The observations embodied in the following thesis are entirely my own except in so far as indicated. Even when the work of other authors has been quoted, in many instances their observations have been confirmed separately; but in all cases full references are given where such work has been used.

The investigation has advanced knowledge in the following respects:-

(I) Fossil plants have been collected from Bagshot Beds of known locality and restricted horizon, and a particular technique has been applied in the examination of epidermal characters, resulting in the establishment of a number of definite types of structure.

(2) The Value of such epidermal features has been criticised by reference to similar characters among genera of living plants, and the conclusion has been reached that the features selected by many authors as diagnostic are of little taxonomic value. Thus, the names of many of the genera and species previously based on these characters should probably be regarded as nomina nuda.

A Study of a Collection of

FOSSIL PLANTS

from

the Lower Bagshot Pipe-Clay

of

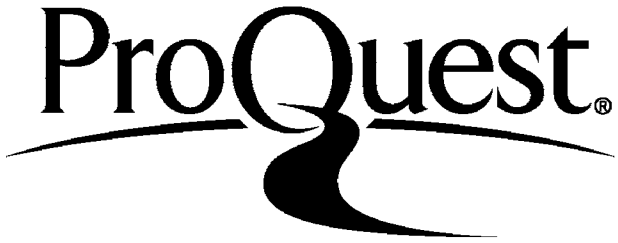
Poole District, Dorset.

with

A Critical Examination of the Value of the Epidermis

in the

Determination of Angiospermous Plants.



C O N T E N T S.

INTRODUCTION.

In a study of the records of J. S. Gardner (26), (27), (28), (29) and others, it is evident that the Hampshire Basin has yielded a quantity and variety of plants of Lower Bagshot age. The fossil flora, named from leaf-form and venation only, is generally described as indicating a sub-tropical climate, and is compared (by Gardner) with plants now living in parts of sub-tropical Australia.

A few localities, such as Studland and Corfe Castle, in the Dorset part of the Hampshire Basin, are recorded as having an especially luxuriant flora, and it was in order to apply modern technique to some of these plant remains that the research was commenced.

The first part of this paper, therefore, gives an account of the collecting of fossil material from the area around these two centres and of the extension of collecting to all the Pipe-Clay region in the immediate neighbourhood of Poole Harbour.

The method, commonly in use at the present day for the naming of plants of Tertiary age, consisting in combining the external plant characters of form and venation with the microscopic epidermal characters, is tried and found to give no satisfactory results. The criticism of

this method forms the subject matter of the second part of the paper.

The DISTRICT INVESTIGATED for FOSSIL MATERIAL.

The district providing the fossil material for this paper is in the extreme S.E. of Dorset, and may be described as occurring within the following boundary lines. (See Map preceding the Plates.)

Northern boundary line: New Town (N. of Constitution Hill) on the E. to Hamworthy on the W.

Western boundary line: Wareham on the N. to N. Purbeck Ridge on the S.

Southern boundary line: the base of the N. slopes of the N. Purbeck Ridge.

Eastern boundary line: the Studland and W. Sandbanks coast-line on the S. to Parkstone on the N.

This area is approximately 49 sq. miles, but about 20 sq. miles in the centre is occupied by Poole Harbour.

The centres examined 1923-1927 are the following, the localities marked thus x indicating good collecting ground.

			Map Ref. Number.
N.E. of area:	near Parkstone	x S. W. Pottery.	(1)
	S. of Parkstone.	Blake Hill Pottery (dis-used many years before 1923).	(2)
	N. of Parkstone.	x Kinson Pottery.	(3)

			Map Ref. Number.
E. of area:	Branksea island.	S. of Lincoln Cliff.	(4)
		on S.W. shore. (disused many years before 1923).	
S.E. of area:	on Newton Heath.	Newton Clay Works (disused before 1923).	(5)
			(6)
		3 old Clay Pits slightly W. of long. 1°59' W lat. 50°39' N (disused many years before 1923).	(7) (8)
	on Godlingston Heath.	2 old Clay Pits	
		½ mile W. of Agglestone Rock.	(9)
		¼ mile N.W. of Agglestone Rock.	(10)
		(disused many years before 1923).	

The centres examined 1925-1927 are the following:-

S.W. of area:	¼ mile N. of Corfe Castle	x Arfleet Clay Works (called "Norden Clay Works" in 6" Ord. Survey of 1902).	(11)

S.W. of area: (cont'd).		Map Ref. Number.
1-2½ miles W.N.W. of Corfe Castle	Tip-heaps of 6 Old Clay Pits of Creech Heath. (disused many years before 1925).	(12) (13) (14) (15) (16) (17)
3 miles W. of Corfe Castle	x Creech Heath Clay Pit.	(18)

(A detailed account of the 4 plant-productive pits (1), (3), (11), (18) can be found on pages 12 - 16).

Centres mentioned by others are the following:-

(a) Studland mentioned by W. B. Clarke[16] (1839)
G. Maw[40] (1868)
J. C. Mansell-Pleydell[48] (1870 and 1895)
J. S. Gardner & C. B. Ettingshausen[28] (1879 - 1882)
O. White[59] (1917)

(b) Bournemouth-Parkstone railway cuttings: J. S. Gardner[26] (1877)

(c) Newbury Pits: R. P. Brodie[26] (1879-82).

The KIND and COMPARATIVE QUANTITY of the MATERIAL COLLECTED.

The material collected from this locality is of 5 different kinds:-
(a) carbonized, (b) pyritized, (c) ferruginous, (d) epidermal, with or without external plant form, and (e) wood splinters. All, except perhaps (c) and some of (b), have a plant origin.

Other collectors from 1839 to 1882 have found "bark and seed vessels of pine", "hymenopterous and coleopterous insects" and "insect wing-cases and shells".

Taking the area as a whole, fossil epidermis, being very fragmentary, is the most abundant in quantity; far less abundant is the pyritized material which slightly exceeds in quantity carbonized remains. Ferruginous forms and the wood splinters are rare and have been found only in one locality.

The GEOLOGICAL AGE of the Fossil-Bearing Beds.

The fossil material has been collected from the clay of the locality.

This clay occurs between London Clay (on the south) and Bracklesham Beds (on the north), on the southern rim of the Hampshire Basin, and the direction of its bedding-planes, seen best in coastal sections, accords with both these formations.

Hence the clay may be regarded as of Eocene age and as a representative of the Bagshot Beds. It has been called by J. S. Gardner (26),(28),(29) "The Lower Bagshot" horizon and by the Survey (59) "The Lower or Pipe-Clay Division" of the Bagshot Beds.

The fossil material collected by Dr. H. Bandulska,(3) on the other hand, is from "The Bournemouth Freshwater Series" of Gardner's classification, or "The Upper Division or Bournemouth Freshwater Beds" of the Survey, a higher horizon than that mentioned in the previous paragraph.

Osborne White (59) in his memoir of the "Geology of the Country around Bournemouth" (1917), draws a distinction between the Lower, or Pipe-Clay Division and the Upper, or

Freshwater Beds, mentioning Gardner's separation of the two divisions based on "dissimilarity of their fossil floras."

The GENERAL DISPOSITION and THICKNESS of the Fossil-Bearing Beds.

The beds of the Pipe-Clay Division have a general, very slight dip northwards, and outcrop at the surface over the greater part of the selected district. (For the district boundaries, see page 3).

The clay is thick and particularly pure in the southern part of the area around Creech; here there is a cliff-face of comparatively pure clay approximately 30 feet in height, and there is extensive mining immediately below this face. Passing northwards to the northern boundary of the district, the clay is reduced in many parts to beds of 10 ft., or even less, in thickness, occurring as lenticular seams in massive beds of sand.

The CLAY MATRIX peculiar to each type of fossil.

The clay in which the carbonized material, (a), (see page 6) occurs is brown to black, highly laminated approaching the nature of a shale, and usually contains much black, fragmentary, organic material which crumbles in collecting.

The clay containing the pyritized material, (b),

is pale to dark brown, sometimes greenish-grey, rather sandy in character and not well laminated. Specimens have also been collected with (a) in a matrix of the nature described above.

The ferruginous material, (c), is found in clay which varies from pure white to shades of yellow and red, or it may be white mottled with yellow and red. This clay is remarkably pure and, in the wet condition, very plastic. Recently, (1926), specimens have also been found together with (a) in a clay resembling the kind which yielded the material (a).

The clay yielding epidermal material, (d), is pale brown to pale yellow in colour, sandy in character and well laminated where the best external leaf forms occur. It is on levering up these lamellæ that fragments of epidermis are often found with, perhaps, a very faint indication of leaf or stem-like form.

Fragmentary epidermis showing no external plant form comes from a less sandy clay which is only fairly well laminated.

Other writers describe the beds from which they obtained epidermis as follows:-

1). Louis H. Ruegg (50) (1854) tabulates a cliff section "near

Corfe Castle and Creech" which contains fossil leaves. The embedding material he describes as a grey or yellow sandy clay. The section is as follows, the beds being arranged in descending order of age.

	Feet.
Bed of lignite:	10
Grey clay with carbonised leaves:	2
Yellow sandy clay with leaves:	2
Ferruginous sand:	few inches
White sand:	30
Pipe Clay:	11 - 14

2). J. S. Gardner (26) (1877) emphasizes the importance of examining clays which are dark brown in colour, though black clays containing completely carbonized plant remains may, in rare cases, be of some value if leaf-form remains. Deep violet clay may also yield occasional fragments "of reed-like aspect."

3). J. C. Mansel-Pleydell (48) (1895) describes the embedding clay as a dark variety, and figures a section in the neighbourhood of Poole Harbour where the dark plant-containing band rests on and is overlain by light clays. Interbedded with the dark clay are bands of sand, 4 ft. in thickness.

4). Osborne White (59) (1917) states that "casts of detached

leaves of sub-tropical plants" of Lower Bagshot age are found in the Pipe-Clay which is white, palest grey to dark blue grey, or in the ruddy, mottled variety. The writer refers particularly to Studland and to the Corfe district.

Other writers have mentioned the leaf-bearing beds of this area as "Pipe-Clay," without further detail. These are:-

H. Dobell (20) (1886)

H. B. Woodward (62) (1887)

Jukes-Browne (10) (1911)

W. T. Ord (44) (1914), who states incorrectly that the clay around Corfe is now worked out.

The woody material, (e), occurs in beds similar to those described as yielding the fragmentary epidermis.

A DETAILED ACCOUNT of the 4 CLAY-PITS which YIELDED FOSSIL MATERIAL.

South Western Pottery. (Map Reference Number (1), see pages 3 and 5).

This pit covers an area of approximately 300 yds. square. The beds have a slight dip northwards, and in the south of the pit are mainly composed of comparatively pure clays, 30 ft. or more in thickness, which are inter-bedded near the ground surface with an impure, brown clay of about 2 ft. in thickness containing plant remains. In the centre of the pit, the same brown clay occurs at about the same distance below the ground surface. In the intervening area, however, this brown clay has not been found, the sequence from the surface downwards containing only whitish clay. Borings in the neighbouring fields show the same brown clay to the S. E. of the centre of the pit, and it is apparent that this plant-containing bed encircles a large, comparatively pure clay area of about 100 yds. square. It is also clear that this circle of brown clay dips in a N. E.ly direction, and that it rests on and is overlain by comparatively pure clays.

The collecting ground in this pit has been (1923 - 1926) principally a tip-heap which has accumulated from

sections made in the S. W. part of the brown, clay circle mentioned in the previous paragraph. This has yielded all but the ferruginous material. The epidermis has been very abundant, but very fragmentary, with no indication of the original plant organ. This tip-heap was cleared of fossil material in 1926.

Secondary in importance as a collecting ground are tip-heaps near the centre of the pit; these consist of comparatively pure clays and contain the ferruginous remains.

Recently (1926) the Pottery has opened pits to the south. The brown, plant-bearing bed here exposed in section has so far (September 1927) very sparsely yielded fragmentary epidermis and very much broken ferruginous forms.

Kinson Pottery. (Map Reference Number (3), see pages 3 and 5).

Most of this area (about 300 yds. square) consists of either pure sands or pure clays, hence only a limited part has been worth searching for plant remains.

The plant-containing clays are brown in colour and occur in sections near the southern side of the Ringwood Road. Fragmentary epidermis (with no indication of the original plant organ), pyritised remains and small fragments of carbonized material have been found here. Tip-heaps have yielded fragments of epidermis attached to stem-like forms.

Arfleet Clay Works. (Map Reference Number (11), see pages 4 and 5).

The open clay pit is approximately 100 yds. square, and presents some interesting problems connected with structure and deposition. The following facts bear this out.

i) The dip of the beds seen in working sections, and evident from borings, is extremely slightly northwards, although the beds are but about 300 yds. north of the nearly vertical Chalk.

ii) The most important cliff section now (1927) being worked for clay passes down from sands at ground level, through reddish-clay to creamy clay, underneath which is a hard carbonaceous layer. The beds in descending order are thus:-

	Thickness in ft.
Sands:	18 - 20
Reddish-clay:	2 - 3
Creamy-clay:	6 - 12
Carbonaceous layer:	at least 2

The carbonaceous layer is glossy black and very compact. Attempts have been made to use it as a fuel, but these have proved unsuccessful. No plant remains have been obtained from this part of the pit during the years 1923-1927, indeed prior

to 1923 the pit is said to have been unproductive of fossil remains.

Due N. of this pit, for a distance of about 4 miles, borings reveal only massive sands, no clay and no carbonaceous layer being found. Still further N. (near the southern shores of Poole Harbour), borings show that a very similar (if not identical) sequence of reddish-clay, creamy clay and carbonaceous material occurs again, but in the reverse order. Many years ago this area is said to have yielded fossil leaves with outline and venation similar to Aralia, Fig, Palm, etc., also "pins" which appear to have been pyritic cylinders similar to those described on page 19 . These fossil remains are stated to have been very abundant at that time, but rarely collected. The particularly fossiliferous bed was a clay which occurred in layers 18 in. to 2 ft. thick in massive sands.

iii) The sequence detailed in (ii) above as occurring in the pit and now worked is found, from borings, to occupy a V-shaped tract of land. The "V" is ¼ mile due N. of the gap between East Hill and Corfe Castle in the N. Purbeck Ridge. Through the gap flows the River Byle northwards to Poole Harbour. The apex of the "V" points north, away from the gap; the arms of the "V", measured along the ground surface, are each roughly 100 yds. long.

The fossil material from this pit has been collected (1925 - 1927) from tip-heaps which skirt ponds (the excavating areas of about 50 years ago), north of and near the Swanage Road. These yield fragments of epidermis and abundant pyritic remains. Leaves, showing external form, but no epidermis, have also been found embedded in a non-laminated calcareous clay.

