & B., comb. nov. Fig. 284.

Round, with a narrow keel-like wing; 40μ-44μ. Tri-radiate mark extending to the wing. Surface smooth.

Cirratriradites rarus (Ibr.) S. W. & B., comb. nov. Fig. 285.

Circular to triangular, with equatorial flange; 60μ. Tri-radiate mark extending to the margin. Spore 25μ, finely reticulate; wing 14μ - 17μ, finely notched.

Cirratriradites saturni (Ibr.) S. W. & B., comb. nov. Fig. 286.

Round to triangular, with equatorial flange; 66μ - 108μ. Tri-radiate mark extending to the margin, with ridges or flanges; a characteristic central ring around the points of intersection of the rays. Surface reticulate to punctate.

Probably equivalent to C5 (Raistrick).

This may be conspecific with C. formosus Ibr.

<u>Cirratriradites tenuis</u> (Loose) S. W. & B., comb. nov. Fig. 287.

Round to oval or polygonal with an equatorial flange; 42μ - 66μ. Tri-radiate mark extending to the margin. Surface reticulate. An equatorial ridge, 6μ - 8μ, supports the equatorial wing by means of struts in the form of fine ridges.

Probably equivalent to <u>A3</u> (Raistrick).

<u>A7</u> (Raistrick). Fig. 288.

Sub-triangular with a thin membranous equatorial wing; total diameter 70μ - 90μ. Tri-radiate mark extending to the margin. Surface of spore body granular; wall 5μ thick; equatorial wing with radial striations.

<u>A9</u> (Raistrick). Fig. 289.

Sub-triangular to round; 50μ - 60μ. Tri-radiate mark not recorded. Surface granular; central area has a thickened edge; wing 20μ, radially striated and wrinkled; margin notched.

<u>C6</u> (Knox, 1942) = Millott No. 1 (1938). Fig. 290.

Sub-triangular to round; 100μ - 120μ. Tri-radiate mark extending to the margin of the spore body. Surface smooth, wing 20μ - 30μ broad, with crenulate edge.

<u>GENUS XII.</u> <u>ALISPORITES</u> Daugherty, 1941.

Monotypic genus:-

<u>Alisporites opii</u> Daugherty. Fig. 12 in S. W. & B.

Spores trilete, radial; spherical with two membranous wings with reticulate markings. Size 100μ - 110μ.

<u>GENUS XIII</u>. <u>ENDOSPORITES</u> Wilson and Coe, 1940.

Spores radial, trilete; oval to slightly triangular; spore body enclosed in a thin-walled bladder. Size 60μ to 175μ. Surface of bladder smooth to granular; a fine meshed reticulum is commonly present but this is probably on the inside of the bladder; spore body smooth.

<u>Endosporites angulatus</u> Wilson & Coe. Fig. 291.

Sub-triangular; 145μ - 175μ. Spore body 75μ - 85μ. Wall thin and transparent; outer wall granulose.

<u>Endosporites globiformis</u> (Ibr.) S. W. & B., comb. nov. Fig. 292.

Spherical; 90μ - 140μ. Spore body 50μ - 60μ. Tri-radiate mark extending to the margin of the spore body. Wing, 25μ - 35μ, faintly reticulate, with margin toothed.

<u>Endosporites ornatus</u> Wilson & Coe. Fig. 293.

Spherical; 91μ - 113μ. Tri-radiate mark extending to the margin of spore body. Walls thin, transparent and granulose. Spore body 47μ - 54μ.

<u>Endosporites pellucidus</u> Wilson & Coe.

Similar to <u>E. ornatus</u> but smaller. Diameter 47μ - 57μ; spore body 25μ - 36μ.

<u>Endosporites rotundus</u> (Ibr.) S. W. & B., comb. nov.

Spherical; 63μ - 81μ. Tri-radiate mark extending to the margin of the spore body. Surface of bladder punctate; margin smooth.

<u>Endosporites rugatus</u> (Ibr.) S. W. & B., comb. nov. Fig. 294.

Spherical; 77μ - 80μ. Tri-radiate mark extending to the margin of the spore body. Wing 6μ - 8μ broad, punctate.

<u>Endosporites volans</u> (Loose) S. W. & B., comb. nov.

Oval to round; 74μ - 140μ. Tri-radiate mark faint and small. Surface of bladder faintly reticulate.

Probably equivalent to <u>3K</u> (Knox, 1942, fig. 4).

<u>Endosporites zonalis</u> (Loose) Knox, comb. nov. Fig. 295.
<u>Cirratriradites zonalis</u> (Loose) S. W. & B., comb. nov.

Spherical to sub-triangular; 75μ - 100μ. Tri-radiate mark extending to the margin, indistinct. Spore body 48μ - 66μ, with wing 6μ - 8μ wide; surface of wing faintly reticulate; wing strengthened round its margin.

Probably equivalent to <u>Cl</u> (Raistrick).

<u>GENUS XIV.</u> <u>CALAMOSPORA</u> S. W. & B.

Spores trilate, radial; spherical or nearly so; 40μ to several hundred microns. Spore coat usually thin and smooth to slightly granular or rugose; often much folded.

<u>Calamospora Hartungiana</u> Schopf Fig. 296.

Spherical; 80μ - 100μ. Tri-radiate mark 1/3 radius. Spore coat thin, minutely granular and folded.

Calamospora laevigatus (Ibr.) S. W. & B., comb. nov.

Oval to spherical; 260μ - 300μ. Tri-radiate mark 1/3 radius. Exospore up to 7μ thick; smooth and folded. Similar to C. mutabilis (fig. 298).

Calamospora microrugosus (Ibr.) S. W. & B., comb. nov. Fig. 297.

Polygonal to round; 58μ - 90μ. Tri-radiate mark 2/3 radius. Exospore smooth and almost always folded.

Calamospora mutabilis (Loose) S. W. & B., comb. nov. Fig. 298.

Oval to round; 63μ - 126μ. Tri-radiate mark 2/3 radius. Exospore smooth.

Probably equivalent to B3 (Raistrick).

Calamospora obesus (Loose) S. W. & B., comb. nov. Fig. 299.

Spherical to ovoid; 97μ - 160μ. Tri-radiate mark 1/3 radius. Exospore 5μ thick, smooth to punctate or faintly reticulate.

Probably equivalent to 7K (Knox, 1942, fig. 4).

Calamospora pallidus (Loose) S. W. & B., comb. nov. Fig. 300.

Oval to polygonal; 67μ by 58μ to 54μ by 47μ. Tri-radiate mark 2/3 radius. Exospore faintly punctate to slightly rough.

Calamospora perrugosus (Loose) S. W. & B., comb. nov.

Oval to round; 122μ - 155μ. Tri-radiate mark 2/3 radius. Exospore smooth and folded. Similar to C. mutabilis.

B7 Raistrick. Fig. 301.

Spherical; 25μ - 35μ. Tri-radiate mark extending almost to the margin. Exospore thin and smooth.

GENUS XV. REINSCHOSPORA S. W. & B.

Spores radial, trilete; sub-triangular in transverse plane with rounded corners. A fimbriate flange may be present to modify the marginal outline. Size 30μ - 85μ. Spore body smooth to granular. Flange closely striate to fimbriate, sometimes so incised as to form a row of apiculae.

Reinschospora bellitas Bentall Fig. 2, S. W. & B.

Sub-triangular; 57μ - 76μ. Tri-radiate extending almost to the margin. Flange fimbriate.

Reinschospora speciosa (Loose) S. W. & B., comb. nov.

Triangular, trefoil shaped; 50μ - 55μ. Tri-radiate mark extending to the margin. Exospore smooth; three wings with radial rays up to 20μ in width on sides of the spore body.

GENUS XVI. RAISTRICKIA S. W. & B.

Spores radial, trilete; spherical to sub-triangular. Size 40μ - 90μ. Ornamentation verrucose or spinose; spines truncate and blunt tipped. The spine tips may be dissected into two to six terminal papillae.

Raistrickia fibratus (Loose) S. W. & B., comb. nov. Fig. 302.

Spherical; 46μ - 58μ. Tri-radiate mark 2/3 radius. Exospore ornamented with fibrous bristles from 2μ broad to 2μ - 4μ long.

Probably equivalent to E3 (Raistrick).

<u>Raistrickia grovensis</u> Schopf. Fig. 303.

Rounded triangular; 50μ. Tri-radiate mark 1/3 radius. Surface ornamented with numerous short, 3μ - 5μ, blunt tipped spines which sometimes appear mutually attached.

<u>Raistrickia saetosus</u> (Loose) S. W. & B., comb. nov. Fig. 304.

Oval to round; 50μ - 93μ. Tri-radiate mark 2/3 radius. The surface is beset with numerous processes, 4μ - 8μ long and 2μ - 6μ broad.

<u>Raistrickia spinosaetosus</u> (Loose) S. W. & B., comb. nov. Fig. 305.

Oval to round, 45μ - 75μ. Tri-radiate mark 2/3 radius. Surface ornamented with processes 1.5μ - 4μ long and 1μ - 3μ broad.

<u>Raistrickia superbus</u> (Ibr.) S. W. & B., comb. nov. Fig. 306.

Ovoid; 46μ - 54μ. Tri-radiate mark extending to the margin. Spines 4μ - 8μ long and 2μ - 4μ broad. Exospore 3μ - 4μ thick.

<u>GENUS XVII.</u> <u>FLORINITES</u> S. W. & B.

Spores apparently bi-lateral; spore body spherical, nearly enclosed by a bladder giving a broadly elliptical outline. Size 50μ - 180μ. Ornamentation of the exterior surface smooth or finely granular; internally the membrane bears a distinct reticulum.

Florinites antiqua Schopf   Fig. in S. W. & B., p. 59, fig. 4.

"Pollen grains" with bi-lateral symmetry with an annulate bladder joined to the central body only on the distal side. The grains are broadly elliptical. Size inclusive of the bladder from 55μ - 90μ in length and 40μ - 75μ broad. The body is almost spherical, 25μ - 45μ. The bladder is smooth to granular with an internal reticulation, 1μ - 3μ; the body wall is thin and smooth.