Creech Heath Clay Pit. (Map Reference Number (18), see page 5).

This pit is the most extensive in the whole area, and, where now (1927) worked, contains the thickest and purest beds of clay (see page 8). Consequently, plant-bearing beds are very few. On the rails leading to tip-heaps, however, blocks of rather sandy and well-laminated clay, especially rich in fossil-leaves have been found (1926); these leaves show good outlines and venation, but the epidermis is always too fragmentary for experimental purposes. The exact locality of this leaf-bearing bed in the pit has been impossible to find. On further examination of the ground in 1927, neither the tracks leading to tip-heaps nor the tip-heaps yielded leaf-material; only pyritic remains could be found, and these in a much broken condition.

A MACROSCOPIC DESCRIPTION of the MATERIAL. (See page 6.)

(a) Carbonized material.

The largest fossil, specimen A, suggests a stem or root, from which 2 branches are arising at marked nodes. The length of the fairly straight main axis is 12 cms.; its cross section is elliptical, the long axis of the section measuring approximately 8 cms. and the short axis 5 cms.. The elliptical cross section of each branch gives measurements of $5\frac{1}{2}$ cms. for the long axis and approximately $1\frac{1}{2}$ cms. for the short axis. These branches are situated on the same whorl 5 cms. apart.

The whole organ, A, appears to be flattened at right angles to the long axis of its cross section, causing one of the branches to be closely adpressed to the stem.

The specimen is practically solid and is glossy black with a fairly uneven surface. Either end shows a once hollow core, now filled in with pyritic substance, which probably corresponds to the pith. The cross section of the carbonized substance surrounding the "pith" shows lines radiating from the centre of the core; these lines closely resemble medullary rays on cross sections of weathered logs of wood. Pyritic substance, in addition to filling in the core, occurs in crevices on all parts of the organ.

Specimen B, the second largest of the carbonized specimens, suggests the interior of a root or stem which has been subjected to lateral pressure. The straight main axis is 18 cms. long; its cross section is elliptical, the long axis measuring on an average 5 cms. and the shorter axis 2½ cms.. Near one end of the main axis there is an indication of branching.

The specimen is solid. It is glossy black with a surface that varies from uneven to markedly ridged; the ridges are fine and narrow and traverse the whole length of the specimen. Longitudinal and transverse cracks are also marked. The surface of either end, like Specimen A, shows lines radiating out from the centre of the ellipse, but there is no hollow indicative of a rotted pith. Crevices in the specimen are filled in with pyritic substance.

Other specimens, resembling flakes of A or B (mentioned just previous to this paragraph), have been largely collected.

In order to preserve this carbonized material, specimens must be kept under water. The purity of the water is maintained by the admission of "carbon" balls (naphthaline).

(b) Pyritized material.

This consists of numerous complete or incomplete cylindrical specimens, varying in size from 3½ cms. long with cross section 4 mm., to minute forms. Sometimes 2 cylinders are found fixed to each other along their lengths. Fine splinters are also numerous. In the material so far collected, there is no suggestion of branching, and, until sections are cut, only a few, from surface markings, can be recognized as plant remains.

The specimens vary from completely solid to obviously hollow. The colour is generally grey, in places showing brassy-yellow lustre, and the surface is rough to the touch. Some specimens have marked external longitudinal ridges, others marked knots, whilst others, again, have plane surfaces, or one specimen may combine all 3 of the above mentioned characters.

This pyritized material is very friable and should be collected in the field into water-containing vessels. If left in the air, rapid decomposition takes place, leaving a fine yellow powdery mass.

(c) Ferruginous material.

This material consists of curious spiral bodies of doubtful origin. Forms similar to them, but on a much

larger scale, are recorded by C. C. O'Harra[42] as occurring in the Harrison beds of the Black Hills Region, U.S.A. in the Arikaree formation of the Miocene period, and are known as Daemonelix or Devil's Corkscrews. Their origin is much disputed. E. H. Barbour[42] suggests a plant origin for these, as many show an abundance of "vegetable cells in the peripheral portion"; others "have considered them as casts of well preserved burrows of animals". No mention seems to be made of their chemical composition.

The forms found in the Pipe-Clay appear to have no internal cellular structure, are very brittle, and, according to the Pottery authorities, are highly ferruginous. They are very rare and usually occur in a fragmentary condition.

The following description is of the most complete specimen.

The form is that of a tapering spiral, the coils of which are separated. The height of the spiral is approximately 6 cms., the diameter across the larger end 6 cms., and across the smaller tapering end 4 cms.. The coil is solid and elliptical in cross section, with diameters of 1½ cms. and 1¼ cms.. At the tapering end of the spiral, the coil ends abruptly as if broken; at the other end of the spiral, the coil expands to a flattened structure which

eventually bifurcates. This flattened structure stretches 4 cms. beyond the limits of the spiral.

Externally the coils are pale reddish-brown in colour, but cross sections show that this colour is only peripheral, the interior part of the coil being a much darker brown. The surface is very rough and often gnarled.

This ferruginous material requires no special precautions for its preservation.

(d) Epidermal material (with or without external plant form).

The epidermis is the most usual type of plant remains found in the area, but it occurs only rarely with complete leaf or stem-like outlines. Its most usual occurrence is in small fragments disseminated in the clay. It is recognised by its leathery texture, black to brown colour and by the fact that, on drying the clay, it readily flakes off from the embedding material.

To preserve the cuticular remains it is found best to keep the clay very damp.

It is this "cohesive film consisting of the mummified cuticle" of a plant, together with leaf-outline and venation, that Dr. H. Bandulska[3] has considered so important in the determination of fossil plants found on the horizon

above the one I have investigated. Certainly in one locality I have found some good leaf-outlines with fragmentary epidermis attached, but so very fragmentary that it has been of no value experimentally. Thus I have not yet been able to combine cuticular examination with external leaf form and venation in the fossil material as Dr. H. Bandulska[3] has been able to do.

Since the epidermis collected from the Pipe-Clay is generally isolated from its particular plant organ, I have been uncertain, not only as to the kind of plant to which it belongs, but also to the particular epidermal-bearing part of the plant. It is this vagueness of field that has led me to a close examination of the epidermis of modern plants, and to an enquiry into the value of the epidermis in plant diagnoses.

(e) Woody material.

Only one minute splinter has so far been found. It was indistinguishable from epidermis in the field and recognised as different from the epidermis only under the microscope.

FOSSIL MATERIAL FOUND by OTHER WRITERS.

1). "Particles of wood, bark and seed vessels of a species of pine."

W. B. Clarke[16] (1839) mentions "particles of wood, bark and seed vessels of a species of pine" as occurring in the Studland shore cliffs. He states that the particles of wood are "extremely minute, and seem to be the relics of some aquatic plant or Juncus." The bark and seed vessels are also described by him as so preserved that it is generally "impossible to detect a portion sufficiently large to discover to what it actually belonged."

2). "Hymenopterous and coleopterous insects."

Louis H. Ruegg[50] (1854), describing plant-bearing beds "near Corfe Castle and Creech", includes fossil remains of "hymenopterous and coleopterous insects" in the Pipe-Clay.

3). "Insect wing-cases and shells."

J. S. Gardner and C. B. Ettingshausen[28] (1879-82) state that "insect wing-cases and shells" occur with fossil plants at Studland.

The TREATMENT NECESSARY for the MICROSCOPIC INVESTIGATION of the FOSSIL MATERIAL.

In order to try and identify these various kinds of fossil material, it was necessary to make sections for microscopic investigation. The following pages describe this preparative work with the attempts at determining the material.

(a) Carbonized material. (See pages 17 and 18.)

These fossils have been found too hard for ordinary razor-sectioning and too soft for the normal rock-cutting method.

Another method was suggested which has proved very successful in the case of hard timbers, namely softening by means of cellulose acetate. The results were found satisfactory. Sections of the lignite type of wood could be made with a razor, except where pyritized or stony particles occurred.

This carbonized material has been examined by Mr. L. A. Boodle of Royal Botanic Gardens, Kew. He suggests that coniferous wood is represented, probably that of Juniperus or Cupressus, and adds that "it appears not to

be a Pine, Spruce, Larch or Yew, but might possibly be Podocarpus or belong to some other genus with wood very similar to that of Juniper."

(b) Pyritized material. (See page 19.)

These remains have so far proved too friable for treatment, but it is hoped that some method may be devised for their identification.

(c) Ferruginous material. (See pages 19-21.)

These forms have not yet been sectioned and their identification is extremely difficult.

(d) Epidermal material. (See pages 21 and 22.)

In the treatment of the fossil epidermis a good method for a) clearing, and b) permanent, dark staining had to be found in order to make microscopic measurements and photographs.

a) For clearing the fossil epidermis from its embedding material and attached, decomposed, underlying tissue, the method employed by Dr. H. Hamshaw Thomas (58) has been adopted.

Either the clay (as small a quantity as possible) containing a fragment of epidermis, or a lifted off fragment of epidermis is placed in a vessel (petri-dish) and enough concentrated nitric acid poured into the dish to

cover the contents. A small quantity of potassium chlorate is then sprinkled on the material and the first fumes allowed to escape before covering the vessel. This is left in a cool place for 2-3 days. At the end of that time it has usually been found that the epidermis has separated from its embedding clay and attached tissue and is floating on the surface of the liquid. It can then be lifted off, well washed and rendered almost clear of adherent particles by very gentle brushing of its surface under water. Only tough epidermis may be safely washed under very dilute nitric acid.

b) For staining the fossil epidermis, either safranin in alcohol or bismarck brown in water was used; either stain was followed by absolute alcohol in order to dehydrate the material; clove oil was used for clearing purposes, and canada balsam for mounting. Neither stain gave a good result, however, as the epidermal walls and stomata were poorly differentiated from the rest of the tissue and photographs were valueless in showing up the features of the several types of epidermis obtained. Dr. H. Bandulska's[3] treatment with water stains followed by glycerine and glycerine jelly also were not found successful. In substituting origanum oil for clove oil, however, more favourable results in spirit staining seemed to be forthcoming.

By immersing the epidermis in a mordant (picric acid) before staining, it has now been found that a more or less permanent dark stain can be obtained which clearly marks out cell-walls, stomata, etc. Thus it has become easy in fossil epidermis to differentiate cells by staining, and so to investigate by measurements the types of epidermis found in the Pipe-Clay Division.

The following is a summary of the order of procedure and average time taken to pass through the treatment with reagents used. It is found that the more frail the tissue, the longer is the time required for it to remain in the stain to produce a depth of colour in the tissue. The times here given are for epidermis of moderate resistance.

Picric acid ... 10-15 mins.

Method I.	Method II.
Bismarck brown in water .. 1-3 days.	Safranin in alcohol .. ½-2 hrs.
Absolute alcohol .. few minutes.	Absolute alcohol .. few minutes.
Origanum oil .. few minutes.	Origanum oil .. few minutes.
Canada balsam	Canada balsam.

Method II., being the quicker, has been the one generally adopted.

As a result of the successful staining, it has been possible to differentiate 16 types of epidermis. The tabulated observations and the illustrative photomicrographs set forth in the following pages (pages 29-53 and plates I-IV) enable quick comparisons between the types to be made in every detail.

Identification of the material, in spite of the possibilities of detailed surface investigations, has been impossible.

In the case of each type, the measurements given on the following pages (29 - 53) are based on the specimen figured.

Types of Epidermis.

TYPE A (11 specimens found).

(Plate I , figure 1).

			Length	Breadth	Opening breadth	
External Glands:	Number:	2.	.048	.042	.024	mm..

Place: Between vein.

Hairs represented by hair-bases.

Number: Fairly numerous. In 4.8 sq. mm. average no. 3.

Place: On veins, and set irregularly.

Distance apart: Varied; common measurements are .24 mm., .12 mm., .08 mm..

Ordinary epidermal cells:

Shape: Oblong, but elongated on veins.

Size: Cells between veins are .036 mm. long and .012 mm. wide usually, with little variation.

Outline of Wall: Sinuate, in centre of vein straight.

mm.
.012 length of wave.

.003)
) height of wave.
.006)

Thickness of Wall: Slight.

Striations on Surface Wall: Parallel to length of leaf.
(not on cells above veins).

Stomata:

	Length	Breadth	Pore breadth
	mm.	mm.	mm.
No. 1)	.03	.024	.006 +
" 2)	.024	.018	.006
" 3)	.033	.021	.006
" 4)	.024	.015	.006
" 5)	.024	.018	.006 +
" 6)	.036	.024	.006
" 7)	.018	.012	.006
" 8)	.018 -	.012	.006
" 9)	.036	.018	.006
" 10)	.024	.018	.006

Number: In 4.8 sq. mm. average no. 11.

Place: Irregular on surface and irregular orientation with regard to each other.

Depth: Level with surface.

Subsidiary Cells:

Number: 2.

Place: One on either side of stoma, parallel to length of stoma.

Size: Breadth of single subsidiary cell .009, .006, .003 mm..

TYPE B (1 specimen found).

(Plate I , figure 2).

External Glands:

Number: ? Absent. 1 Hole.

Hairs represented by hair-bases which are much thickened.

Number: Sparse. In 4.8 sq. mm. average no. 1.

Place: On veins, and set irregularly.

Distance apart: Varied; common measurements are .36, .24, .048 mm.:

Thickened areas are extensively developed from hair-bases.

Ordinary epidermal cells:

Shape: Oblong to rounded, but rectangular on veins.

Size: Cells between veins are .036 mm. long and .012 mm. wide usually, with little variation.

Outline of Wall: Sinuate to non-sinuate. Centre of vein straight.

mm.
.012)
) length of wave.
.018)

.003 height of wave.

Thickness of Wall: Slight.

Stomata:

	Length mm	Breadth mm	Pore breadth mm
No. 1)	.024 +	.024 -	closed
" 2)	.024	.018	.003
" 3)	.024	.021	closed
" 4)	.021	.018	closed
" 5)	.036	.024	closed
" 6)	.024	.024	closed
" 7)	.027	.018	closed

Number: In 4.8 sq. mm. average no. 9.

Place: Very irregular on surface, and irregular orientation with regard to each other.

Depth: Level with surface.

Subsidiary cells:

Number: 2. Sometimes absent.

Place: One on either side of stoma, parallel to length of stoma.

Size: Breadth of single subsidiary cell .012 mm..

TYPE C (only specimen found).

(Plate I , figure 3).

External Glands:

Absent.

Hairs:

Absent.

Ordinary epidermal cells:

Shape: Rounded, but rectangular on vein.

Size: Diameter .012 mm..

Outline of Wall: Very slightly sinuate; in centre of vein straight.

mm.	
.003	length of wave.
.003	height of wave.

Thickness of Walls: Slight.

Stomata:

Absent.

TYPE D (2 specimens found).

(Plate I , figure 4).

External Glands:

Number: 1.

Hairs represented by hair-bases.

Number: Sparse. In 4.8 sq. mm. average no. 2.

Place: On veins, and set irregularly.

Distance apart: Varied; common measurements are .48, .24, .12 mm..

Ordinary epidermal cells:

Shape: Oblong to rounded, but very rectangular on veins.

Size: Oblong cell (.048 mm. long.
(.018 mm. wide.

Rounded cell diameter .024 mm..

Outline of Wall: Sinuate; on vein straight.

mm.	
.012	length of wave.
.003)	) height of wave.
.012)	

Thickness of Walls: Slight.

Striations on Surface Wall: Parallel to length of leaf. Faint on cells above veins.

Stomata:

	Length mm	Breadth mm	Pore breadth mm
No. 1)	.024	.03	nearly closed.
" 2)	.024	.024	closed
" 3)	.03	.018	closed
" 4)	.024	.024	closed
" 5)	.03	.024	closed
" 6)	.03	.024	closed
" 7)	.024	.024	closed

Number: In 4.8 sq. mm. average no. 8.

Place: Very irregular on surface, and irregular orientation with regard to each other.

Depth: Level with surface.

Subsidiary cells:

Number: 2. Sometimes absent.

Place: One either side of stoma, parallel to length of stoma.

Size: Breadth of single subsidiary cell .003 mm..

Staining: Faint compared with surrounding ordinary epidermal cells.

TYPE E (only specimen found).

(Plate II , figure 5).

External Glands:

Absent.

Hairs:

Absent.

Ordinary epidermal cells:

Shape: Rounded, but elongated on vein.

Size: Diameter .012 mm.

Outline of Wall: Sinuate; on vein straight.

mm	
.012	length of wave.
.006)	
)	height of wave.
.003)	

Thickness of Walls: Slight.

Stomata:

Absent.

TYPE F (only specimen found).

(Plate II , figure 6).

External Glands:

Absent.

Hairs represented by hair-bases.

Number: Very numerous. In 4.8 sq. mm. average no.,
(7 at branching of vein.
(5 on straight part of vein.

Place: On veins, and set irregularly.

Distance apart: Varied; common measurements are .12 mm., .036 mm., .024 mm..

Ordinary epidermal cells:

Shape: Rounded between veins.
Oblong near veins.
Rectangular on veins.

Size: Rounded - diameter .012 mm..
Oblong - .024 mm. long.
.012 mm. wide.

Outline of Wall: Sinuate; on veins straight.

mm.
.012 length of wave.

.003 height of wave.

Thickness of Walls: Slight.

Striations on Surface Wall: Very faint.

Stomata:

	Length mm	Breadth mm	Pore breadth. mm
No. 1)	.024	.021	closed
" 2)	.021	.018	.003
" 3)	.021	.015	.003
" 4)	.036	.018	closed
" 5)	.021	.021	closed
" 6)	.024	.021	closed
" 7)	.03	.018	closed
" 8)	.024	.015	closed
" 9)	.024	.021	closed

Number: In 4.8 sq. mm. average no. 12.

Place: Very irregular on surface, and irregular orientation with regard to each other.

Depth: Level with surface.

Subsidiary cells:

Number: Generally absent, or 2.

Place: One on either side of stoma, parallel to length of stoma.

Size: Breadth of single subsidiary cell .003 mm..

TYPE G (only specimen found).

(Plate II , figure 4).

External Glands:

Absent ?

Hairs represented by hair-bases.

Number: Very numerous. In 4.8 sq. mm. average no:
(4 on veinlet,
(6 on main vein.

Place: On veins, and set irregularly.

Distance apart: Varied; common measurements are .24, .12, .036 mm..

Ordinary epidermal cells:

Shape: Rounded to oblong, but rectangular on veins.

Size: Rounded cell - diameter .018 mm..

Oblong cell - (.024 mm. long.
(.012 mm. wide.

Outline of Wall: Sinuate; on vein straight.

mm.
.012 length of wave.

.003)
) height of wave.
.006)

Thickness of Walls: Slight.

Striations on Surface Wall: Very faint.

Stomata:

	Length mm	Breadth mm	Pore breadth. mm
No. 1)	.015	.015	.003 -
" 2)	.027	.015	closed
" 3)	.024	.018	closed
" 4)	.012	.012	closed
" 5)	.027	.024	closed
" 6)	.027	.018	closed
" 7)	.012	.012	closed
" 8)	.024	.018	closed
" 9)	.024	.015	closed
" 10)	.024	.018	closed
" 11)	.036	.027	closed
" 12)	.03	.024	.006

Number: In 4.8 sq. mm. average no. 12.

Place: Very irregular on surface, and irregular orientation with regard to each other.

Depth: Level with surface.

Subsidiary cells:

Number: Generally absent, or 2.

Place: One on either side of stoma, parallel to length of stoma.

Size: Breadth of single subsidiary cell .006 mm..

Wall: Common to subsidiary cell and ordinary epidermal cell irregular in outline.

TYPE H (6 specimens found).

(Plate II , figure 8).

External Glands:

Absent.

Hairs:

Absent.

Ordinary epidermal cells:

Shape: Rounded to oblong, but rectangular on veins.

Size: Rounded cell - diameter .036 mm..

Oblong cell - .048 mm. long.

.012)
) mm. wide.
.024)

Outline of Wall: Very sinuate.

mm.
.024 length of wave.

.006)
) height of wave.
.024)

Thickness of Walls: Great.

Stomata:

	Length mm.	Breadth mm.	Pore breadth. mm.
No. 1)	.024	.018	closed
" 2)	.012	.012	closed
" 3)	.015	.015	closed
" 4)	.024	.021	closed
" 5)	.024	.018	closed
" 6)	.012	.012	closed
" 7)	.018	.012	closed
" 8)	.012 +	.012 -	closed
" 9)	.012 +	.012	closed

Number: In 4.8 sq. mm. average no. 7.

Place: Irregular on surface. Nearly parallel orientation with regard to each other.

Depth: Sunken below general surface.

Staining: Deeper colouration than surrounding ordinary epidermal cells.

Subsidiary cells:

Absent ?

TYPE I (only specimen found).

(Plate III , figure 9).

External Glands:

Absent.

Hairs:

Absent.

Ordinary epidermal cells:

Shape: Rounded.

Size: Diameter .012 mm..

Outline of Wall: Finely sinuate; on veins straight.

mm.
.006 length of wave.

.003 - height of wave.

Thickness of Walls: Slight.

Stomata:

Absent.

TYPE J (6 specimens found).

(Plate III , figure 10)

Description same as for Type I with the following exceptions:-

Ordinary epidermal cells:

Outline of Wall: Height of wave varies from .006 mm. to .012 mm..

Thickness of Walls: Rather great.

TYPE K (16 specimens found).

(Plate III , figure 11).

External Glands:

Absent.

Hairs represented by hair-bases.

Number: Very numerous. In 4.8 sq. mm. average no. 7.

Place: Scattered over surface irregularly, but especially placed on veins.

Distance apart: Varied; common measurements are .036, .12 mm..

Ordinary epidermal cells:

Shape: Elongated.

Size: .024 mm. long.

.012 mm. wide.

Outline of Wall: Straight.

Thickness of Walls: Slight.

Arrangement: Radiating out from hair-bases.

Stomata:

	Length mm	Breadth mm	Pore breadth. mm
No. 1)	.006	.003	closed
" 2)	.012	.003	closed
" 3)	.009	.006	closed

Number: In 4.8 sq. mm. average no. 15.

Place: Irregular on surface, and irregular orientation with regard to each other.

Depth: Level with surface.

Staining: Paler colouration than surrounding ordinary epidermal cells.

Subsidiary cells:

Absent ?

TYPE L (17 specimens found).

{Plate III , figure 12
{Plate IV , figure 13 }.

External Glands:

Absent.

Hairs:

Absent.

Ordinary epidermal cells:

Shape: 5-sided and rectangular.

Size: 5-sided - diameter .024 mm..

Rectangular - .036 mm. long.

.024 mm. wide.

Outline of Wall: Straight.

Thickness of Walls: Great; on veins very great.

Stomata:

	Length mm	Breadth mm	Pore breadth. mm
No. 1)	.024	.024	closed
" 2)	.024 -	.018	closed
" 3)	.021	.018	closed
" 4)	.024	.018	closed
" 5)	.021	.021	closed
" 6)	.03	.012	closed
" 7)	.024	.024	closed
" 8)	.018	.018	closed

Number: In 4.8 sq. mm. average no. 14.

Place: Confined to definite areas, but irregularly placed in these areas, and orientation irregular.

Depth: Slightly sunken below general level.

Subsidiary cells:

Number: 2, well defined.

Place: One on either side of stoma, parallel to length of stoma.

Size: Breadth of single subsidiary cell .012, .009 mm..

TYPE M (6 specimens found).

(Plate IV , figure 14).

External Glands:

Absent.

Hairs:

Absent.

Ordinary epidermal cells:

Shape: Rectangular.

Size: .12 mm. long.

.036 mm. wide.

Outline of Wall: Straight, with occasional bends.

Thickness of Walls: Slight.

Striations on Surface Walls: Faint.

Arrangement of Cells: Long axes parallel to each other.

Stomata: Single and double stomata occur.

(a) Single stomata.

	Length. mm	Breadth. mm	Pore breadth. mm
No.1)	.036	.018	closed.

(b) Double stomata.

	Length.		Breadth.		Pore breadth.	
	A (attached to)	B.	A (attached to)	B.	A (attached to)	B.
	mm	mm	mm	mm	mm	mm
No.1)	.03	.033	.015	side view.	closed	side view.
" 2)	.036	.042	.021	" "	closed	" "
" 3)	.036	.042	.018	" "	.003 -	" "
" 4)	.024	.036	.012	" "	closed	" "

(a) & (b) considered together unless otherwise stated.

Number: In 4.8 sq. mm., 2 of (b), rarely 1 of (a).

Arrangement: Linear, at infrequent intervals. Orientation parallel in all cases.

Depth: (a) Level with surface.

(b) (A level with, or slightly raised above, surface.
(B slightly raised above A.

Subsidiary cells:

Absent.

TYPE N (5 specimens found).

(Plate IV , figure 15).

External Glands:)
)
)
Hairs:) Similar to M.
)
)
Ordinary epidermal cells:)

Stomata: only single type occurs.

	Length mm	Breadth mm	Pore breadth. mm
No. 1)	.036	.024	closed
" 2)	.03	.012	closed
" 3)	.033	.024	closed
" 4)	.027	.024	closed

TYPE O (14 specimens found).

(Plate IV , figure 16).

External Glands:

Absent.

Hairs: represented by probable bases.

Number: Moderate. In 4.8 sq. mm. average no. 3.

Ordinary epidermal cells:

Shape: Rounded and 5-sided.

Size: Rounded - diameter .012 mm..

5-sided - " .018 mm..

Outline of Wall: Straight.

Thickness of Walls: Rather slight.

Stomata:

Absent.

TYPE P (only specimen found).

(Plate , figure).

External Glands:

Absent.

Hairs:

Absent.

Ordinary epidermal cells:

Shape: Rectangular.

Size: Length ? (no end walls).

Width .048 mm..

Outline of Wall: Sinuate.

mm

.036 length of wave.

.006 height of wave.

Thickness of Walls: Great.

Cell contents: Globular and linear secretions of resinous character are abundant.

(e) Woody material. (See page 22.)

The treatment for clearing the splinter of fossil wood has been the same as for the fossil epidermis (pages 25 & 26). It has not been necessary to stain it.

Type of Wood.

The single type found is described as follows:- The specimen is a thin, longitudinal-radial section of wood showing bordered pits.

The tracheid walls are parallel and are .024 mm. apart. The bordered pits, easily visible, are evenly placed, at intervals of .012 mm., in a linear, longitudinal series, and only rarely are missing in the series. The pit, itself, has a diameter of .018 mm., and the pore a diameter of .003- mm..

From the sparseness of wood present, it has been difficult to identify this material specifically, and coniferous wood is the only diagnosis possible.

The LIVING PLANTS SELECTED for COMPARISON with the FOSSIL FORMS.

Having differentiated 16 types of fossil epidermis, I obtained samples of modern epidermis in order to compare fossil with modern types. It was hoped that this comparison of the epidermis would lead to the identification of the fossil remains.

The first selection of modern epidermis was based on J. S. Gardner's[26],[27],[28],[29] records of plants from the Lower Bagshot Beds. He has identified (from leaf-outline and venation only) the following underlined families and genera. Living species belonging to these several genera were obtained, the epidermis receiving the treatment described on pages 59-61.

Family.	Genus.	Species examined.
Proteaceae	Protea	cegnaroides
		lanceolatea
	Banksia	integrifolia
		serrata
Lauraceae	Laurus	nobilis

Family.	Genus.	Species examined.
Araliaceae	Aralia	cunninghamii
		abellii
		chabrieri
		filicifolia
Myricaceae	Myrica	rubra
		aethiopica
		californica
		cordifolia
		asplenifolia
Urticaceae	Ficus	nitida
		bengalensis
		lyrata
		vogelii
		barteri
		infectoria
		australis
		artocarpoides
		religiosa
		elastica
		sycamorus
		sagittifolius
Salicaceae	Salix	alba

Family.	Genus.	Species examined.
Aceraceae	Acer	Pseudo-platanus
Hippocastanaceae	AEsculus	Hippocastanum
Palmae	Sabal	
Leguminosae	(Lathyrus	odoratus
	(Cytisus	scoparius
Filicineae	Scolopendrium	vulgare
	Aspidium	Filix-mas
	Polypodium	vulgare

The epidermis of these families and genera (from the species named in the third column on the right, pages 55 – 5½) did not resemble the fossil epidermis, consequently reference was made to other lists of plants occurring in Lower Bagshot Beds. Writers naming plants of this age are:- W. B. Clarke[16] (1839), Louis H. Ruegg[50] (1854), H. Dobell[20] (1886), H. B. Woodward[62] (1887), J. C. Mansel-Pleydell[48] (1895), F. H. Knowlton[34] (1902), W. T. Ord[44] (1914), O. White[59] (1917).