Florinites pumicosus (Ibr.) S. W. & B., comb. nov.

Oval to round; 62μ - 92μ. Surface micro-reticulate, and reticulatum indistinct in the centre.

Florinites visendus (Ibr.) S. W. & B., comb. nov.

Ovate to round; 115μ - 175μ. Spore body with a wing which is micro-reticulate. Reticulation in the centre of the spore is faint.

This spore is similar to 3K (Knox, 1942, fig. 4) and to Endosporites globiformis (fig. 292).

COMPARISON OF PALAEOZOIC SPORES WITH THOSE OF LYCOPODIUM, SELAGINELLA and ISOETES.

It is now possible to make certain generalisations and comparisons between the genera of Palaeozoic spores and the groups of spore types in the genera Lycopodium, Selaginella and Isoetes.

Indications have been given in the preceding pages that the spore ornamentation in the Lycopodiaceae and Selaginellaceae bears a striking resemblance in many instances to that of isolated fossil spores from plant bearing strata of the Palaeozoic.

The reticulate or pitted nature of the exospore in the genus Lycopodium is an acknowledged fact; in all probability, therefore, a large proportion of the fossil spores assigned to the genera Microreticulati-sporites and Reticulati-sporites are of Lycopodean affinity, with the possible exception of Reticulati-sporites polygonalis (fig. 255) and 5K (fig. 257); ornamentation of the spores of the latter resemble closely the sculpturing seen in Selaginella Willdenovii (fig. 95).

The Palaeozoic genus Triquitrites recalls the spores of the group of Lycopodium Selago (figs. 1-6) in shape and in the thickened, truncate corners, though lacking the pitted exospore characteristic of the living species.

The microspores of the Selaginellaceae have been demonstrated to be divisible into two main series:- (1) those with a membranous wing or annular ring; and (2) those without a wing but furnished with excrescences varying in shape, size and disposition.

The comparable fossil spores possessing a thin encircling bladder are classed together in the genus Endosporites; some members of this genus closely resemble species included in the group of Selaginella sibirica, e.g. Endosporites rugatus (fig. 294), though larger, is otherwise similar to S. struthoiloides (fig. 79), while Endosporites angulatus and Endosporites zonalis (figs. 291 & 295) recall S. Wallacei (fig. 81).

The spores of Selaginella which have an annular ring (group of S. scandens, figs. 98-101) and those with an equatorial flange (group of S. sanguinolenta, figs. 83-89) have both their counterparts in the Palaeozoic genera of Densosporites and Cirratriradites respectively. The species of Cirratriradites possessing a membranous flange are allied to such types as S. semicordata, S. Mayeri and others of the group of S. megastachys (figs. 97, 90 & 96).

Close parallels can also be cited between Palaeozoic spores and spores of living representatives of Selaginellaceae in which the exospore exhibits either spines, tubercles or rod-like processes. The resemblances are too many to quote here; suffice to indicate the similarities of fossil genera to spore groups:-

Spinoso-sporites, with ornamentation of pointed processes, corresponds to groups XV-XVIII, i.e. the groups of S. subarborescens, S. anceps, S. uncinata and S. magnifica.

Plani-sporites, with smooth or granular spores, corresponds to groups V-VII, i.e. the groups of S. firmula, S. helvetica and S. cathedrifolia.

Verrucoso-sporites, with ornamentation of rounded, warty or tuberculate processes, corresponds to groups VIII-X, i.e. the groups of *S. radicata*, *S. leptophylla* and *S. vaginata*.

Raistrickia, with blunt, straight-sided processes, corresponds to groups XIII and XIV, i.e. the groups of *S. biformis* and *S. latifrons*.

Of the remaining genera of Palaeozoic spores, the bilateral, monolete *Laevigato-sporites* forms are probably of Filicean affinity, though a few may be related to *Isoetaceae*. The large, thin-walled, spherical, unornamented types of the genus *Calamospora* are almost certainly Calamarian; *Alisporites*, *Florinites* and some species of *Endosporites* are known to be related to *Cordaianthus* and *Caytonanthus*. They thus represent "a part of the upper Palaeozoic gymnospermic alliance" (Schopf, 1944).

Whilst many fossil spores may be related to the Lycopodalean families it must not be forgotten that close parallels can also be drawn with spores of the Hepaticae (Knox, 1939); and it is not unlikely that Bryophytic plants contributed their share to the formation of the coal swamps (Walton, 1925, 1928).

It is important to realise that evolutionary convergence as well as community of derivation account for the recurrence of similar specific features in spore morphology in different phyla and in different geologic periods. Consequently the relationship of isolated fossil spores to the parent stock can only be hinted at; only as microfossils are found in organic connection with a known species can any certainty of lineage be maintained.

The suggestions put forward are therefore purely tentative; not until our knowledge of the fossil flora is greatly increased can positive assertions be made; time alone can prove the correctness of our judgments and the veracity of our theories.

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EXPLANATION OF PLATES.

In figures 1-197 the magnification is x 500; in figures 198-306 the magnification is x 250.

Ap. = apical view. Ab-ap. = Ab-apical view.
l. = lateral view.

PLATE I. Lycopodiaceae.

I. Spores of Lycopodium Selago Group.

Fig. 1a. L. Selago L. (ab-ap.)

1b. L. Selago (ap.)

2. L. fontinaloides Spring (ap.)

3a. L. serratum Thunb. (ap.)

3b. L. serratum (ab-ap.)

4. L. miniatum Spring (ab-ap.)

5. L. ceylanicum Spring (ap.)

6. L. lucidulum Michx. (ap.)

II. Spores of Lycopodium Phlegmaria Group.

7. L. Sieboldii Miguel. (ab-ap.)

8. L. robustum Klotzsch (ab-ap.)

9. L. aqualipianum Spring (ap.)

10. L. callitrichaefolium Mett. (ab-ap.)

11. L. carinatum Desv. (ab-ap.)

12. L. casuarinoides Spring (ap.)

13. L. cryptomerinum Maxim. (ap.)

14. L. Dalhousieanum Spring (ap.)

PLATE I. (Contd.)

Fig. 15. L. erythraeum Spring (ab-ap.)

16. L. Hamiltonii Spring (ab-ap.)

17. L. mollicomum Mart. (ap.)

18. L. myrsinites Lam. (ab-ap.)

19a. L. Phlegmaria L. (ab-ap.)

19b. L. Phlegmaria (ap.)

20. L. sarmentosum Spring (ap.)

21. L. dichotomum Jacq. (ap.)

22. L. firmum Mett (ap.)

23. L. Lindeni Spring (ap.)

24. L. megastachyum Baker (ap.)

25. L. Saururus Lam. (ap.)

26. L. compactum Hook. (ap.)

27. L. Jamesoni Baker (ab-ap.)

28. L. obtusifolium Sw. (ap.)

29. L. reflexum Lam. (ap.)

30. L. tetragonum Hk. & Gr. (ap.)

PLATE II. Lycopodiaceae.

Spores of Group II (contd.)

Fig. 31. L. affine Hk. & Gr. (ap.)

32. L. echinatum Spring (ap.)

33. L. gnidioides Lf. (ap.)

34. L. myrtuosum Spring (ap.)

PLATE II. (Contd.)

Fig. 35. L. rufescens Hook. (ap.)

36. L. setaceum Hamilt. (ab-ap.)

37. L. subulatum Desv. (ap.)

38. L. Billardieri Spring (ab-ap.)

39. L. cancellatum Spring (ab-ap.)

40. L. insulare Carm. (ab-ap.)

41. L. nummularifolium Blume (ap.)

42a. L. Pearcei Baker (ab-ap.)

42b. L. Pearcei (ap.)

43. L. pinifolium Blume (ab-ap.)

III. Spores of Lycopodium Verticillatum Group.

44. L. taxifolium Sw. (ap.)

45. L. verticillatum L. (ap.)

46. L. polytrichoides Klf. (ap.)

47. L. rubrum Cham. (ap.)

48. L. xiphophyllum Baker (ap.)

IV. Spores of Lycopodium Clavatum Group.

49. L. diaphanum Sw. (ab-ap.)

50a. L. contiguum Klotzsch (ab-ap.)

50b. L. contiguum (ap.)

51. L. Wightianum Wall (ab-ap.)

52. L. scariosum Forst. (ab-ap.)

53a. L. vestitum Desv. (ab-ap.)

53b. L. vestitum (ap.)

PLATE II (Contd.)

Fig. 54. L. volubile Forst. (l.)

55a. L. annotinum L. (ap.)

55b. L. annotinum (ab-ap.)

PLATE III.

Spores of Group IV (contd.)

Fig. 56a. L. laterale R. Br. (ap.)

56b. L. laterale (ab-ap.)

57a. L. magellanicum Sw. (ab-ap.)

57b. L. magellanicum (ap.)

58. L. ramulosum Kirk (l.)

59. L. Sprucei Baker (l.)

60a. L. alpinum L. (ab-ap.)

60b. L. alpinum (ap.)

61A. L. clavatum L. (ab-ap.)

61b. L. clavatum (ap.)

62a. L. paniculatum Desv. (ab-ap.)

62b. L. paniculatum (ap.)

63a. L. complanatum L. (ap.)

63b. L. complanatum (ab-ap.)

64a. L. adpressum Champ. (ap.)

64b. L. adpressum (l.)

65a. L. cernuum L. (ap.)

65b. L. cernuum (ab-ap.)

PLATE III. (Contd.)

Fig. 66. L. phyllanthum Hook. & Arn. (ab-ap.)

67. Phylloglossum Drummondii Kunze (ab-ap.)

68. L. spurium Willd. (l.)

69a. L. obscurum L. (l.)

69b. L. obscurum (ab-ap.)

70. L. Drummondii Spring (ap.)

71a. L. inundatum L. (ap.)

71b. L. inundatum (ab-ap.)

72a. L. fastigiatum R. Br. (ap.)

72b. L. fastigiatum (ab-ap.)

73. L. diffusum R. Br. (ap.)

74a. L. carolinianum L. (ab-ap.)

74b. L. carolinianum (ap.)