Constant reference has also been made to records of plants from the Middle Bagshot Beds, particularly to Dr. H. Bandulska's[3],[4],[5] collection which is in progress on the adjoining area.

The material selected for further comparison with the fossil epidermis was the following.

Family.	Genus.	Species examined.
Lauraceae	Cinnamomum	camphora
		Loureirii
	Persea	Linque
		gratissima
	Litsaea	ferruginea
	Sassafras	officinale (var. variifolium)
Salicaceae	Populus	nigra (var. pyramidalis)
Betulaceae	Betula	
Cupuliflorae	Fagus	sylvatica
	Quercus	pedunculata
Araucariaceae	Araucaria	bidwillii
		cunninghamii
		(var. varflauca)

The TREATMENT NECESSARY for the MICROSCOPIC INVESTIGATION of the EPIDERMIS in LIVING PLANTS.

In the treatment of modern epidermis a good method had to be found for a) clearing, and b) permanent, dark staining in order to differentiate structures for measurement and photography.

(a) The clearing, included the separation of the two skins (in leaf material) and the removal of all adhering tissue on the internal surface of the epidermis. The method adopted by Dr. H. Hamshaw Thomas (58) was first tried, but was found to be slow; and there was no marked hastening of the process even after cutting open the material to allow easier flow of the solution to the internal surface of the epidermis. The method now adopted for clearing has been shown me by Mr. L. A. Boodle, and is as follows.
A portion of the stem or leaf is cut out and dropped into a test-tube and enough nitric acid added to cover the material. (Concentrated nitric acid is used for thick epidermis and diluted nitric acid for frail epidermis.) Gentle heating of the liquid causes (in the case of leaf material) the lower and upper epidermis to separate; with tough epidermis continued heating thoroughly clears the material; tender samples, however, disintegrate rapidly if the heating is continued much beyond the

separating stage. Frail skins should be removed from the liquid soon after separation, therefore, and brushed clear of attached tissue either in water or in very dilute nitric acid.

(b) For staining the modern epidermis I have used the same method as for the fossil epidermis, and have found, generally, that safranin in alcohol gives a good result, though it is rather erratic in its behaviour. This stain may show up cell walls, stomata and even striations on the cell wall remarkably well at the outset, but after 2-3 months it has often dispersed over the epidermis so that these characters are no longer clearly differentiated. This is particularly the case with the less resistant kind of epidermis found, for example, in Acer Pseudo-platanus, AEsculus, or Fagus sylvatica.

In the epidermis of modern plants, I find that the mordant (picric acid) should remain on the epidermis for an hour or more, and the safranin in alcohol from 1-2 hours.

The following is a summary of the order of procedure and average time taken to pass through the reagents used. (The same remarks as for fossil epidermis regarding depth of colour and texture of material (page 27) should be added here.)

Picric acid .. 1-2 hours.

Method I.	Method II.
Bismarck brown in water .. 1-2 hours.	Safranin in alcohol .. 1-2 hours.
Absolute alcohol . few minutes.	Absolute alcohol .. few minutes.
Origanum oil . few minutes.	Origanum oil .. few minutes.
Canada balsam.	Canada balsam.

Method II is the one generally adopted.

The INVESTIGATION of EPIDERMIS of LIVING PLANTS.

From the variety of genera examined, it was hoped that it would be easy to see the microscopic, epidermal features peculiar to each family, genus and species. The particular characters studied were the external glands and hairs, the degree of sinuation of the ordinary cell-wall, and the size and structure of the stoma, as these seemed to be considered important features in much of the present-day diagnostic work.

No definite conclusions resulted. Indeed the examination revealed so much lack of character in the epidermis that its use for plant determinative work was very much doubted.

The only structure that appeared to have diagnostic value was the stoma. The researches of others, especially those of H. Solereder[55] and L. Kny,[35] seemed to bear out this decision. The former observes that external glands and hairs are very rarely characteristic of a family or genus, the latter states that the degree of sinuation of the cell-wall varies according to the light intensity and is thus a most unreliable epidermal character.

A detailed investigation of the more important characters of the stoma was then started. The two stomatal

characters selected were (1) the size and (2) the structure (surface view only). The figures recorded in the following pages were obtained from this study.

1) The Size of the Stoma.

Family.	Genus.	Species.	Length of Stoma.	Breadth of Stoma.	Breadth of Stomatal pore.
			mm	mm	mm
Proteaceae	Protea	cegnaroides	.072	.054	.024
			.072	.06	.024
			.072	.042	.015
			.072	.072	.024
			.072	.06	.024
		lanceolatea	.06	.06	.012
			.06	.06	.012
			.054	.06	.012
			.06	.06	.012
			.072	.06	.012
			.072	.06	.012
	Banksia	integrifolia	.009	.012	closed
			.012	.012	"
			.012	.012	"
			.009	.009	"

Family.	Genus.	Species.	Length of Stoma.	Breadth of Stoma.	Breadth of Stomatal pore.
			mm	mm	mm
Proteaceae (contd.)	Banksia (contd).	serrata	.018	.012	closed
			.024	.018	"
			.024	.018	slightly open.
			.024	.018	closed.
			.024	.018	"
Lauraceae	Laurus	nobilis	.03	.018	closed
			.024 +	.024 -	"
			.03	.03	"
			.03 -	.024	"
			.024 +	.024	"
			.024	.024	"
			.024	.024	"
			.03	.018	"
	Cinnamo-mum	camphora	.024	.024	closed
			.024	.024 -	"
			.024	.024	"
			.024	.03	"
			.024	.024	"

Family.	Genus.	Species.	Length of Stoma.	Breadth of Stoma.	Breadth of Stomatal pore.
			mm	mm	mm
Lauraceae (contd).	Cinnamomum (contd).	Loureirii	.018	.024	closed
			.018	.015	"
			.018	.015	"
			.018	.015	"
			.018	.015	"
	Persea	Linque	.03	.024	closed
			.027	.024	"
			.03	.024	"
			.027	.024	"
			.024	.03	"
			.03	.024	"
			.03	.024	"
		gratissima	.018	.021	closed
			.021	.012	"
			.021	.021	"
			.018	.018	"
			.012	.018	"
			.018	.018	"
			.018	.018	"

Family.	Genus.	Species.	Length of Stoma.	Breadth of Stoma.	Breadth of Stomatal pore
			mm	mm	mm
Lauraceae (contd).	Litsaea	ferruginea	.024	.021	closed
			.024	.021	"
			.024	.021	"
			.024	.012	"
			.024	.021	"
	Sassafras	officinale (varifolium)	.024	.009	closed
			.024	.009	"
			.024	.009	"
			.018	.009	"
			.024	.009	"
Araliaceae	Aralia	cunninghamii	.034	.034	v.slightly open.
			.034 +	.034	" "
			.038	.024	" "
			.046	.029	" "
			.051	.042	" "
		abellii	.029	.025	closed
			.029	.025	"
			.029	.025	"
			.034	.025 +	"
			.042	.025	"
			.034	.029	"

Family.	Genus.	Species.	Length of Stoma.	Breadth of Stoma.	Breadth of Stomatal pore.
			mm	mm	mm
Araliaceae (contd).	Aralia (contd).	chabrieri	.017	.017 +	slightly open.
			.025	.017	" "
			.025	.017	" "
			.025	.017	" "
			.025	.017	" "
		filicipolia	.017	.008	.003
			.021	.017	.003
			.021	.008	.003
			.021 +	.012	.003
			.017	.017 -	.003
Urticaceae	Ficus	artocarpoides	.021	.012	closed
			.021	.012	"
			.018	.012	"
		australis	.034	.017	slightly open.
			.034	.025	" "
			.025	.021	" "
		nitida	.034	.034	closed
			.034	.025	"
			.025	.021	"

Family.	Genus.	Species.	Length of Stoma.	Breadth of Stoma.	Breadth of Stomatal pore.
			mm	mm	mm
Urticaceae (contd).	Ficus (contd).	lyrata	.017	.008	closed
			.017 +	.017	"
			.017	.008	"
		bengalensis	.017	.017	closed
			.017	.017	"
			.021	.021	"
		vogelii	.017	.017	closed
			.012	.012	"
			.012	.012	"
			.025	.017	"
			.021	.012	"
		barteri	.025	.008	closed
			.017	.008 +	"
Myricaceae	Myrica	cordifolia	.03	.027	closed
			.03	.036	slightly open.
			.03	.036	.003
			.03	.036	.003
			.024	.024	.003 -
			.03	.03	.003

Family.	Genus.	Species.	Length of Stoma.	Breadth of Stoma.	Breadth of Stomatal pore.
			mm	mm	mm
Myricaceae (contd).	Myrica (contd).	rubra	.024	.024	closed
			.024	.018	"
			.024	.024	"
			.021	.021	"
			.024	.024 -	"
		californica	.024	.021	.003
			.024	.024	slightly open.
			.024 +	.015	closed
			.024	.024	"
			.024	.024	slightly open.
		aethiopica	.018	.012	.006
			.012	.012	slightly open.
			.012	.012	.003
			.015	.012	slightly open.
			.015	.015	.006
			.018	.012	slightly open.
			.012	.012	" "

Family.	Genus.	Species.	Length of Stoma.	Breadth of Stoma.	Breadth of Stomatal pore.
			mm	mm	mm
Salicaceae	Populus	nigra var. pyramidalis.	.024	.012	closed
			.018	.012	"
			.024 +	.012	"
			.024	.012	"
Araucariaceae	Araucaria	bidwillii	.048	.024	.006
			.042	.024 +	.006
			.048	.024	.006
			.054	.024 +	.006
			.039	.024 +	.006
		cunninghamii var. varflauca	.048	.036	.006
			.048	.03	.006
			.054	.03	.006
			.048	.036	.006
			.045	.03	.006

Family.	Genus.	Species.	Length of Stoma.	Breadth of Stoma.	Breadth of Stomatal pore.
			mm	mm	mm
Betulaceae	Betula	alba	.036	.024	closed
			.03	.018	"
			.03	.024	"
			.036-	.024	"
			.054	.024	"
			.048	.024	"
			.033	.024-	"
			.033	.024	"
Cupuliflorae	Fagus	sylvatica	.027	.015	closed
			.024	.018	"
			.024	.015	"
			.024	.024-	"
			.024	.018	"
			.024	.015	"
	Quercus	pedunculata	.03	.018	closed
			.033	.024	"
			.027	.021	"
			.024	.021	"
			.027	.018	"
			.03	.024	.012
			.03	.024	.012

Family.	Genus.	Species.	Length of Stoma.	Breadth of Stoma.	Breadth of Stomatal pore.
			mm	mm	mm
Aceraceae	Acer	Pseudo-platanus	.024	.018	closed
			.024	.015	"
			.024	.018	"
			.03	.015	"
			.027	.024	"
			.027	.021	.003-
Hippocastan-aceae	AEsculus	Hippocastanum	.024	.012	closed
			.024	.012	"
			.03	.012	.003-
			.03	.009	closed
			.03	.012	"
			.024	.009	"
			.03	.018	"
			.021	.009	"

From a study of the mechanism of the stoma, and from the writings and diagrams of Haberlandt,(30) it seems clear that in the opening and closing of the stoma, the "length of the stoma" remains approximately the same, whereas the "breadth of the stoma" and the "breadth of the stomatal pore" necessarily alter. Therefore the first column of figures (pages 63-72)

has been taken to be the only one of possible diagnostic value.

But on reference to this column, it is obvious that very similar figures are found in widely different families, in different genera of one family and in different species of one genus, making it impossible in the material examined to take the size of the stoma as a characteristic of a family, genus or species, except possibly in some very few cases where the stomata are unusually small (as in Banksia integrifolia and Cinnamomum Loureirii) or unusually large (as in Aralia Cunninghamii, species of Araucaria, species of Protea).

Solereder[65] states that "especially in extreme cases (very large or very small stomata, occasionally even stomata of 2 sizes on the same leaf-surface .....)" the size of the stomata "may be employed for the diagnosis of species and occasionally even of more extensive taxonomic groups."

2) The Structure of the Stoma (surface view only).

With regard to the structure of the stoma, surface views of the modern material collected showed such similarity of stomatal structure in widely different families that this character also seemed useless in plant diagnoses.

These conclusions led to a more critical examination of the epidermis to find out whether the epidermis had any value in the determination of plants.

The criticism which follows is particularly connected with Angiospermous material, as this kind of plant is said to predominate in the Lower Bagshot Pipe-Clay.

A. The Value of EXTERNAL GLANDS in the Diagnosis of Plants.

According to H. Solereder,(55) external glandular hairs of Angiosperms may be divided into two main groups. Group I contains glands which are small with a simple structure. Group II contains those which are large and have a complicated structure.

Group I is further divided into 3 sub-groups (a), (b) and (c). (a) includes all glandular hairs which are unicellular in structure and tubular in form: (b) includes all multicellular structures which are club-shaped: (c) includes external glands with a multicellular structure, terminating in either a peltate or spherical head.

Into each of the main groups (I and II) and into each of the sub-groups numerous families are massed, showing that a particular glandular structure may occur in several families. This wide plant range makes it evident that

external glands are of no use in the determination of plants.

Also, many families possess more than one type of glandular structure. Tiliaceae and Rutaceae, for example, have types I (a) and I (b); Bixineae, Sapindaceae and Hippocastanaceae have types I (b) and I (c); Moraceae has types I (b) and II; Malvaceae has types I (a), I (b), I (c), and II.

It may be concluded, therefore, that EXTERNAL GLANDULAR HAIRS cannot be used for determining Angiospermous plants.

B. The Value of CLOTHING HAIRS in the Diagnosis of Plants.

Clothing hairs may be distinguished from glandular hairs by the absence of oil, resin, mucilage or water. Solereder (55) enumerates 5 kinds of clothing hairs, distinguished from each other by their varying structures. They are as follows:-

I. Simple.
II. Peltate.
III. Stellate.
IV. Candelabra.
V. Shaggy.

As in the case of the glandular hairs, families are numerously represented in each group, and often one family may appear in several groups. Loganiaceae and Verbanaceae have hair structures I, II and IV: Dilleniaceae and Anonaceae have hair structures I, II and III: Ericaceae has hair structures I, II, III, IV and V.

It may be concluded, therefore, that CLOTHING HAIRS cannot be used for identifying Angiospermous plants.

C. A Critical Examination of the Value of the ORDINARY EPIDERMAL CELL in the Diagnosis of Plants.

The characters examined are 1) the shape, 2) the size, 3) the sinuation of the wall, 4) the thickness of the wall.

(The material observed was mature in all cases.)

1) The SHAPE of the Ordinary Epidermal Cell.