75a. L. densum Labill. (ab-ap.)

75b. L. densum (l.)

PLATE IV. Selaginellaceae.

I. Spores of S. sibirica Group.

Fig. 76. S. uliginosa Spring (ap.)

77. S. sibirica (Milde) Hieron. (ap.)

78. S. arenicola Underw. (ap.)

79. S. strutholoides (Presl.) Underw. (ap.)

80. S. pygmaea Kaulf. (ap.)

81. S. Wallacei Hieron. (ap.)

PLATE IV (Contd.)

Fig. 82. S. Preissiana Spring (ap.)

II. Spores of S. Sanguinolenta Group.

Fig. 83a. S. laevigata Baker (ap.)

83b. S. laevigata (l.)

84a. S. valdepilosa Baker (ap.)

84b. S. valdepilosa (l.)

85. S. saccharata A. Br. (ap.)

86. S. sanguinolenta (L.) Spring (ap.)

87. S. boreale Spring (l.)

88a. S. pedata Klotzsch (ap.)

88b. S. pedata (l.)

89a. S. stenophylla A. Br. (ab-ap.)

89b. S. stenophylla (l.)

PLATE V. Selaginellaceae.

III. Spores of S. megastachys Group.

Fig. 90a. S. Mayeri Hieron. (ap.)

90b. S. Mayeri (ab-ap.)

91a. S. tylophora vA. vR. (ap.)

91b. S. tylophora (ab-ap.)

92a. S. integerrima Spring (l.)

92b. S. integerrima (ap.)

93. S. asperula vA. vR. (ap.)

PLATE V (Contd.)

Fig. 94. S. flaccida Spring (l.)
95. S. Willdenovii Baker (ab-ap.)
96a. S. megastachys Baker (ap.)
96b. S. megastachys (ab-ap.)
97a. S. semicordata Spring (ap.)
97b. S. semicordata (ab-ap.)

IV. Spores of S. scandens Group.

Fig. 98a. S. puberula Spring (l.)
98b. S. puberula (ap.)
99a. S. scandens Spring (l.)
99b. S. scandens (ap.)
100a. S. stellata Spring (ap.)
100b. S. stellata (l.)
101a. S. Parkeri Spring (ap.)
101b. S. Parkeri (l.)

PLATE VI. Selaginellaceae.

V. Spores of S. firmula Group.

Fig. 102. S. cordifolia Spring (ap.)
103. S. firmula A. Br. (ap.)
104. S. Volkensii Hieron. (ap.)
105. S. Roxburghii (Hk. & Gr.) Spring (ap.)
106. S. Hochreutineri Hieron. (ap.)

PLATE VI (Contd.).

Fig. 107. S. nana (Desv.) Spring (ap.)

108. S. Burbidgei Baker (ap.)

109. S. marginata Spring (ap.)

VI. Spores of S. helvetica Group.

Fig. 110. S. Whitmeei Baker (ap.)

111. S. helvetica Link (ap.)

112. S. Kernbachii Hieron. (ap.)

113. S. philippina Spring (ap.)

114. S. megaphylla Baker (ap.)

115. S. arbuscula Spring (ap.)

VII. Spores of S. cathedrifolia Group.

Fig. 116. S. tamariscina (Beauv.) Spring (ap.)

117a. S. cathedrifolia Spring (ap.)

117b. S. cathedrifolia (l.)

118. S. producta Baker (ap.)

119. S. heterostachys Baker (ap.)

120. S. falcata Spring (ap.)

121. S. savatieri Baker (ap.)

122. S. platybasis Baker (ap.)

VIII. Spores of S. radicata Group.

Fig. 123a. S. apus Spring (ap.)

123b. S. apus (ab-ap.)

124. S. Ludoviciana A. Br. (ap.)

PLATE VI (Contd.)

Fig. 125. S. velutina Cesati (ap.)

126. S. palidissima Spring (ap.)

127. S. Balfourii Baker (ap.)

128. S. abyssinica Spring (ap.)

129. S. radicata (Hk. & Gr.) Spring (ap.)

130. S. sub-diaphana (Wall) Spring (ap.)

131. S. tenera Spring (ab-ap.)

IX. Spores of S. leptophylla Group.

Fig. 132. S. pentagona Spring (ab-ap.)

133. S. effusa Alston (ap.)

134. S. ciliaris (Retz.) Spring (ab-ap.)

135. S. leptophylla Baker (ap.)

PLATE VII. Selaginellaceae.

X. Spores of S. vaginata Group.

Fig. 136. S. Mettenii A. Br. (ap.)

137. S. tenuifolia Spring (ab-ap.)

138. S. opaca Warb. (ab-ap.)

139. S. sinensis (Desv.) Spring (ab-ap.)

140a. S. vaginata Spring (ab-ap.)

140b. S. vaginata (ap.)

PLATE VII (Contd.)

XI. Spores of S. repanda Group.

Fig. 141. S. Beccarriana Baker (ap.)

142. S. calcicola Hieron. (ap.)

143a. S. repanda (Desv.) Spring (ab-ap.)

143b. S. repanda (ap.)

XII. Spores of S. stolonifera Group.

Fig. 144. S. Hookeri Baker (ap.)

145. S. monospora Spring (ab-ap.)

146. S. permutata Hieron. (l.)

147. S. polystachya (Warb.) Hieron. (ap.)

148. S. inaequifolia (Hk. & Gr.) Spring (ab-ap.)

149. S. stolonifera Spring (ab-ap.)

150. S. conferta Moore (ab-ap.)

XIII. Spores of S. biformis Group.

Fig. 151. S. intermedia (Bl.) Spring (ab-ap.)

152. S. caulescens (Wall) Spring (ap.)

153. S. haematodes Spring (ab-ap.)

154. S. ascendens vA. vR. (ab-ap.)

155. S. frondosa Warb. (l.)

156. S. biformis A. Br. (ab-ap.)

157. S. trachyphylla A. Br. (l.)

XIV. Spores of S. latifrons Group.

Fig. 158. S. atroviridis Spring (ab-ap.)

159. S. sumatrana Hieron. (l.)

PLATE VII (Contd.)

Fig. 160. S. longipinna Warb. (l.)

161. S. latifrons Warb. (l.)

162. S. denudata Spring (ab-ap.)

PLATE VIII. Selaginellaceae.

XV. Spores of S. sub-arborescens Group.

Fig. 163a. S. sub-arborescens Hook. (ab-ap.)

163b. S. sub-arborescens (l.)

164. S. Elmeri Hieron. (ab-ap.)

165. S. cupressina A. Br. (ab-ap.)

166. S. erectifolia Spring (l.)

167. S. peltata Presl. (ab-ap.)

XVI. Spores of S. anceps Group.

Fig. 168. S. Wallichii Spring (ab-ap.)

169. S. anceps Presl. (ab-ap.)

170. S. erythropus (Warb.) Spring (l.)

171a. S. blepharostachys Alston (ab-ap.)

171b. S. blepharostachys (ap.)

172. S. Mayerhoffii Hieron. (ab-ap.)

XVII. Spores of S. uncinata Group.

Fig. 173. S. Eggersii Sodiro (ab-ap.)

174. S. intacta Baker (ap.)

175. S. articulata Spring (ab-ap.)

PLATE VIII (Contd.)

Fig. 176. S. bombycina Spring (ap.)

177a. S. uncinata Spring (ab-ap.)

177b. S. uncinata (ap.)

178. S. chilensis Spring (ab-ap.)

179. S. geniculata Spring (ap.)

180. S. Poeppigiana Spring (ab-ap.)

XVIII. Spores of S. magnifica Group.

Fig. 181. S. cagayensis Hieron. (ab-ap.)

182. S. Spanielema Alston (ab-ap.)

183. S. Brooksii Hieron. (l.)

184. S. magnifica Warb. (ab-ap.)

185. S. adligans Hieron. (l.)

XIX. Spores of S. Selaginoides Group.

Fig. 186a. S. Selaginoides Link (ap.)

186b. S. Selaginoides (ab-ap.)

187. S. atirrensis Hieron. (ab-ap.)

XX. Spores of S. Kraussiana Group.

Fig. 188. S. Kraussiana A. Br. (ap.)

189. S. Kunzeana A. Br. (ab-ap.)

PLATE VIII (contd.)

Isoetaceae.

I. Spores of I. echinospora Group.

Fig. 190a. I. Drummondii A. Br. (l.)

190b. I. Drummondii (ap.)

191a. I. echinospora Dur. (l.)

191b. I. echinospora (ap.)

II. Spores of I. adspersa Group.

Fig. 192a. I. ovata Pfeiffer (l.)

192b. I. ovata (ap.)

193a. I. Gardneriana Kze. (l.)

193b. I. Gardneriana (ap.)

194a. I. adspersa A. Br. (l.)

194b. I. adspersa (ap.)

III. Spores of I. Hystrix Group.

Fig. 195. I. habbemensis Alston (l.)

196. I. japonica A. Br. (l.)

197a. I. Hystrix Dur. (l.)

197b. I. Hystrix (ap.)

PLATE IX.

Fossil Spores.

I. Spores of Genus SPINOSO-SPORITES Knox, gen. nov.

Fig. 198. S. aculeatus (Ibr.) Knox, comb. nov.

199. S. globosus (Loose) Knox, comb. nov.

200. S. latigranifer (Loose) Knox, comb. nov.

201. S. spinosus (Loose) Knox, comb. nov.

202. S. spinulastratus (Loose) Knox, comb. noc.

203. S. microsaetosus (Loose) Knox, comb. nov.

204. S. microspinosus (Ibr.) Knox, comb. nov.

205. 18 K. (Knox).

206. E 1. (Raistrick)

207. E 2 (Raistrick)

208. E sp.

II. Spores of Genus PLANI-SPORITES Knox, gen. nov.

Fig. 209. P. aureus (Loose) Knox, comb. nov.

210. P. granifer (Ibr.) Knox, comb. nov.

211. P. microtuberosus (Loose) Knox, comb. nov.

212. P. parvipunctatus (Kosanke) Knox, comb. nov.

213. P. punctatus (Ibr.) Knox, comb. nov.

214. P. sphaerotriangulatus (Loose) Knox, comb. nov.

215. P. deltiformis (S. W. & B.) Knox, comb. nov.

216. P. deltoides (Ibr.) Knox, comb. nov.

217. P. granulatus (Ibr.) Knox, comb. nov.

PLATE IX (Contd.)

Fig. 218. P. micrograniifer (Ibr.) Knox, comb. nov.

219. P. piroformis (Loose) Knox, comb. nov.

220. P. priddyi (Berry) Knox, comb. nov.

221. P. verrucosus (Wilson & Coe) Knox, comb. nov.

222. 6 K. Knox

223. 11 K. Knox

III. Spores of Genus VERRUCOSO-SPORITES Knox, gen. nov.

Fig. 224. V. bucculentus (Loose) Knox, comb. nov.

225. V. firmus (Loose) Knox, comb. nov.

226. V. grumosus (Ibr.) Knox, comb. nov.

227. V. insignitis (Ibr.) Knox, comb. nov.

228. V. microverrucosus (Ibr.) Knox, comb. nov.

229. V. papillosus (Ibr.) Knox, comb. nov.

230. V. verrucosus (Ibr.) Knox, comb. nov.

231. V. tuberculatus (Berry) Knox, comb. nov.

232. V. gibbosus (Ibr.) Knox. comb. nov.

233. V. triquetris (Ibr.) Knox, comb. nov.

234. 16 K. Knox

235. 20 K. Knox

236. 21 K. Knox

237. 23 K. Knox

PLATE X.

IV. Spores of Genus MICRORETICULATI-SPORITES Knox, gen. nov.

Fig. 238. M. corrugatus (Ibr.) Knox, comb. nov.

239. M. cusus (Loose) Knox, comb. nov.

240. M. lacunosus (Ibr.) Knox, comb. mov.

241. M. maculatus (Ibr.) Knox, comb. nov.

242. M. nobilis (Wicher) Knox, comb. nov.

243. M. reticulocingulum (Loose) Knox, comb. nov.

244. M. trigonoreticulatus (Loose) Knox, comb. nov.

245. M. velatus (Loose) Knox, comb. nov.

246. M. fistulosus (Ibr.) Knox, comb. nov.

247. M. parvus (Ibr.) Knox, comb. nov.

248. M. torquifer (Loose) Knox, comb. nov.

249. M. trigonus (Ibr.) Knox, comb. nov.

250. M. Theissenii (Kosanke) Knox, comb. nov.

V. Spores of Genus RETICULATI-SPORITES (Ibrahim, 1933) emend., S. W. & B.

Fig. 251. R. corporeus Loose

252. R. facetus (Ibr.) S. W. & B., comb. nov.

253. R. mediareticulatus Ibr.

254. R. ornatus (Ibr.) S. W. & B., comb. nov.

255. R. polygonalis (Ibr.) S. W. & B., comb. nov.

256. R. reticuliformis Ibr.

257. 5 K. Knox

PLATE X (Contd.)

VI. Spores of Genus ALATI-SPORITES Ibrahim, 1933.

Fig. 258. A. pustulatus Ibr.

VII. Spores of the Genus LAEVIGATO-SPORITES (Ibrahim, 1933) emend., S. W. & B., comb. nov.

Fig. 259. L. bilateralis (Loose) S.W. & B., comb. nov.

260. L. desmoinensis (Wilson & Coe), S. W. & B., comb. nov.

261. L. minimus (Wilson & Coe) S. W. & B., comb. nov.

262. L. minutus (Ibr.) S. W. & B., comb. nov.

263. L. pennovalis Berry

264a. L. vulgaris Ibr. forma major

264b. L. vulgaris, forma minor

VIII. Spores of Genus DENSO-SPORITES (Berry, 1937) emend. S. W. & B.

Fig. 265. D. annulatus (Loose) S. W. & B., comb. nov.

266. D. indignabundus (Loose) S. W. & B., comb. nov.

267. 9 K. Knox

IX. Spores of Genus TRIQUITRITES Wilson & Coe, 1940.

Fig. 268. T. arculatus Wilson & Coe

269. T. spinosus Kosanke

270. T. tribullatus (Ibr.) S. W. & B., comb. nov.

271. T. trigonappendix (Loose) S. W. & B., comb. nov.

272. T. triturgidus (Loose) S. W. & B., comb. nov.

273. T. auriculaferens (Loose) Knox, comb. nov.

PLATE X (Contd.)

X. Spores of Genus LYCOSPORA S. W. & B., gen. nov.

Fig. 274. L. micropapillatus (Wilson & Coe) S. W. & B., comb. nov.

275. L. minutus (Wilson & Coe) S. W. & B., comb. nov.

276. L. pellucidus (Wicher) S. W. & B., comb. nov.

277. L. pusillus (Ibr.) S. W. & B., comb. nov.

PLATE XI.

Fossil Spores.

XI. Spores of Genus CIRRATRIRADITES Wilson & Coe, 1940.

Fig. 278. C. argutus (Ibr.) S. W. & B., comb. nov.

279. C. cicatricosus (Ibr.) S. W. & B., comb nov.

280. C. faunus (Ibr.) S. W. & B., comb. nov.

281. C. formosus (Ibr.) S. W. & B., comb. nov.

282. C. maculatus Wilson & Coe

283. C. peacocki Berry

284. C. penningtonensis (Berry) S. W. & B., comb. nov.

285. C. rarus (Ibr.) S. W. & B., comb. nov.

286. C. saturni (Ibr.) S. W. & B., comb. nov.

287. C. tenuis (Loose) S. W. & B., comb. nov.

288. A 7. (Raistrick)

289. A 9 (Raistrick)

290. C 6 (Knox) Millott No. 1 (1938)

PLATE XI (Contd.)

XII. Spores of Genus ENDOSPORITES Wilson & Coe, 1940.

Fig. 291. E. angulatus Wilson & Coe

292. E. globiformis (Ibr.) S. W. & B., comb. nov.

293. E. ornatus Wilson & Coe

294. E. rugatus (Ibr.) S. W. & B., comb. nov.

295. E. zonalis (Loose) Knox, comb. nov.

XIII. Spores of Genus CALAMOSPORA S. W. & B., gen. nov.

Fig. 296. C. Hartungiana Schopf

297. C. microrugosus (Ibr.) S. W. & B., comb. nov.

298. C. mutabilis (Loose) S. W. & B., comb. nov.

299. C. obesus (Loose) S. W. & B., comb. nov.

300. C. pallidus (Loose) S. W. & B., comb. nov.

301. B 7. (Raistrick)

XIV. Spores of Genus RAISTRICKIA S. W. & B., gen. nov.

Fig. 302. R. fibratus (Loose) S. W. & B., comb. nov.

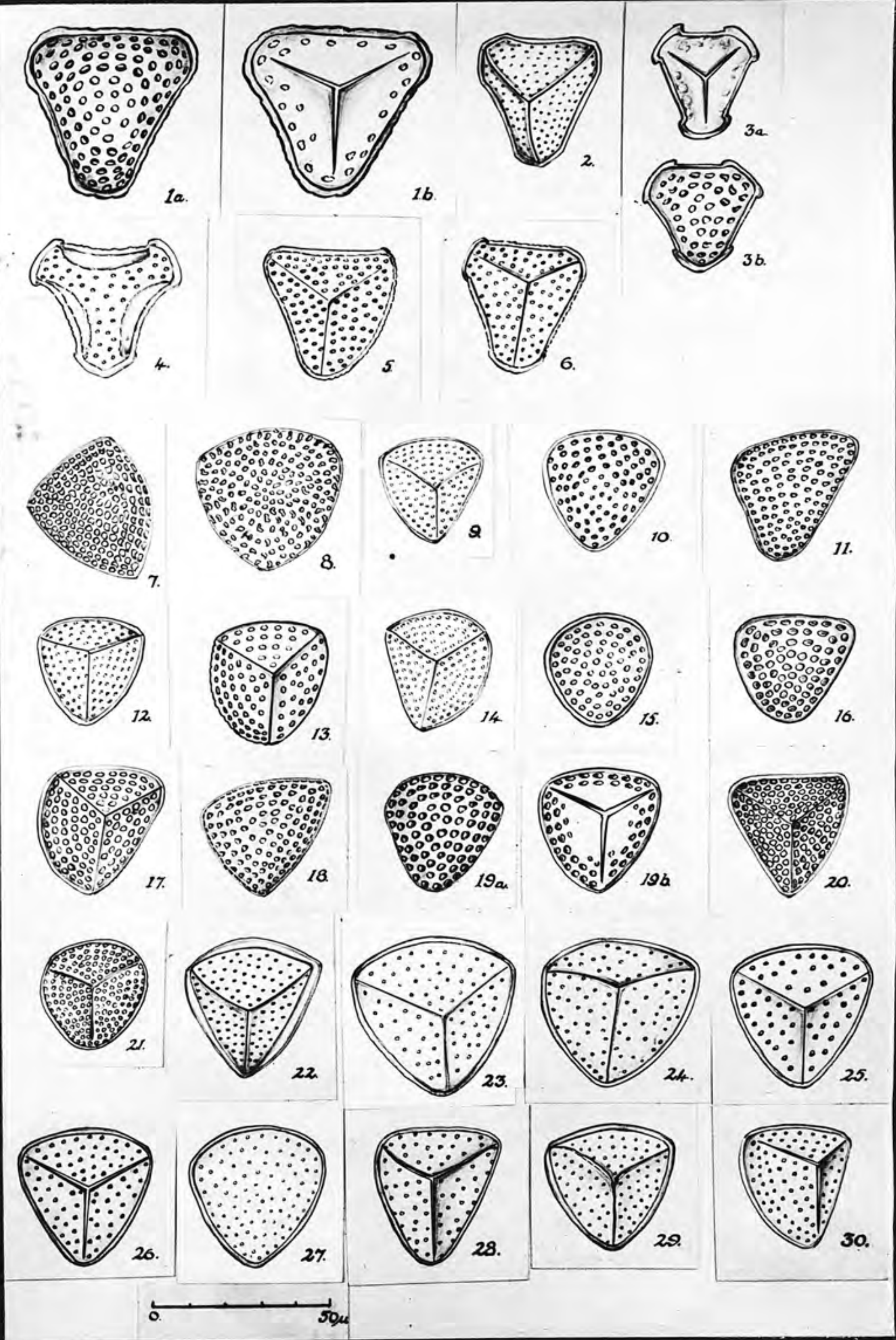
303. R. grovensis Schopf

304. R. saetosus (Loose) S. W. & B., comb. nov.

305. R. spinosaetosus (Loose) S. W. & B., comb. nov.

306. R. superbus (Ibr.) S. W. & B., comb. nov.

PLATE I.