In the modern material examined, the ordinary epidermal cell of Myrica cordifolia foliage leaves is seen to be round. In Myrica aethiopica, on the other hand, the cells vary in shape from rectangular to oblong. Aralia cunninghamii has definite 5-sided cells; Aralia abellii has oblong-shaped cells. Other instances of the unreliability

of the shape of the cell for diagnosing a family or genus can be cited from Lauraceae, Urticaceae, etc.

And further, it is evident that the shape of the epidermal cell can vary in a single species, for Acer Pseudo-platanus sun-leaves have 5-sided cells, whilst the shade-leaves on the same tree have cells which are oblong. L. Kny,(35) working on Fagus sylvatica sun- and shade-leaves, also found a difference in the shape of the cells in these two kinds of leaves.

This last observation gives clear proof that the shape of the epidermal cell in the leaf is largely, if not wholly, determined by light intensity, and, in consequence, this character of the epidermis is unstable and of no use in the diagnosis of plants.

It is interesting to notice in connection with this character of the epidermis that Solereder(55) attributes elongated epidermal cells to narrow leaves, "the long axis of the cell" being "generally parallel to the median vein"; the narrow leaves of Caryophyllaceae, Papilionaceae, etc. are quoted as examples of this. I find, however, that the epidermal cells on petioles, stems, etc. are also elongated, the long axis of the cell being parallel to the long axis of the organ in question, and that this shape of cell occurs independently of the shape of the epidermal

cell in the lamina. This "elongated" cell, then, covers a wider field than that described by Solereder, and, in consequence of this common occurrence, is of no diagnostic value.

2) The SIZE of the Ordinary Epidermal Cell.

In Lauraceae foliage leaves, Cinnamomum camphora has larger epidermal cells than Litsaea ferruginea. Myrica cordifolia, also, shows a larger cell in the leaf than either Myrica rubra or Myrica californica.

In Ficus vogelii or Ficus infectoria the epidermis is composed of larger cells than are found in any of the following:- Ficus nitida, F. bengalensis, F. lyrata, F. barteri. It is evident, then, that the size of the epidermal cell varies in a family and in a genus.

Again this character may vary in one and the same leaf, for in Aralia chabrieri the cells composing the upper epidermis are larger than those in the lower epidermis; L. Kny[35] observes this fact also in Fagus sylvatica, stating that on the under epidermis the "cells are a little smaller than those of the upper surface."

J. B. Farmer[14] and S. E. Chandler[14] experimenting "on the influence of an excess of CO_2 in the air on the Form and Internal Structure of Plants", remark on the decreased size of the epidermal cells in a plant treated with excess

CO_2. Their "excess of CO_2" in the air is stated to be 3.5 times the amount of CO_2 normally present in air. The control plant was grown in an atmosphere containing 3.29 parts of CO_2 in 10,000 volumes of air, which they take as the normal content of CO_2 in air.

This experiment would indicate that the size of the epidermal cell may alter with changing external conditions. Sun- and shade-leaves from one and the same plant, moreover, have shown no apparent difference in the size of the epidermal cell. Plants examined for this purpose were AEsculus Hippocastanum, Fagus sylvatica, Quercus pedunculata and Acer Pseudo-platanus.

The variation of the size of the epidermal cell in a family, genus and species, and the tendency to vary with a different proportion of carbon dioxide in the surrounding air, prove sufficiently that this character of the epidermis is unreliable and also somewhat unstable, and therefore cannot be of use in plant determinations.

3) The OUTLINE or SINUATION of the Epidermal Cell-Wall.

Species of Aralia (Aralia cunninghamii, etc.) and Cinnamomum (Cinnamomum camphora, etc.) are seen to possess an epidermis on both the lower and upper surfaces of the foliage leaf composed of cells with straight walls. Other species of these genera (Aralia abellii, Cinnamomum

Loureirii, etc.) show a marked sinuation of the cell wall in both the lower and upper epidermis of the foliage leaf.

But in Myrica aethiopica it is noticed that straight walls characterise the upper epidermis of the foliage leaf, whereas wavy walls characterise the lower. A comparatively greater degree of sinuation of the wall of the lower epidermal cells is commonly found in mesophytic Angiosperms: specimens of Æsculus Hippocastanum, Fagus sylvatica and Quercus pedunculata have shown this fact remarkably well.

In some plants, for example Persea gratissima, however, the upper epidermis may be composed entirely of cells with wavy walls, while straight-walled cells characterise the lower epidermis.

This variation of cell-wall outline in a genus and species is proof that this character of the epidermal cell cannot be used in plant determinations.

And further, instability of this character is evident from the difference between sun- and shade-leaves. L. Kny (35) and others have commonly found that the amount of illumination on the epidermis largely controls the degree of sinuation of the cell-wall. It is well-known that straight walls are characteristic of sun-leaves and that wavy walls characterise shade-leaves. Again straight

walled cells generally indicate also a dry habitat, whereas sinuation of the wall is indicative of a damp habitat.

To test the effect of light on the outline of the epidermal cell-wall, sun- and shade-leaves of AEsculus Hippocastanum, Fagus sylvatica, Quercus pedunculata and Acer Pseudo-platanus were examined. The area of the foliage leaf selected for examination was in each case the base of the lamina and near to the midrib; the material was "fixed" in absolute alcohol immediately after the plucking of the leaf. The specimens were collected on the same day, July 24th, 1926. A detailed investigation was made of the upper epidermis of each specimen, and in nearly every case the shade-leaf was found to have a greater degree of sinuation of its cell-wall. For the sake of comparison, the results of these observations are noted below.

AEsculus Hippocastanum.

Upper epidermis.

Specimen A.

Sunleaf: Epidermal walls tendency to wave.

Shade leaf: " " " " "

Specimen B.

Sunleaf: Epidermal walls slightly wavy.

Shade leaf: Epidermal walls wavy.

It is noticeable in Specimen B that the decrease of light has increased the sinuation of the epidermal cell-wall. This is not apparent, however, in Specimen A.

Fagus sylvatica.

Upper epidermis.

		Wave
Specimen A.		
Sunleaf:	Epidermal walls wavy.	(vertical height: .009 mm.. (length: .018 mm..
Shade leaf:	Epidermal walls very wavy.	(vertical height: .012 mm.. (length: .012 mm..
Specimen B.		
Sunleaf:	Epidermal walls wavy.	(vertical height: .009 mm.. (length: .018 mm..
Shade leaf:	Epidermal walls very wavy.	(vertical height: .015 mm.. (length: .012 mm..

Both Specimens A and B show a marked increase in the sinuation of the epidermal cell-wall with decreased illumination.

Quercus pedunculata.

Upper epidermis.

Specimen A.

Sunleaf: Epidermal walls straight.

Shade leaf: " " tendency to wave.

Specimen B.

Sunleaf: Epidermal walls straight.

Shade leaf: " " "

Only Specimen A showed the outline of the epidermal wall changing in form with variation of light intensity.

Acer Pseudo-platanus.

Upper epidermis.

Specimen A.

Sunleaf: Epidermal walls straight.

Shade leaf: Epidermal walls wavy. Wave. (vertical height: .009 mm. (length: .018 mm.

Specimen B.

Sunleaf: Epidermal walls straight.

Shade leaf: Epidermal walls wavy. Wave. (vertical height: .012 mm. (length: .018 mm.

The amount of light on the lamina has clearly

controlled the form of the outline of the cell-wall, for in both cases (A and B) a considerable degree of sinuation of the wall has been produced in the shade-leaves. Leaves intermediate in position, that is to say in neither a true sun position nor in a true shade position, were found to have their epidermal walls less waved than the true shade-leaves.

In consequence of these results, the value of the descriptive work of Dr. H. Bandulska (3) in connection with the sinuation of epidermal walls appears lessened, and such reasoning as the following may be questioned. "The epidermal cells have very wavy walls and are very thick-walled, showing pits: thus it would seem that if Araucarites Gopperti is an Araucaria, it must be a different species of Araucaria from A. Cunninghamii since the walls of its epidermal cells are straight."

This writer seems to attach too much value to the sinuation of the cell-wall, for the fossil Dicotylophyllum sinuatum appears to have been named from the presence of "very sinuate" cell-walls, a feature shown to be unreliable in the above research.

4) The THICKNESS of the Epidermal Cell-Wall.

J. Y. Bergen (6) working on "the "Sun Leaves and Shade Leaves of Olea Europaea and other broad-leaved Evergreens," has

found that the cutinized layer of the upper epidermis is much more developed in the sun-leaves than in the shade-leaves. L. Kny,[35] observing the sun- and shade-leaves of Fagus sylvatica, finds that "the outer epidermis wall of the sun-leaves is distinguished from the shade-leaves by its greater thickness and more strongly developed cuticle." The thickness of the cuticle thus varies with light intensity.

The sun- and shade-leaves of Quercus pedunculata show that the lateral walls of the epidermal cells vary in thickness with variations of light intensity. A strong illumination appears to cause a thickening of the wall.

There is evidence, therefore, that the thickness of the epidermal cell is an unstable character of the epidermis and is of no use in the determination of plants.

It is clear, then, that the Shape and Size of the ORDINARY EPIDERMAL CELL, the degree of Sinuation of the Cell Wall, the Thickness of the Cuticle, the Thickness of the Lateral Walls, may vary in different parts of one and the same plant, or even in a single leaf if lower and upper epidermis are compared. A single species may also show variations of each of the above cell characters if grown in different habitats.

This instability of each character of the ORDINARY EPIDERMAL CELL is decisive proof that the epidermis is of little value as a diagnostic feature.

D. A Critical Examination of the Value of STOMATA in the Diagnosis of Plants.

At the present time, the Size and Structure of the Stoma, and the Number and Arrangement of the Subsidiary Cells around the guard cells are considered the most important features of the stomatal apparatus for plant diagnosis. The Level of the Stoma in the epidermal tissue, the Orientation and General Arrangement of the Stomata and the Number of Stomata also appear to stand out as rather important characters in determinative work.

These characters therefore have been studied to ascertain their usefulness in the identification of plants. The critical examination is recorded below.

1) The NUMBER of Stomata.

In order to find out whether families and genera have a characteristic number of stomata in a given area of the lamina, mature leaves of species of Ficus, Aralia, Myrica, etc. were examined. In each case the particular area investigated was at the base of the lamina close to

the midrib, since stomata were found to be more numerous near the base of the leaf than at the apex, and towards the midrib rather than near the margin of the leaf. The selected area contained, therefore, the maximum number of stomata. (My observations in this connection accord with S. H. Eckerson's[21] results in connection with oblong leaves, but are much at variance with E. J. Salisbury's[51] work recently published. This latter writer has made a very extensive examination of woodland flora to ascertain "the Causes and Ecological Significance of Stomatal Frequency." It is clear that in the material investigated by this writer there is a marked increase of stomata from the base to the apex of the lamina and from the midrib to the leaf-margin.)

The figures obtained from the examination are recorded as follows.

Family.	Genus.	Species.	Number of Stomata in 4.8 sq. mm..
Urticaceae	Ficus	nitida	10
		bengalensis	12
		lyrata	25
		vogelii	16
		barteri	17
		infectoria	13
		australis	7
		religiosa	14
		elastica	6
		sagittifolius	20
Araliaceae	Aralia	cunninghamii	10
		abellii	6
		chabrieri	16
		filicifolia	17
Myricaceae	Myrica	rubra	25
		aethiopica	22
		californica	18
		cordifolia	12
Lauraceae	Laurus	nobilis	10
	Cinnamo-mum	camphora	22
		Loureirii	24

Family.	Genus.	Species.	Number of Stomata in 4.8 sq. mm..
Lauraceae (cont'd).	Persea	Linque	17
		gratissima	17
	Litsaea	ferruginea	17
	Sassafras	officinale (variifolium).	17

It is clear from the similarity of figures in the 4 families considered, that there is no characteristic number of stomata marking off one family from another. Also from the marked similarity of figures in the 3 genera of Lauraceae (Persea, Litsaea and Sassafras) and from the wide range of figures in varying species of Myrica, Aralia and Ficus it is equally clear, that there is no particular number of stomata characteristic of any of these genera.

From these observations there appears to be no value in the number of stomata in a given area of plant epidermis.

Other writers (S. H. Eckerson,(21) J. Y. Bergen,(6) J. V. G. Loftfield,(39) J. B. Farmer(14) & S. E. Chandler,(14) E. J. Salisbury(51)) confirm this conclusion: indeed they find a marked variation in the number of stomata on different leaves of one and the same plant, and attribute the

variation to the different conditions of light intensity, humidity and CO_2 content of the air surrounding the leaf.

S. H. Eckerson[21] states that "marked variations in number .... of stomates occur, not only in different varieties of the same species, but in the same varieties grown under different external conditions."

J. Y. Bergen,[6] observing the Transpiration of the "Sun and Shade Leaves of Olea Europaea and other broad-leaved Evergreens", writes that the stomata are found to be more numerous on the sun- than on the shade-leaves. Two determinations give 15% excess for the sun-leaves.

J. V. G. Loftfield,[34] investigating sun- and shade-leaves and their respective development of stomata per unit area, states that "a leaf developed in the shade has fewer ... stomata per unit area than one produced in sunlight." Further, that "the number and size of the stomata on any given area of leaf are influenced by the conditions under which they were formed." Additional work by the same writer on the number of stomata per unit area on a leaf of Malva rotundifolia produced in June 1916 and another leaf on the same plant produced in July 1916, again shows variation of number with changing external conditions. Leaves developed in June had 173 stomata

per sq. mm.,[x] whilst leaves developed "during the hot dry weather of the first part of July" had 241 stomata per sq. mm..[x] But "the ratio of stomata to other epidermal cells was the same, and hence the difference was merely one of expansion or the size of the cells."

J. B. Farmer (14) and S. E. Chandler, (14) experimenting on "the influence of an excess of CO_2 in the air on the form and internal structure of plants," find that plants grown in air containing 3.5 times the normal amount of CO_2 have more stomata than those grown in air containing the normal per cent. of CO_2 (3.29 parts of CO_2 in 10,000 volumes of air). In the case of Solanum atropurpurem "the number of stomates per unit area of the leaf surface is greater in the CO_2 than in the air plant in the proportion 1.3 : 1.0." This is found to be the case, also, in experimenting with Begonia gracilis and species of Fuchsia. ~~species~~.

E. J. Salisbury, (51) after a thorough investigation of woodland flora, concludes that "the number of stomata per unit area of the leaf surface" of any plant "is extremely variable, even upon the same leaf." (This

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x There appears to be some error in the area mentioned, and probably "sq. mm." should read "sq. cm".. In either case the principle involved is the same.

observation has been mentioned on page 87).
A special examination of grasses confirmed the opinion held by Yapp[51] and Rea[51] that there is, also, a regular increase of stomata per unit area on passing from the basal to the apical leaves of the same plant. Salisbury also finds in species of Ranunculus that the radical leaves have fewer stomata per unit area than the cauline leaves on the same plant, and adds that this is "probably a general feature of herbaceous species" and may also occur in "trees and shrubs when these are growing isolated." This writer also mentions that sun-leaves have a greater stomatal frequency than shade-leaves and that plants grown in dry air or in a dry environment have a greater number of stomata per unit area than similar species grown in moist air or in a moist environment; a change from water to land conditions also brings about an increase of stomata in a species.

E. B. Copeland[15] observes the difference in the number of stomata on the stem and leaf of the same plant. The stem always appears to have fewer stomata per unit area than the leaf.

Contrary to the opinion of these writers, Solereder finds some diagnostic value in the number of stomata on a given piece of epidermis, stating that

"especially in extreme cases ... (very many or very few stomata)" the number of stomata "may be employed for the diagnosis of species and occasionally even of more extensive taxonomic groups." Reviewing the tabulated observations on pages 88 and 89, it is possible to say that the 3 plants Ficus lyrata, Myrica rubra and Cinnamomum Loureirii, belonging to widely different families have "very many" stomata, that is to say 24-25 stomata in 4.8 sq. mm.; and other plants examined could be added to this list. "Very few" stomata (6-7 in 4.8 sq. mm.) may be said to occur in Ficus australis, Ficus elastica and Aralia abellii, etc. Solereder's[55] opinion is therefore difficult to substantiate from these figures.

From the present investigation and the observations of other workers, one is driven to the conclusion that the Number of Stomata is of no importance in plant determination.

2) The GENERAL ARRANGEMENT and ORIENTATION of Stomata.

From a study of the epidermis of the Dicotyledonous foliage leaves mentioned on pages 55-58, it is clear that the placing and orientation of the stomata in these genera is so similar that neither of these characters can be used for the determination of Dicotyledons. In Banksia, Acer Pseudo-platanus, and, as observed by Solereder[55], in Sarcolaena, Schizolaena, Soulamea, Dryandra and Ficus, it is true that there are noticeable assemblages of stomata in well-defined areas, which are frequently sunken below the general level of the epidermal surface; this arrangement allows these genera to be fairly well distinguished, but occurs in too many genera to be of use in diagnostic work.

Foliage leaves of Monocotyledons (according to Solereder[55]) and of most Gymnosperms (according to Dr. H. Bandulska[3]) and stems of both Monocotyledons and Dicotyledons show a linear arrangement of the stomata. The general occurrence of this arrangement shows at once that unknown epidermis having this character may be placed in any one of these plant groups.

There is clear evidence, therefore, that the General Arrangement and Orientation of Stomata are weak diagnostic characters of the epidermis.

3) The LEVEL of the Stoma in the Epidermal Tissue.

Since a single plant species may show a difference in the level of the stoma in the epidermal tissue in response to differences of habitat, it is clear that this stomatal character cannot be used in the diagnosis of plants.

And, moreover, some plants possess stomata which show a remarkable difference in their level in the epidermis as the guard cells open and close. Work has been done by E. B. Copeland[14] on the variation of depth in the opening and closing of stomata in Medeola Virginica and Mnuim cuspidatum; observations prove that as the pore closes the guard cells rise. The difference in level from the closed to the open position could not be measured, however, in these plants for want of focussing marks, but approximately accurate measurements of depth by focussing with a micrometer screw adjustment were possible in other plants. It is interesting to notice in connection with this change in level of the stoma that, according to this writer, Mosses "seem to rely on an increase in the depth of the guard-cells to open the pore."

4) The NUMBER of SUBSIDIARY CELLS around the Stoma.

In the material examined some families (e.g.

Myricaceae, Cupiliferae) have no subsidiary cells around their stomata; other families (e.g. Lauraceae, etc.) have marked subsidiary cells surrounding the guard cells. Hence, it might appear possible to draw up two distinctive types of stomata and to differentiate a few families, at least, by the utilization of this stomatal character; but the further differentiation of genera and species by this means is found to be impossible and the character at once becomes weak for diagnostic work.

Many observations of subsidiary cells have been made by H. Solereder.(55) In this writer's account of the "Structure of the Lamina of the Leaf", there are many families which may or may not have subsidiary cells around the stoma. This uncertainty shows that very little, if any, diagnostic value can be given to the presence or absence of these cells surrounding the stoma.

5) The PLACING of SUBSIDIARY CELLS around the Stoma.

From Solereder's(55) account of the "Structure of the Lamina of the Leaf", the variation in the placing of the subsidiary cells around the stoma in one family is seen to be too great for use in diagnosing plants. For example, in Araliaceae some genera have subsidiary cells parallel to the long axis of the pore, other genera have these cells

surrounding the stoma in one or more rings, each ring consisting of three subsidiary cells, (Cruciferous type), still other genera have no subsidiary cells. Other families (e.g. Solanaceae) possess subsidiary cells lying transversely to the pore, and this type, moreover, "side by side with other types".

Thus the Placing of Subsidiary Cells around the Stoma is an uncertain stomatal character and too indefinite for general use in the determination of plants.

6) The STRUCTURE of the Stoma.

Detailed research into the value of stomatal structure for the identification of plants has been done by H. Solereder.(55) This writer states that "the mode of attachment of the epidermal cells (surrounding the stomata) to the pairs of the guard-cells" is of greatest systematic importance. As this is "intimately connected with the course of development of the stomata from the cells of the dermatogen" there has been a close study of the latter; as a result of this examination 4 main types of development have been determined and named as follows:-

Type 1. Ranunculaceous:

Type 2. Rubiaceous:

Type 3. Caryophyllaceous:

Type 4. Cruciferous.

Type 1. Ranunculaceous: Development of stomata results in no subsidiary cells around the stoma.

Type 2. Rubiaceous: Development of stomata results in subsidiary cells being formed on either side of the stoma "parallel to" the long axis of "the pore".

Type 3. Caryophyllaceous: Development of stomata results in subsidiary cells being formed on either side of the stoma at right angles to the long axis of the pore.

Type 4. Cruciferous: Development of stomata results in the formation of a ring of subsidiary cells around the stoma.

Recognising these 4 main lines of development, the writer lists families which have stomata agreeing with one or other of these types. It is apparent from these lists that most families show more than one type of stomatal development; indeed Bixineae, Polygaleae and Vochysiaceae each exhibit 3 types. Clearly, then, this method for identifying plants is weak.

Further, these types of development "are very commonly quite unrecognisable in the mature leaf", so that Solereder[55] writes "the utilization of these different types of stoma for systematic purposes is involved in great

difficulties in practice." As an instance of the difficulties, the mature structures of the Ranunculaceous and Cruciferous types are quoted; these are often quite indistinguishable at maturity though the course of development of the two stomatal types leading to these final structures is quite different.

Tognini's[55] investigations, quoted by Solereder,[55] prove that "the development of the stomata on the various organs (e.g. foliage leaf, cotyledon, petal, stem) of the same plant-species may either be identical or may vary."

There seems to be little possibility of plant identification from a knowledge of stomatal development, therefore.

Referring to the build of the mature stoma, Solereder[55] finds certain features "of great systematic importance." It appears to this writer that plants may be determined if the following features of the mature stomatal structure are observed:-

1. The contour of the pairs of guard-cells.
2. The shape of the front cavity.
3. The structure of the back cavity.
4. The varied character and chemical nature of the unequal thickening of the walls of the guard cells.

5. The corresponding differences in the shape of the lumina of the guard cells.
6. The thickening ridges which arch over the front and back cavities (mostly strongly cuticularised).
7. The epidermal joints found on either side of the guard cells.

From these facts it is evident that, to obtain a complete picture of the structure of a stoma, a surface view only is most inadequate, as features 3 to 7 inclusive, are only seen in vertical section. Most present day descriptions of stomatal structure are based on mere surface views of the epidermis and consequently stomata of widely different families appear to show great similarity of form and lack much character. In the living material collected for this research the following plants exemplify this well, the stomata in surface view, being almost identical, Acer Pseudo-platanus (Aceraceae), Aralia chabrieri (Araliaceae), Betula (Betulaceae), Quercus pedunculata (Cupiliflorae), Fagus sylvatica (Cupiliflorae), Myrica cordifolia (Myricaceae). Other instances of similarity of stomatal structure, when seen merely in surface view, appear in Laurus nobilis and Persea Linque (Lauraceae), also in Aralia cunninghamii and Aralia

abellii (Araliaceae).

The importance of a vertical section for a complete structural picture of the stoma is emphasized also by B. Hryniewiecki.(31),(32) This writer figures vertical sections through stomata of Compositae, Saxifragaceae and other Dicotyledonous plants. 17 species of Senecio are figured and each species is seen to have a distinct type of stomatal structure when viewed in vertical section.

But other genera of Compositae show that stomatal structure, even in complete view (surface and vertical section) cannot be used in the majority of cases for purposes of plant determination. The reasons for this conclusion follow. Eupatorium, Pluchea and Telekia have stomata so remarkably similar in vertical section that this character of the stoma alone could not distinguish one genus from another.

On the other hand dissimilarity of stomatal structure in the one plant occurs in many cases; instances of this dissimilarity have been found by B. Hryniewiecki(32) in the following plants:- Senecio sarracenicus, Senecio kleinioides, Dahlia variabilis, where, in each case, the stomatal structure on the upper epidermis of the foliage leaf is different from that on the lower epidermis of the same leaf. In Helichrysum, two

adjacent stomata on a foliage leaf differ in structure. Platanus occidentalis gives an instance of a young stoma differing very considerably in structure from a mature stoma. In Boykinia rotundifolia and Senecio articulatus the stomata of the foliage leaf are most unlike the stem stomata. This difference of stomatal structure in the one plant has been observed also by J. V. G. Loftfield;(39) this writer has noticed that "in most plants" the stomata on the lower surface of a leaf differ from those on the upper surface of the same leaf. Sugar-beet is said to be "unique" in having "similar stomata on both surfaces of the leaf". This author further says that "the stomata on the stems" of plants "usually differ materially from those of the leaves in structure and relation to water-supply."

So far it seems clear that the Structure of the Stoma is of very little, if any, use in the identification of Angiospermous and probably Gymnospermous plants.

7) The SIZE of the Stoma.

Mention has been made on page 73 of the similarity of stomatal size in the plants examined and recorded on pages 63 – 72 . Further work confirms the conclusion there set forth that the size of the stoma is of little use in plant determinations.

That the length of the stoma is the only measurement usually stable in the opening and closing of the pore is brought forward by F. E. Lloyd.[38] This writer, experimenting on Fouquieria splendens, gives measurements of the length and width of the stoma, and of the pore in the open and closed positions of a stoma. The stability of the length of the stoma is clearly shown. The measurements are as follows, the figures representing micra.

Fouquieria splendens.

	Width		Length	
	stoma	pore	stoma	pore
Experiment (a)				
Open stoma:	30	9	36	18
Closed stoma:	27	0	36	12
Experiment (b)				
Open stoma:	27	6	33	13.5
Closed stoma:	27	0	33	12

E. B. Copeland,[17] experimenting on Medeola Virginica L. and on Funaria hygrometrica, also records the stability of the length of the stoma in the opening and

closing of the guard cells. The measurements taken are as follows, the figures representing micra.

Medeola Virginica L.

	Experiment I.		Experiment II.	
	Open	Closed	Open	Closed
Length of stoma:	62	62	59	59
Width of stoma:	46	46	47.5	47.5
Width of guard-cells:	20	22 +	21	23 +
Width of pore:	6	1.5	5 +	1

Funaria hygrometrica.

	Open	Closed
Length of stoma:	45	45
Width of stoma:	35	35
Width of pore:	5	3
Depth of guard-cell:	13.7	8.4

Both these writers (F. E. Lloyd (38) and E. B. Copeland (17)) also give instances which show the instability of the length of the stoma with the opening and closing of the guard cells. F. E. Lloyd (38) shows that in Verbena ciliata the stomatal length increases with the opening of the pore; E. B. Copeland (17) shows in Dennstaedtia punctilobula Bernh. a

diminution of the length of the stoma with the opening of the pore. The measurements in micra are as follows.

Verbena ciliata.

	Width		Length	
	stoma	pore	stoma	pore
Open stoma:	36	6	36	15
Partly closed stoma:	31.5	3	33	10
Open stoma:	28	5.6	26.6	9.8
Partly closed stoma:	25	.7	25.2	5.6

Dennstaedtia punctilobula (Bernh.)

	Open	Closed
Width of stoma:	30	28.5
Width of guard-cells:	13.5 & 14	14 & 14.5
Width of pore:	2.5	0
Length of stoma:	44	45
Depth of stoma:	17	14

It is evident, therefore, that the length of the stoma may vary with the opening and closing of the guard-cells.

Dr. H. Bandulska,[3] however, appears to consider the size of the stoma important in plant determinations. This writer also mentions "average length" of stoma in many plant descriptions (see Araucarites Göpperti, Dicotylophyllum Stopesii, Dicotylophyllum sinuatum, called in this last case "average width of guard cells parallel to pore"). These "average" figures are misleading for the following reasons.

From measurements given on page 65, it is noticed that the stomatal average length in Persea gratissima and in Cinnamomum Loureirii is ·018 mm., but Persea gratissima has a wide range of lengths from ·012 mm. to ·021 mm., whereas Cinnamomum Loureirii has a constant length of ·018 mm..

Again, the average length of the stoma in Ficus vogelii (recorded on page 68) and in Ficus lyrata (page 68) is ·017 mm.. Ficus vogelii, however, has a range of lengths from ·012 mm. to ·025 mm., whereas Ficus lyrata has a constant length of ·017 mm..

The range of stomatal size on one plant, the similarity of range of stomatal size in widely different families (both facts exemplified in AEsculus Hippocastanum,

Quercus pedunculata, Myrica cordifolia, Persea Linque, Laurus nobilis), the occurrence of approximately the same stomatal size in different genera (exemplified in Cinnamomum camphora, Litsaea ferruginea, Myrica rubra, Myrica californica) are all points which show that Stomatal Size can be of very little use in the diagnosis of plants.