1a.
1b.
2.
3a.
3b.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
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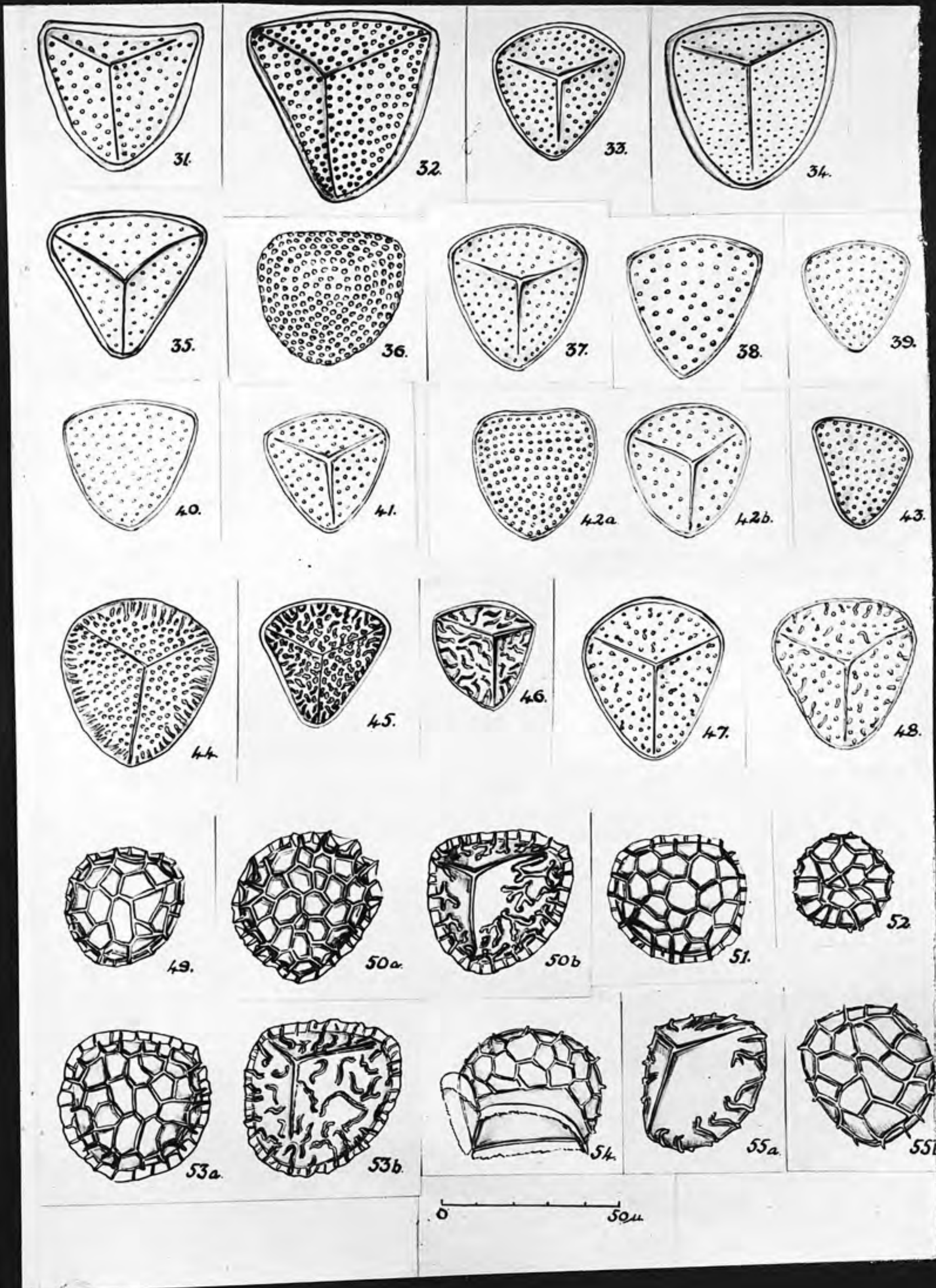
16.
17.
18.
19a.
19b.
20.
21.
22.
23.
24.
25.
26.
27.
28.
29.
30.
0.
50μ

PLATE II.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46.
47.
48.
49.
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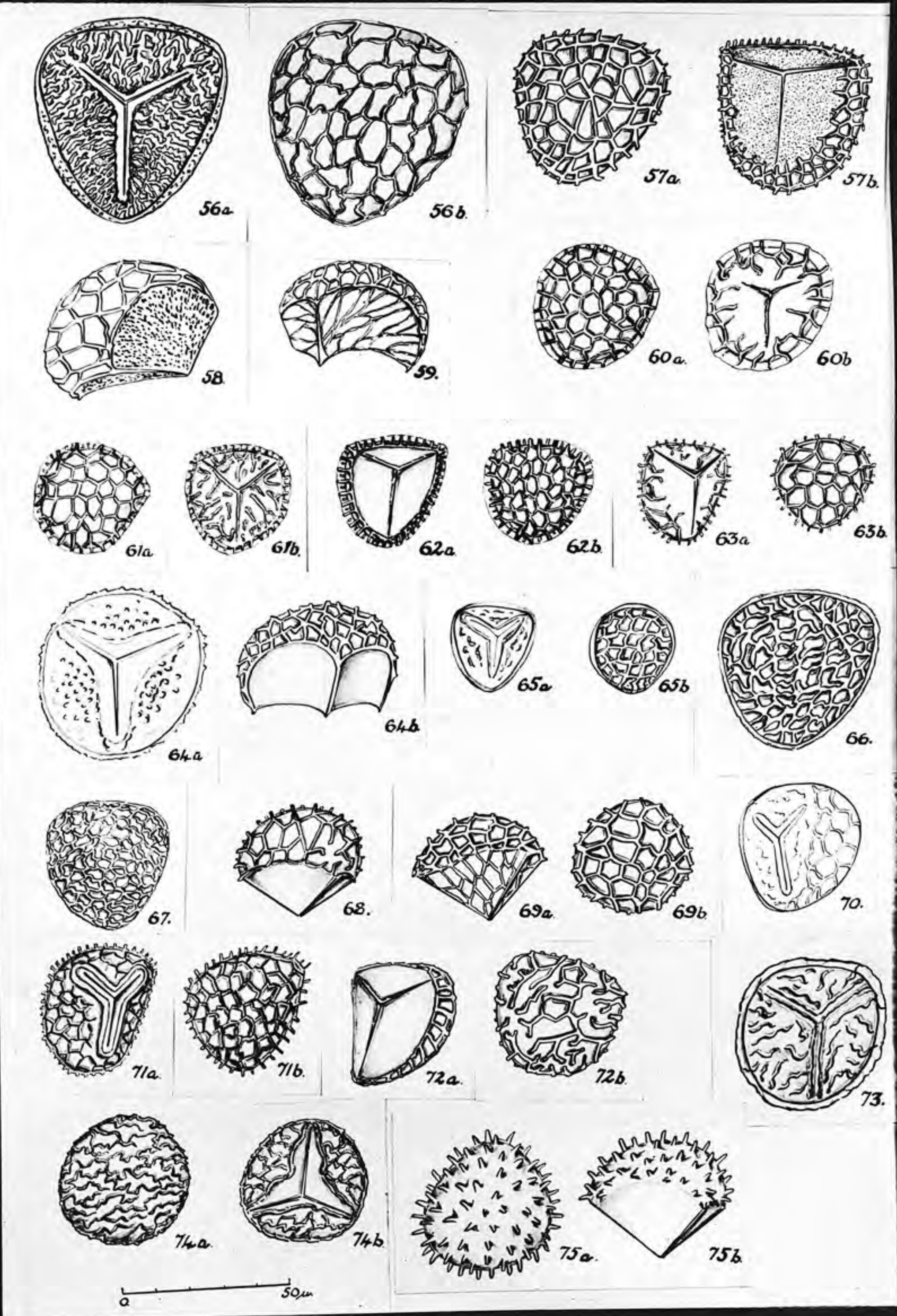
50b
51.
52.
53a.
53b.
54.
55a.
55b
0
50u.