In the tabulated results on pages 103 and 105 it is interesting to notice the change in length of the pore as the guard cells open and close. The increasing length of the pore as the stoma opens has been figured by F. E. Lloyd,(38) whose diagrams clearly show that readings of "length of stomatal pore" are useless unless it can be proved that the pore is open to its widest extent. Dr. H. Bandulska's(3) descriptions of Araucaria and Sequoia species of Sequoia contain readings of length ("long axis") of stomatal pore, but there is no mention that the widest aperture has been ensured; these readings would appear therefore to be of little diagnostic value.

Experimental work was then carried out to test the stability or instability of Stomatal Size with

I. Various "after-treatments" of the epidermis.

II. Various changes in the environment.

I. "After-treatments" of the Epidermis.

Two mature foliage leaves of each of the following plants, (i) Quercus pedunculata, (ii) Fagus sylvatica, (iii) Betula, and (iv) AEsculus Hippocastanum were plucked from the tree and immediately measured. They were kept in a cool, shaded and still atmosphere and deprived of an intake of liquid. After a week the same leaves were measured again and in each case a marked shrinkage of the lamina was recorded. The measurements taken in mm. were as follows.

	Specimen A		Specimen B		
	Lamina		Lamina		
	Length	Breadth	Length	Breadth	
(i) Quercus pedunculata.	107	55	91	46.5	July 10.
	104.5	52.5	88.5	44.5	July 17.
(ii) Fagus sylvatica.	68	52	72.5	55	July 10.
	64	54.5	69.5	52.3	July 17.

	Specimen A		Specimen B		
	Lamina		Lamina		
	Length	Breadth	Length	Breadth	
(iii) Betula.	51	40.5	49.5	45.5	July 10.
	47	34	47	39	July 17.
(iv) AEsculus Hippocastanum.	194	94	177.5	81.5	July 10.
	187	86	172	76	July 17.

With this evidence of external shrinkage of the lamina at hand one wondered whether an internal shrinkage of the lamina cells had also taken place, and, if so, whether the contraction varied with the treatment of the leaf after being plucked from the plant. Various "after-treatments" were then tried.

1) A small area near the mid-rib at the base of a mature shade-leaf of Quercus pedunculata was rapidly cut out whilst the leaf was attached to the tree. The excised area was immediately plunged into absolute alcohol. This process was followed (when convenient) by the "boiling nitric acid" method (see page 59) to separate the epidermis.

2) An area similar in all respects to that used in the first "after-treatment" was selected on another

mature shade-leaf of the same tree (Quercus pedunculata). Again this area was rapidly cut out from the leaf whilst the organ was attached to the tree, and, as rapidly as possible, plunged into nitric acid. The separation and mounting of the lower and upper epidermis was continued as in the first case.

3) An excised area, similar in all respects to the former, was allowed to shrink in a cool, dry atmosphere. It was then boiled in nitric acid and the process continued as in the "after-treatments" one and two.

Two other examples of Quercus pedunculata were selected and mature shade-leaves given the same 3 "after-treatments" mentioned above.

Epidermis of Fagus sylvatica, AEsculus Hippocastanum and Acer Pseudo-platanus were then worked in exactly the same way.

These trees yielded similar results in all cases. The ordinary epidermal cell had not appeared to change in size, and the degree of sinuation of the cell wall was stable; the stomata, also, were unchanged in size and shape.

The observations of S. H. Eckerson[21] support the above result that there is no appreciable difference in the size of the cells with varying "After-treatments." This writer removed pieces of epidermis from different parts of full-grown representative leaves and dropped them immediately into absolute alcohol. Many comparisons were made between data yielded by these "fixed" and other "unfixed" specimens; no particular difference in size of the cells was noticed.

On the other hand F. E. Lloyd[36] maintains with Von Mohl that stomata mounted in water "suffer sudden changes in contour." Verbena ciliata, for example, has stomata which suddenly enlarge their transverse (tangential) measurements when water reaches them. But if, on plucking, the material has been at once submerged in absolute alcohol, these stomata do not show changes in form when in contact with water. Direct observations on Fouquieria splendens have also been made by this writer, and it is apparent that the size of the stomata, as well as their form, remain unchanged if the material is at once plunged into absolute alcohol after plucking. Czeck[38] (1869) also agrees with these results.

Lloyd[38] adds that the "slight shrinkage of general dimensions" which takes place upon removal of a piece of

epidermis must have an "exceedingly small" effect upon the condition of the stoma. As a safe-guard against shrinkage, however small the shrinkage may be, Lloyd (38) proposes the general use of a fixing agent, to be applied to "removed" epidermis, not to the whole plucked leaf. The "removing" of the epidermis allows immediate free access of the fixing agent to the stomata and they are "fixed" (if open) in an open position. If the fixing agent has to traverse a large part of the leaf between the lower and upper epidermis before reaching the stomata, it must necessarily be much diluted by the water in the leaf and its "fixing" power consequently reduced. This slow fixation of a stoma may cause a gradual withdrawal of the water from the guard cells and hence a closed or closing position of the stoma, thus reducing the size to some extent.

Dr. E. M. Delf's work on halophytes also brings out the importance of "fixing" material immediately after severance from the parent organ. If this material is "unfixed", the shrinkage of the cells is great. The shrinkage in this group of plants is attributed to the lack of cutin in the epidermis. This conclusion can well be extended to other types of plants and most probably accounts for the alteration in size of the stoma with the opening and closing of the guard-cells in such poorly

cutinized epidermis as occurs in Verbena ciliata, as well as for the stability of stomatal size with varying after-treatments in such well cutinized material as Quercus, etc.

II. Various Changes in the Environment.

(1) The amount of CO_2 in the air surrounding the plant.

J. B. Farmer[14] and S. E. Chandler[14] working on plants surrounded by an excess of CO_2 (3.5 times the normal amount of CO_2 present in air) and comparing the form and internal structure of such plants with similar ones grown in air containing a normal per cent. of CO_2 (3.29 parts of CO_2 in 10,000 volumes of air) report on the stability of stomatal size. They state that the guard-cells of the "CO_2" and of the "normal" plants are approximately the same size. If there is any difference between the two plants, the guard-cells of the plant grown in CO_2 "excess" are the greater.

(2) The amount of Light falling on the lamina.

The material prepared for the observations on the value of simuation (pages 79-84) was used also for this enquiry.

Sun- and shade-leaves of AEsculus Hippocastanum,

Fagus sylvatica, Quercus pedunculata and Acer Pseudo-platanus were fixed in absolute alcohol and stomatal measurements taken. The figures so obtained are as follows.

AEsculus Hippocastanum.

		Length of stoma. mm	Breadth of stoma. mm	Breadth of stomatal pore. mm
Sun-leaf A.	No. 1)	.024	.009	closed
	" 2)	.027	.012	.003
	" 3)	.033	.012	.003
	" 4)	.018	.006	closed
	" 5)	.024	.006	closed
Shade-leaf A.	" 1)	.033	.012	closed
	" 2)	.018	.009	closed
	" 3)	.021	.012	closed
	" 4)	.018	.006	closed
	" 5)	.024	.009	closed
Sun-leaf B.	" 1)	.024	.012	closed
	" 2)	.024	.012	closed
	" 3)	.024	.012	closed
	" 4)	.03	.015	closed
	" 5)	.03	.012	closed
	" 6)	.027	.015	closed
	" 7)	.024	.009	closed

AEsculus Hippocastanum (cont'd).		Length of stoma. mm	Breadth of stoma. mm	Breadth of stomatal pore. mm
Shade-leaf B.	No. 1)	.024	.012	closed
	" 2)	.024	.012	closed
	" 3)	.03	.012	.003-
	" 4)	.03	.009	closed
	" 5)	.03	.012	closed
	" 6)	.024	.009	closed
	" 7)	.03	.018	closed
	" 8)	.021	.009	closed
Fagus sylvatica.				
Sun-leaf A.	No. 1)	.036	.03	closed
	" 2)	.033	.03	closed
	" 3)	.036	.036	closed
	" 4)	.024	.018	closed
	" 5)	.024	.021	closed
Shade-leaf A.	" 1)	.024	.018	closed
	" 2)	.024	.021	closed
	" 3)	.024	.021	closed

Fagus sylvatica (cont'd).		Length of stoma. mm	Breadth of stoma. mm	Breadth of stomatal pore. mm
Sun-leaf B.	No. 1)	.03	.024	closed
	" 2)	.03	.021	closed
	" 3)	.033	.024	closed
	" 4)	.024	.024	closed
	" 5)	.024	.018	closed
	" 6)	.018	.024	closed
	" 7)	.024	.024	closed
	" 8)	.03	.018	closed
Shade-leaf B.	No. 1)	.036	.024	closed
	" 2)	.012	.012	closed
	" 3)	.024	.024	closed
	" 4)	.024	.024	closed
	" 5)	.024	.024	closed
	" 6)	.024	.021	closed
	" 7)	.024	.018	closed
	" 8)	.024	.021	closed

Quercus pedunculata.

		Length of stoma. mm	Breadth of stoma. mm	Breadth of stomatal pore. mm
Sun-leaf A.	No. 1)	.03	.024	closed
	" 2)	.036	.021	closed
	" 3)	.03	.024	closed
	" 4)	.024	.024	closed
	" 5)	.024	.024	closed
	" 6)	.03	.024	closed
Shade-leaf A.	" 1)	.027	.015	.003 ?
	" 2)	.024	.015	closed
	" 3)	.027	.024	closed
	" 4)	.027	.018	.003
	" 5)	.03	.024	closed
	" 6)	.024-	.012	closed
Sun-leaf B.	" 1)	.03	.024	closed
	" 2)	.036	.024	closed
	" 3)	.027	.018	closed
	" 4)	.03	.03	closed
	" 5)	.03	.03	closed
	" 6)	.024	.021	closed
	" 7)	.036	.033	closed

Quercus pedunculata (cont'd).		Length of stoma. mm	Breadth of stoma. mm	Breadth of stomatal pore. mm
Shade-leaf B.	No. 1)	.024	.018	closed
	" 2)	.021	.018	closed
	" 3)	.03	.024	closed
	" 4)	.024	.012	closed
	" 5)	.024	.018	closed
	" 6)	.024-	.018	closed
	" 7)	.03	.015	closed
Acer Pseudo-platanus.				
Sun-leaf A.	No. 1)	.027	.024	closed
	" 2)	.03	.024	closed
	" 3)	.03	.024	closed
	" 4)	.024	.021	closed
	" 5)	.027	.018	closed
	" 6)	.024	.024	closed
	" 7)	.024	.024	closed
	" 8)	.024	.018	closed

Acer Pseudo-platanus.
(cont'd).

		Length of stoma. mm	Breadth of stoma. mm	Breadth of stomatal pore. mm
Shade-leaf A.	No. 1)	.024	.018	closed
	" 2)	.024	.015	closed
	" 3)	.024	.018	closed
	" 4)	.03	.015	closed
	" 5)	.027	.024	closed
	" 6)	.027	.021	.003-
Sun-leaf B.	" 1)	.024	.024	closed
	" 2)	.024	.018	closed
	" 3)	.027	.018	closed
	" 4)	.024	.018	closed
	" 5)	.024	.024	closed
Shade-leaf B.	" 1)	.024	.018	closed
	" 2)	.024	.018	closed
	" 3)	.024	.018	closed
	" 4)	.024	.024	closed
	" 5)	.024	.018	closed
	" 6)	.027	.015	closed

It is noticeable from these figures that the range of stomatal measurements is very much the same for sun- and shade-leaves on the one tree. (In the shade-leaves of Fagus A, there was an exceptionally small area to examine owing to difficulties in mounting, hence these figures may not represent the true range of stomatal size. In Quercus B, the shade-leaves appear to have smaller stomata than the sun-leaves, but the difference of size in these 2 leaves is so small that this observation can be of no great importance).

L. Kny,(35) also working on the sun- and shade-leaves of Fagus sylvatica, figures epidermis from both types of leaves. Again the stomata are remarkably similar in size in both kinds of leaves.

From the above observations it seems apparent that the size of the stoma is stable for different intensities of sunlight.

E. J. Salisbury,(51) however, has found that the stomata on shade-leaves are larger than those on the sun-leaves of the same plant.

(3) The amount of Moisture and Heat in the environment.

J. V. G. Loftfield(39) observing leaves of Malva rotundifolia produced during the hot, dry weather of the first

part of July 1916 and comparing them with those produced a month earlier, remarks on the different size of the stomata in the 2 leaves. The average length of the July stoma was 6.1 μ., whilst that of June was 7.9 μ..

E. J. Salisbury (51) finds in connection with a woodland flora that a plant grown in a moist habitat has larger stomata than the same species grown in a dry habitat.

To summarise the last investigations (pages 108-121), there appears to be stability in the size of the stoma with varying "after-treatments" as long as there is cutin present in the epidermal tissue; with no cuticularisation, the tissue shrinks on removal from the plant organ. This shrinkage may be avoided in the usual way by submerging the tissue in absolute alcohol.

With varying proportions of carbon dioxide in the air surrounding the plant there is probably stability of stomatal size; differences in light intensity and differences in the amount of moisture and heat in the environment seem to bring about an alteration in stomatal size in the same plant species.

These conclusions show that Stomatal Size is of no use in the diagnosis of plants, though occasionally something

may be learnt from this character of the stoma about the conditions under which the organ grew.

The Use of Combining Epidermal and External Plant Characters for the Determination of Plant Families, Genera and Species.

Finding the microscopic epidermal characters of no general use in the diagnosis of plants, I next considered if the microscopic features in combination with the external features of form and venation would yield the apparently satisfactory determinations that are forthcoming in present day work.

In order to select the most valuable microscopic characters of the epidermis it is best to glance back at pages 74 - 121 . Here it has been shown that the External Glands and Hairs of Angiospermous material are of no use in determinative work. The Ordinary Epidermal Cells between the stomata have been shown to change in shape, size, situation of the cell-wall and thickness of the cell-wall with varying external conditions; they are unstable, therefore, and are consequently of little value in the diagnosis of plants. The remaining epidermal feature, the Stoma, appears to have only one character (particularly in cases where the subsidiary cells are absent, as is very usual), the

structure, which perhaps is of sufficient importance for diagnostic work.

Combining, then, stomatal structure with external form and veining, investigations were made to find out if this combination were satisfactory for plant diagnosis.

As vertical sections of the epidermis of plants of Lower Bagshot age have so far proved unsuccessful in taxonomic work, surface views of fossil epidermis are the only means of studying the structure of stomata. Since the present investigations of modern epidermis were being carried out to assist in the identification of the fossil epidermis, the character "stomatal structure" mentioned in the last paragraph includes only surface views of the epidermis.