PLATE III.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61a
61b
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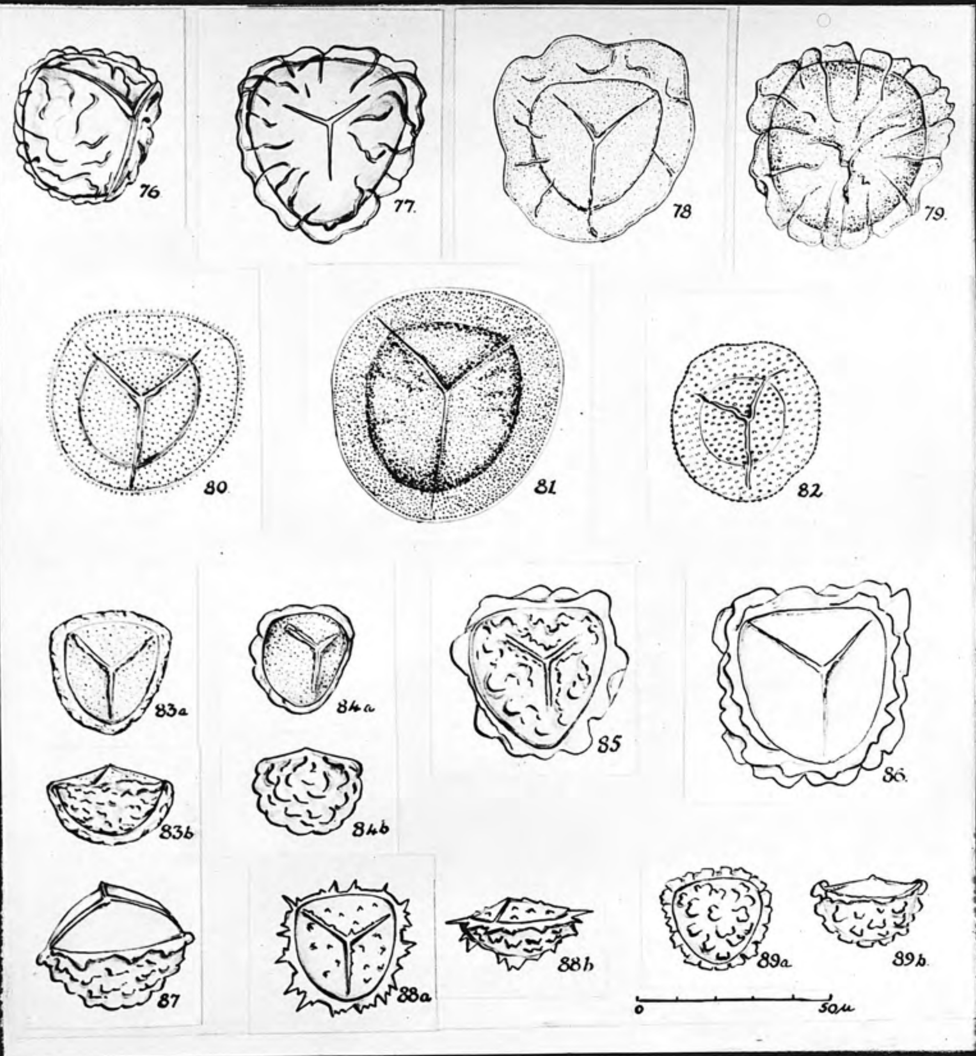
65b
66
67
68
69a
69b
70
71a
71b
72a
72b
73
74a
74b
75a
75b
0
50µ

PLATE IV.



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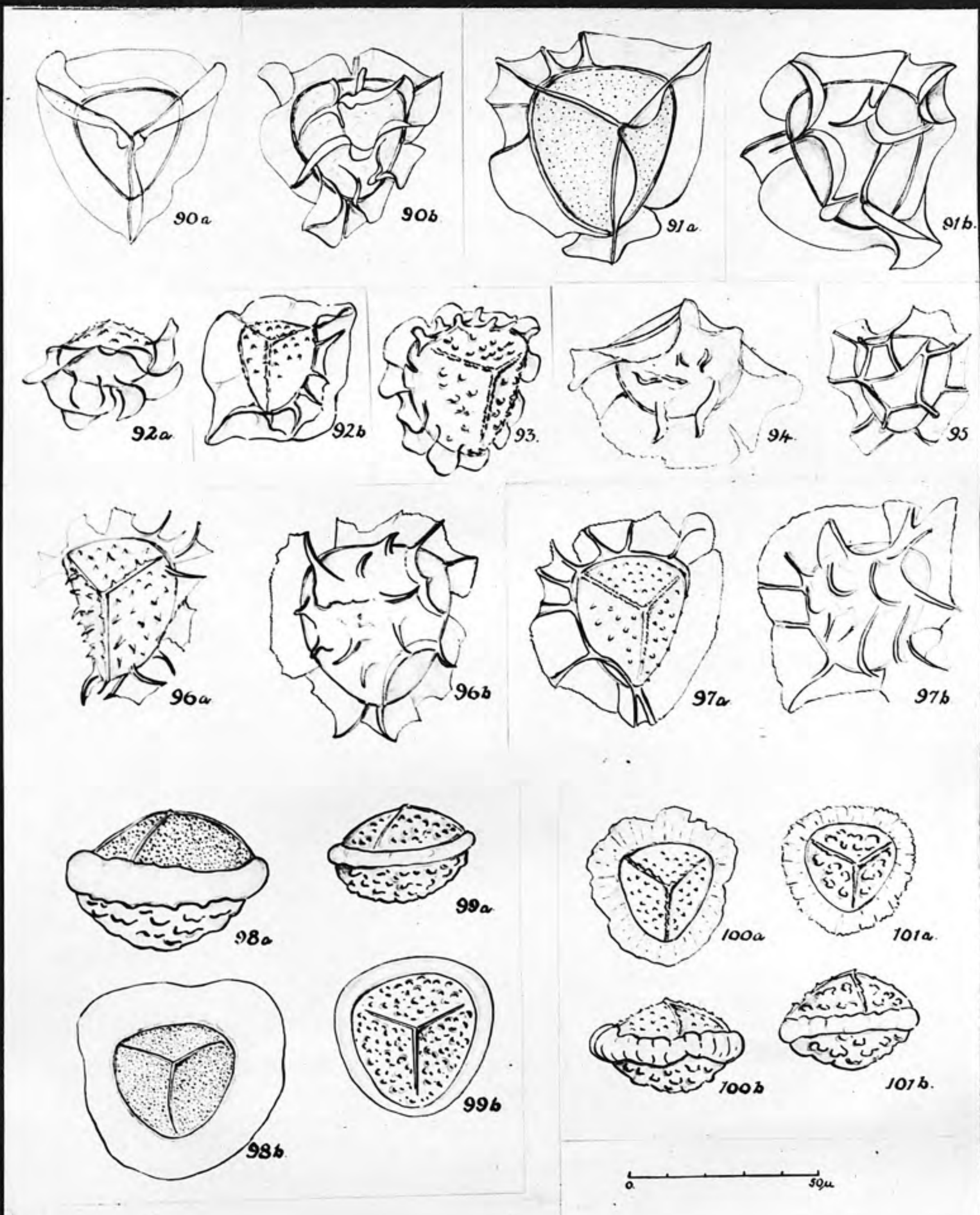
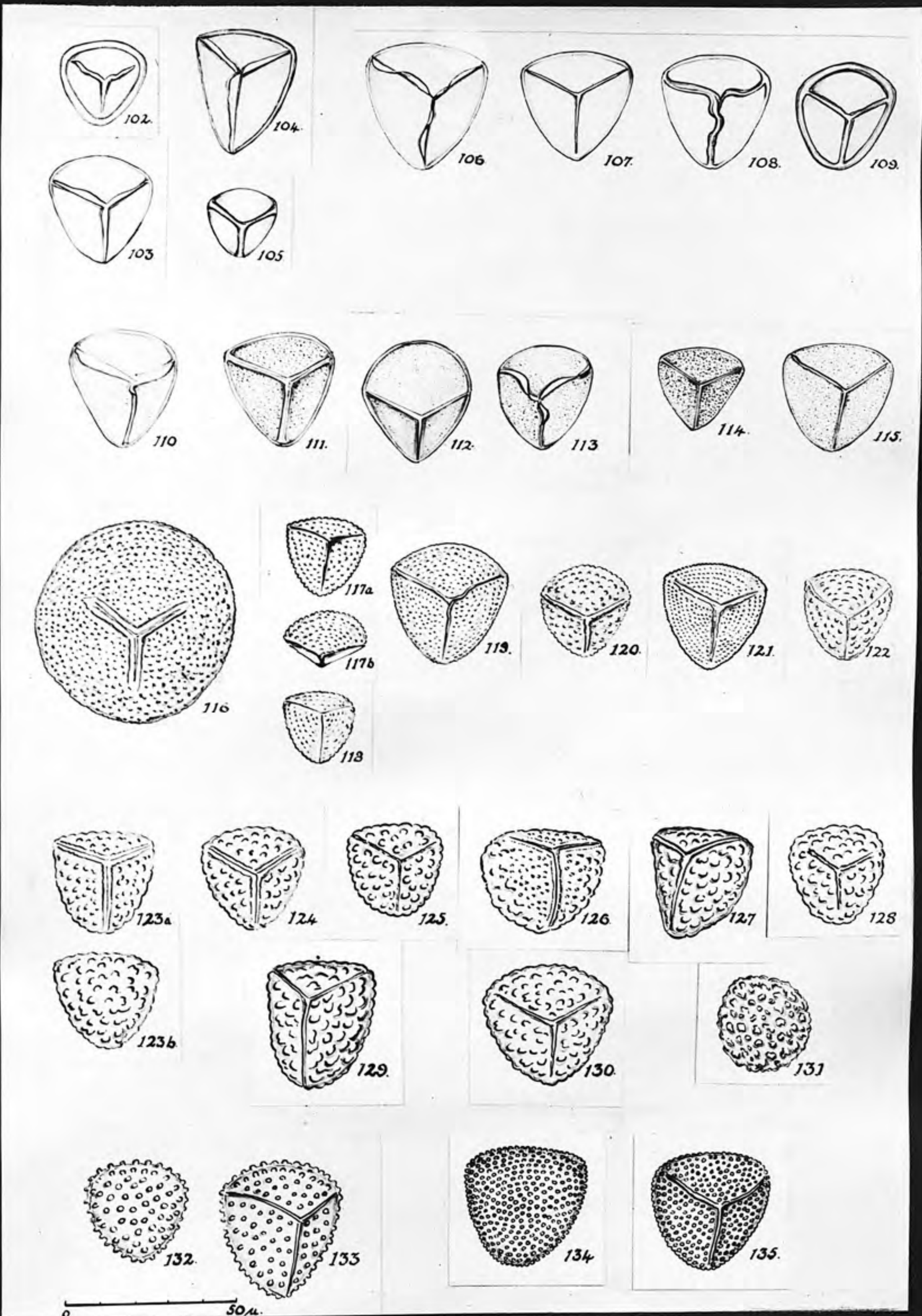


90a
90b
91a
91b.
92a
92b
93.
94.
95
96a
96b
97a
97b
98a
99a
100a
101a.
98b
99b
100b
101b.
0.
50μ.

PLATE VI.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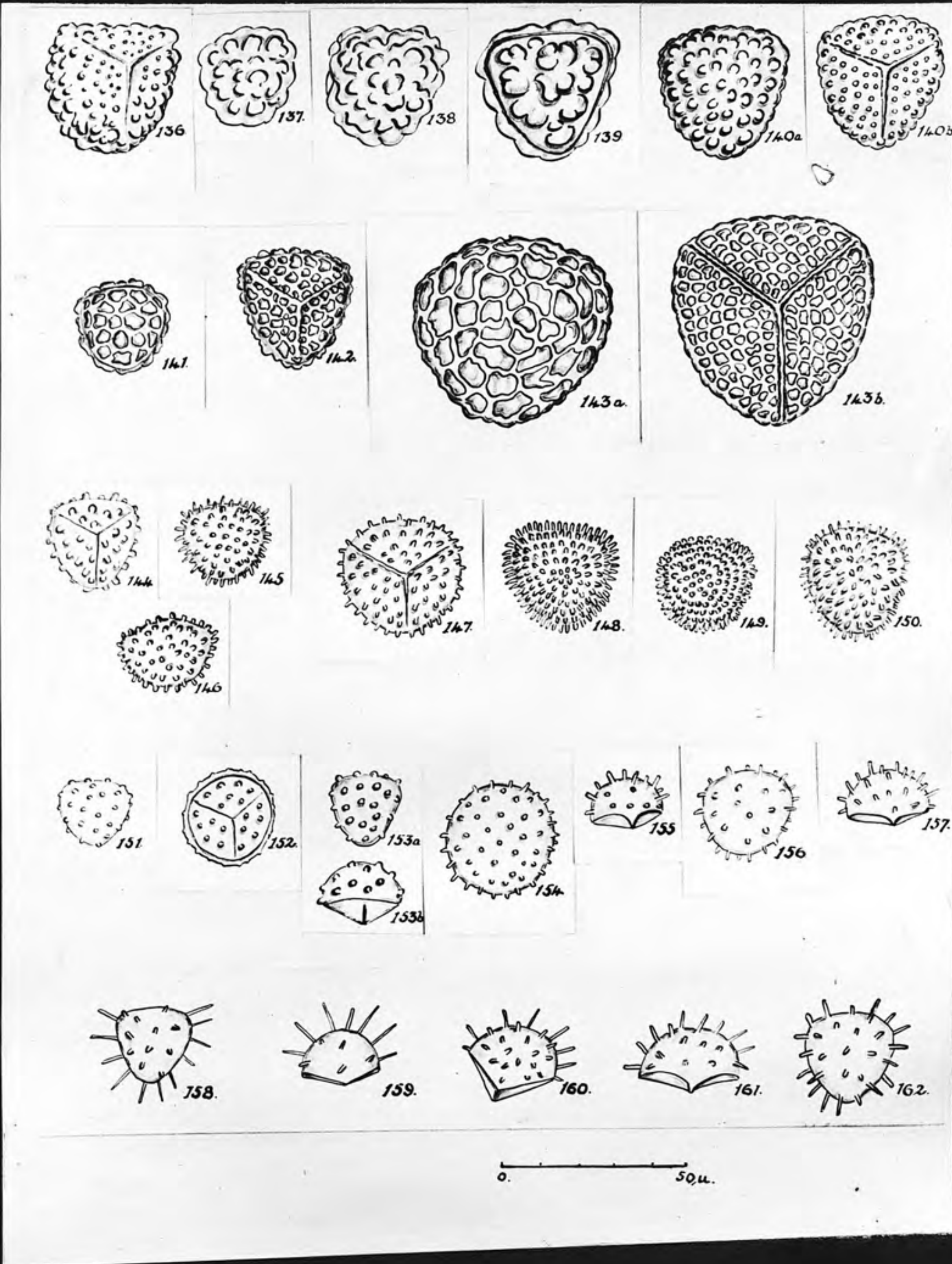
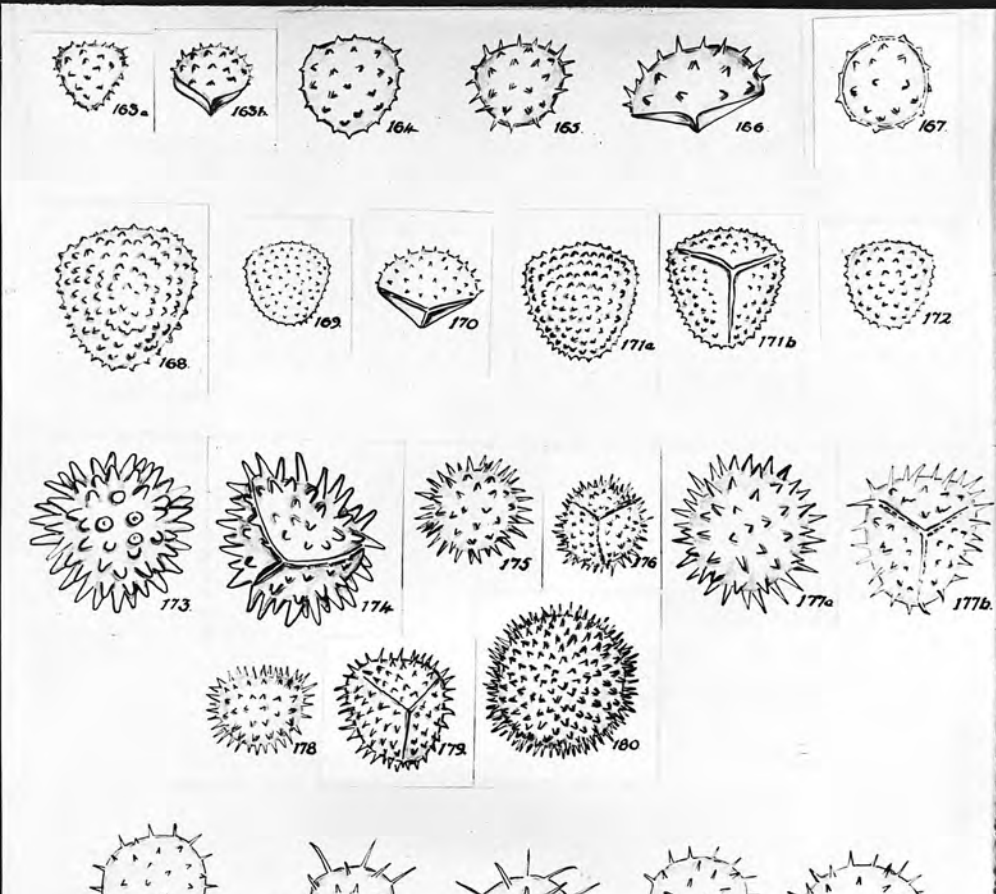
119.
120.
121.
122
123a
124
125.
126.
127
128
123b
129.
130.
131
132.
133
134
135.
0
50μ.

PLATE VII.



136
137
138
139
140a
140b
141
142
143a
143b
144
145
146
147
148
149
150
151
152
153a
153b
154
155
156
157
158
159
160
161
162
0.
50μ.

PLATE VIII.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171a
171b
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173
174
175
176
177a
177b
178
179
180
181
182
183
184
185
186a
186b
187
188
189
0
50μ.

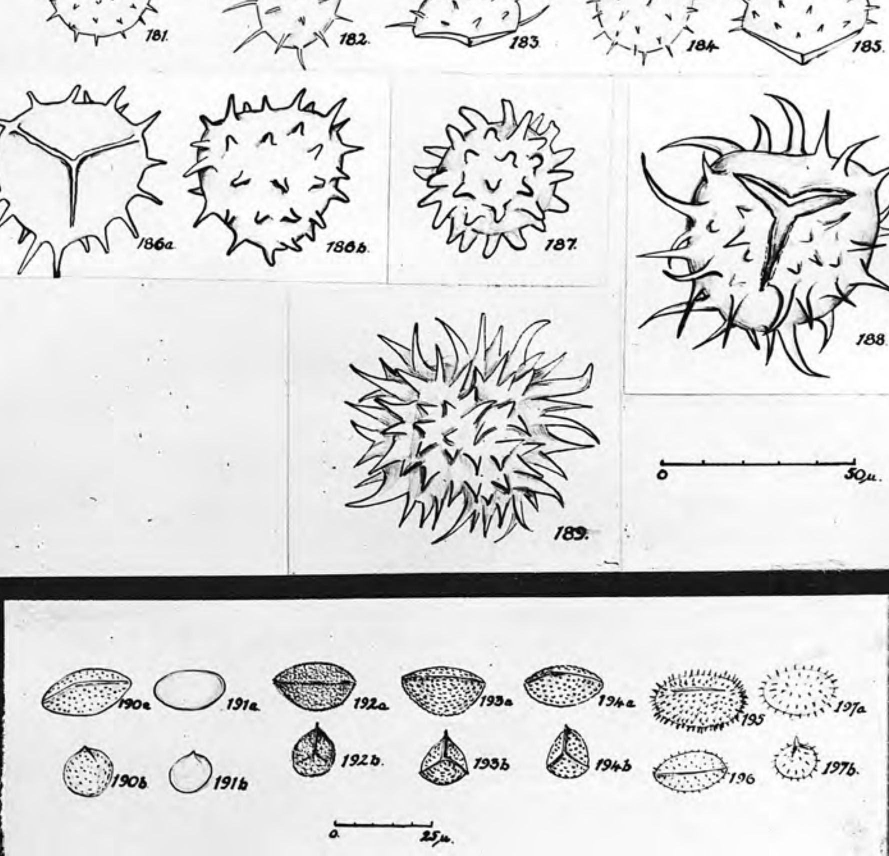
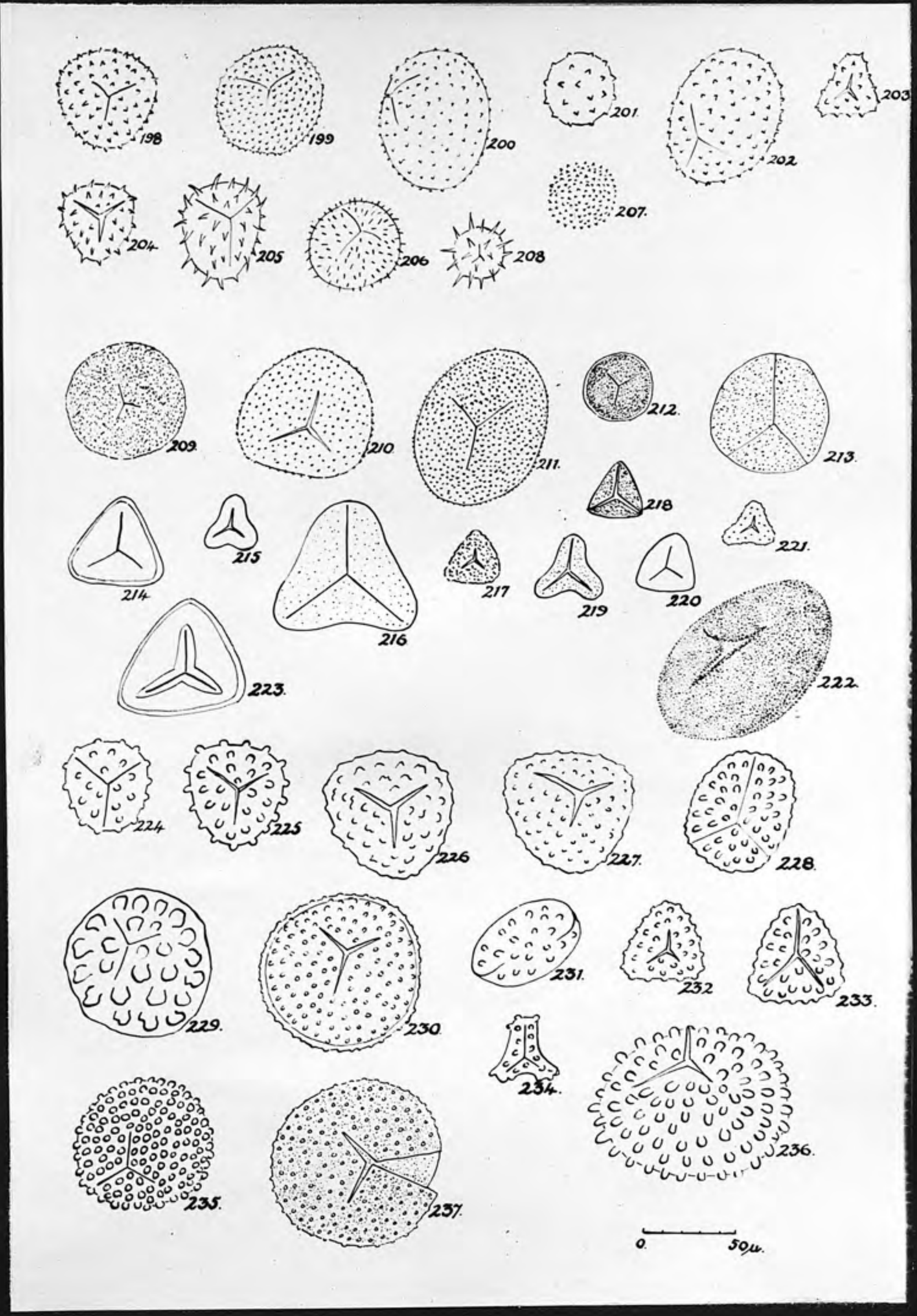

190a
191a
192a
193a
194a
195
197a
190b
191b
192b
193b
194b
196
197b
0
25μ.

PLATE IX.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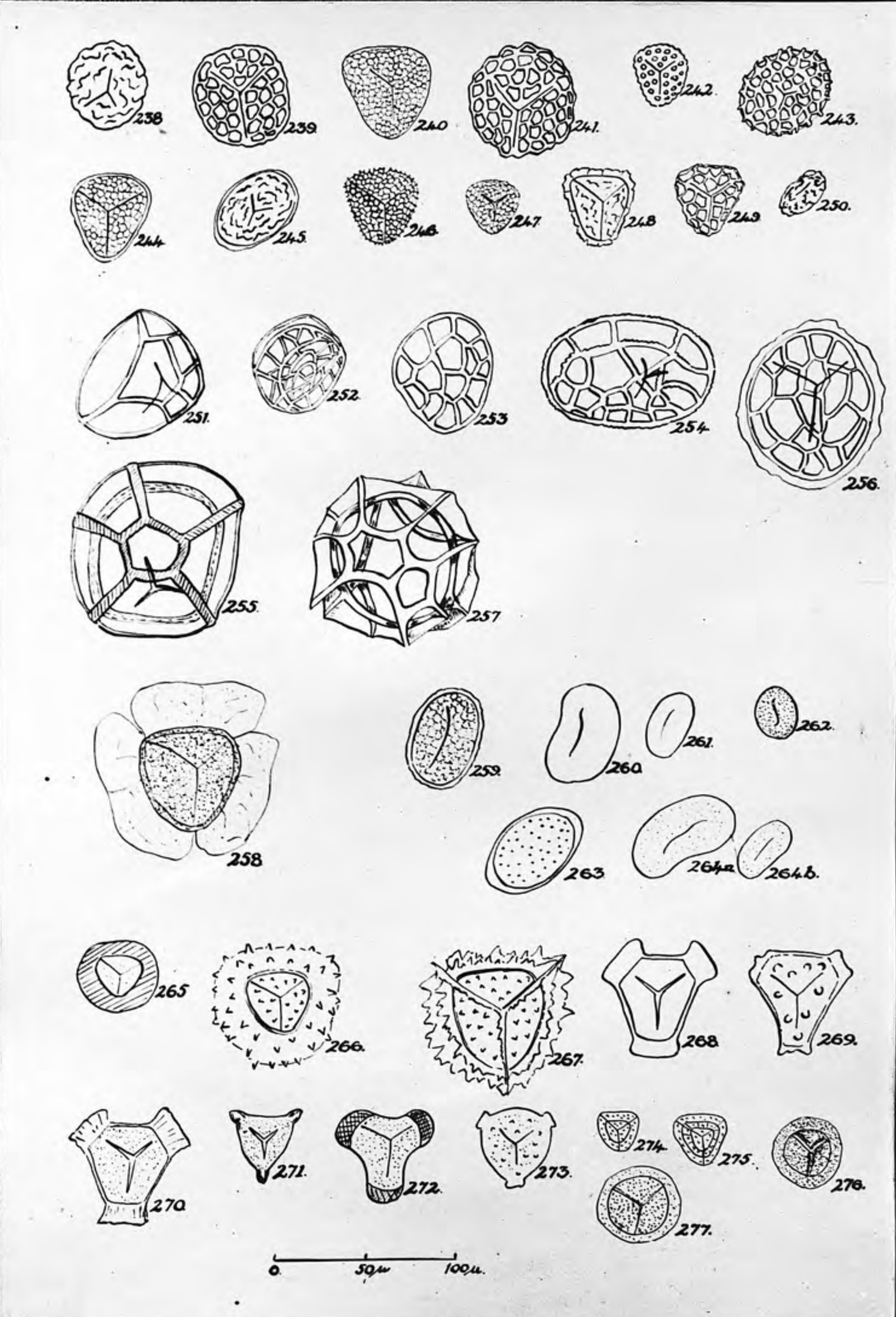
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
0
50μ.

PLATE X.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244
245
246
247
248
249
250
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252
253
254
255
256
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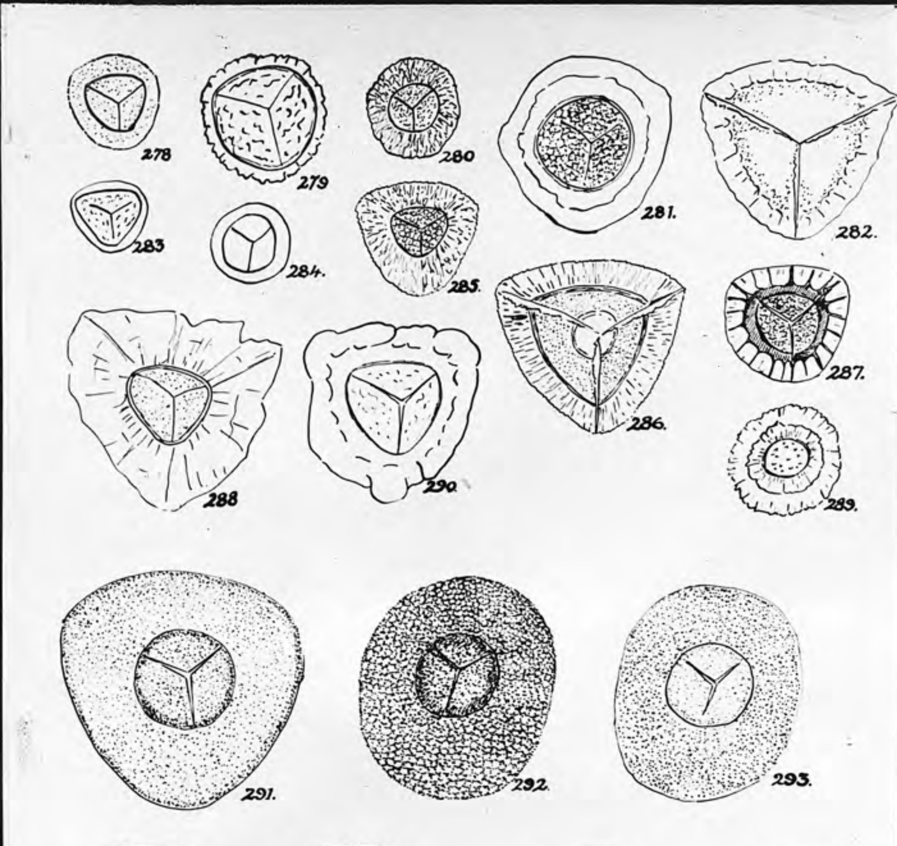
259
260
261
262
263
264a
264b
265
266
267
268
269
270
271
272
273
274
275
276
277
0
50µ
100µ

PLATE XI.



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279
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281.
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284.
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291.
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295.
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297.
298
299.
300.
301.
302.
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304
305
306.
0.
50μ