Here it is unnecessary to quote the numerous instances of similarity of stomatal structure (surface view only), leaf-form and venation found in Angiospermous material alone, hence even a Combination of Epidermal with External Plant Characters fails to diagnose very many plant families, genera and species.

CONCLUSIONS.

From the evidence adduced above, it would appear that the vegetative parts of Angiospermous plants are clearly inadequate for the purpose of specific diagnosis.

Since the conditions causing variation in the Angiospermous leaf are equally applicable to other plant groups, a similar conclusion seems justifiable for plants in general. Where special surface features characterise any group of plants, the case is of course different.

The general result would follow, that diagnoses of fossil plants from epidermal leaf characters alone seem quite inadequate. While not unexpected, this is unfortunate, as little confidence can be placed in the specific determination of fossil plants when only fragmentary parts of leaves and stems are preserved.

In consequence I have refrained from giving names to the fossil epidermis from the Lower Bagshot Pipe-Clays of Poole District, Dorset, which are described in the early part of this dissertation.

SUMMARY.

The first part of the paper is an account of 5 kinds of fossils collected from the Lower Bagshot Pipe-Clay around Poole Harbour, Dorset. The material includes carbonized, pyritized, ferruginous, epidermal and woody remains.

The clay matrix peculiar to each type of fossil and the geological horizon of these clays in the four more important clay-pits is described in detail.

As macroscopic observations prove insufficient for the identification of the fossil material, preparative work for microscopic investigation is attempted. Success in the treatment of the fossil epidermis enabled sixteen types to be differentiated.

An attempt is then made to identify the fossil epidermis by comparison with epidermis of possible modern representatives of the Lower Bagshot flora.

The second part of the paper is a critical examination of the diagnostic value of the epidermal tissue.

External Glands and Hairs are found useless for this purpose.

The Ordinary Epidermal Cell is next considered;

the characters examined are the shape and size of the cell, the outline and thickness of the cell-wall. Each character is found to vary on a single species, being largely controlled by external conditions.

An examination of the Stomata shows that their number, size and level in the epidermal tissue are unstable; their general arrangement conforms only to two types, each of widespread occurrence; subsidiary cells are only very rarely characteristic of a genus. The only remaining character, the structure, is extremely weak from a diagnostic point of view; indeed, where vertical sections of the stoma are impossible, as is the case with epidermis of Lower Bagshot age, this character is of no consequence.

Finally, the most stable part of the epidermis (stomatal structure, surface view only) is combined with external characters of form and venation. This combination is found useless for the diagnosis of very many Angiospermous plants. Consequently, no names have been suggested for the fossil plants from Poole.

ACKNOWLEDGMENTS.

I should like to tender my thanks and gratitude to Professor W. T. Gordon for his invaluable help and sympathetic encouragement throughout the whole period of research.

I have also received very kind help from Dr. E. M. Delf and from Mr. L. A. Boodle.

The Director of Kew Gardens has most kindly provided me with modern plants from time to time, and this has naturally much facilitated my work.

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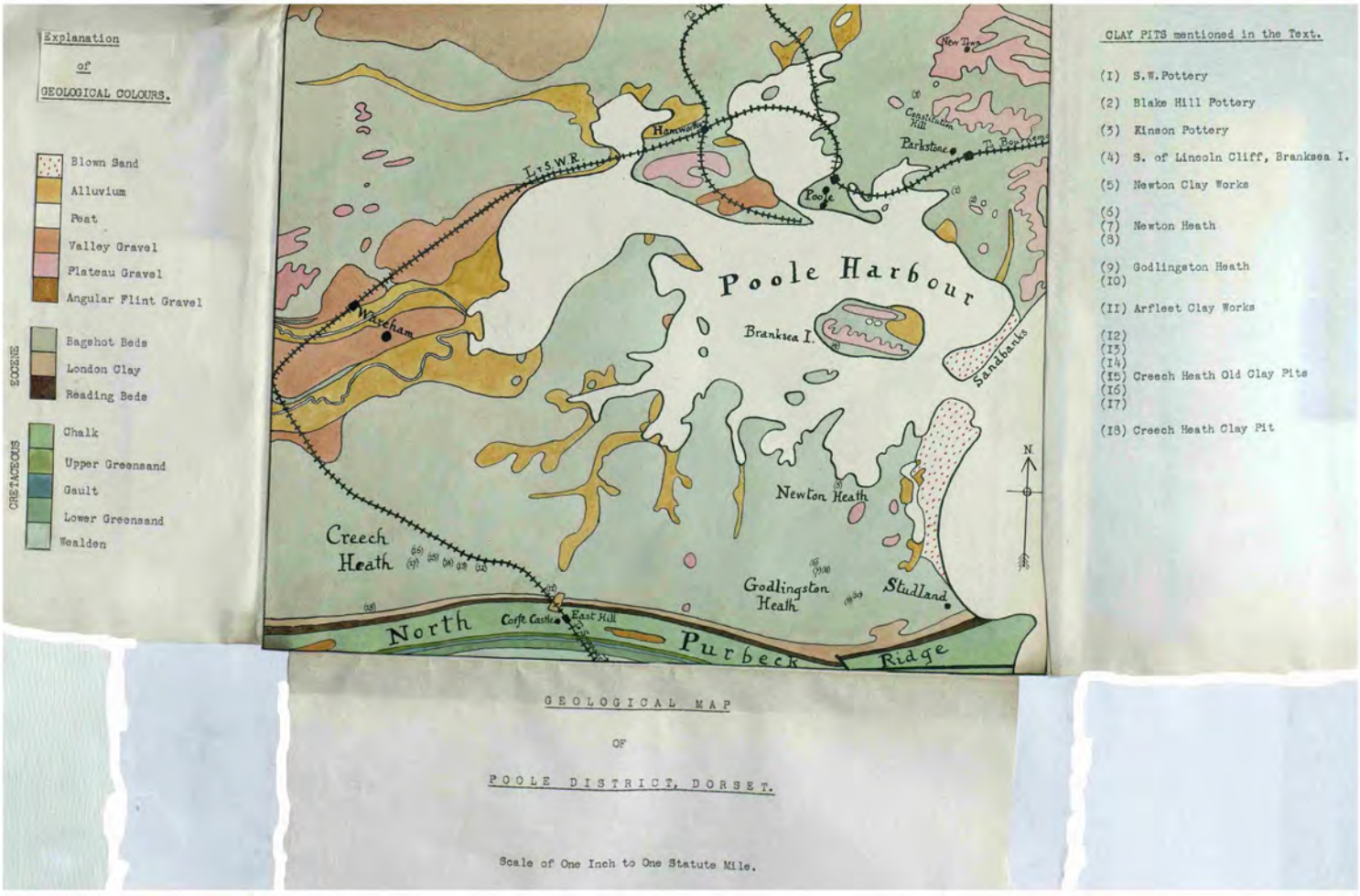


GEOLOGICAL MAP

OF

POOLE DISTRICT, DORSET.

Scale of One Inch to One Statute Mile.

Explanation of the Plates

Plate I.

Figure 1. Fossil Epidermis. Type A. ×175. Showing Stomata and 4 Hair-bases. (See pages 29 and 30.)

Figure 2. Fossil Epidermis. Type B. ×175. Showing Stomata and thickened areas around Hair-bases. (See pages 31 and 32.)

Figure 3. Fossil Epidermis. Type C. ×175. Showing Epidermal Cells with finely sinuate outline. (See page 33.)

Figure 4. Fossil Epidermis. Type D. ×175. Showing Stomata and epidermal area over Vein. (See pages 34 and 35.)

Plate II.

Figure 5. Fossil Epidermis. Type E. ×175. Showing Epidermal Cells with strongly sinuate outline (See page 36.)

Figure 6. Fossil Epidermis. Type F. ×175. Showing small and large Stomata and numerous Hair-bases. (See pages 37 and 38.)

Figure 7. Fossil Epidermis. Type G. ×175. Showing Stomata and epidermal area over Vein. (See pages 39 and 40.)

Figure 8. Fossil Epidermis. Type H. ×175. Showing very small Stomata sunken in epidermis and their nearly parallel orientation. (See pages 41 & 42.)

Plate III.

Figure 9. Fossil Epidermis. Type I. x145. Showing Epidermal Cells with very finely sinuate outline. (See page 43.)

Figure 10. Fossil Epidermis. Type J. x145. Showing Epidermal Cells with sinuate outline and thick walls. (See page 44.)

Figure 11. Fossil Epidermis. Type K. x145. Showing numerous, very small Stomata with irregular orientation and Hair-bases over Vein on right side of the photograph. (See pages 45 and 46.)

Figure 12. Fossil Epidermis. Type L. x145. Showing numerous, closed Stomata. (See pages 47 and 48.)

Plate IV.

Figure 13. Fossil Epidermis. Type L. x145. Showing numerous, closed Stomata and epidermal area over Vein. (See pages 47 and 48.)

Figure 14. Fossil Epidermis. Type M. x145. Showing Double and Single Stomata and characteristic elongated epidermal cells. (See pages 49+50)

Figure 15. Fossil Epidermis. Type N. x145. Showing Single Stomata (similar to Type M.) and characteristic elongated epidermal cells. (See page 51.)

Figure 16. Fossil Epidermis. Type O. x145. Showing Epidermal Cells with straight outline and probable Hair-bases. (See page 52.)

Plate I.

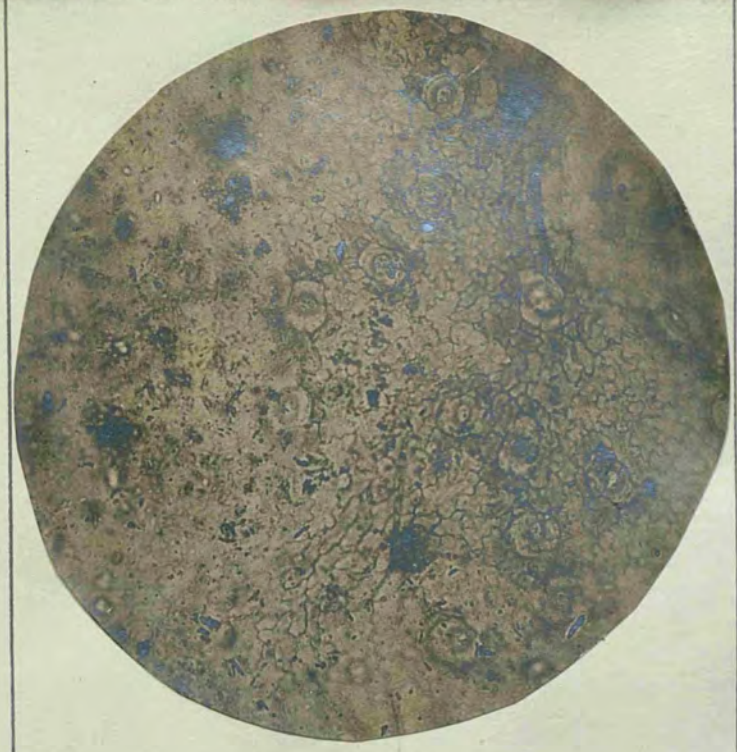


Figure 1.

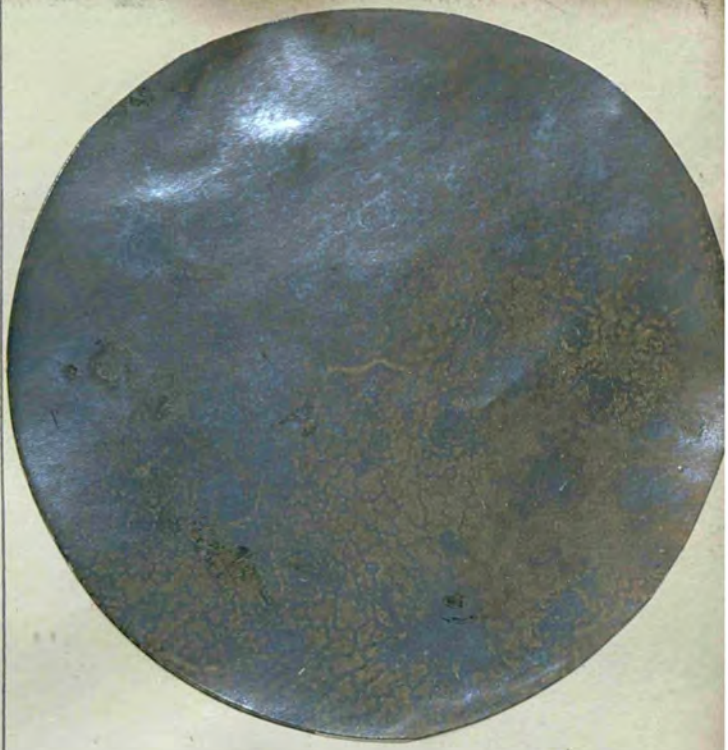


Figure 2.

Figure 3.

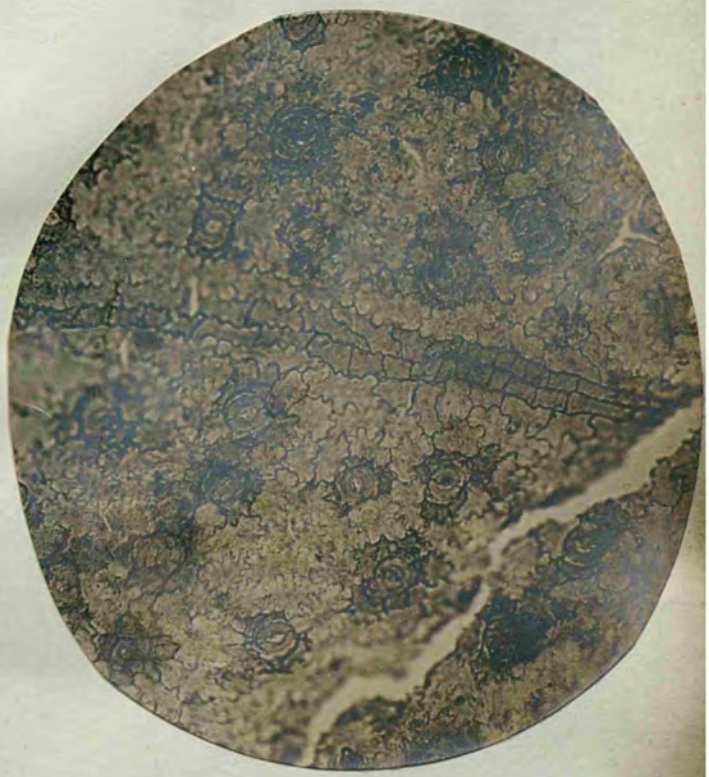


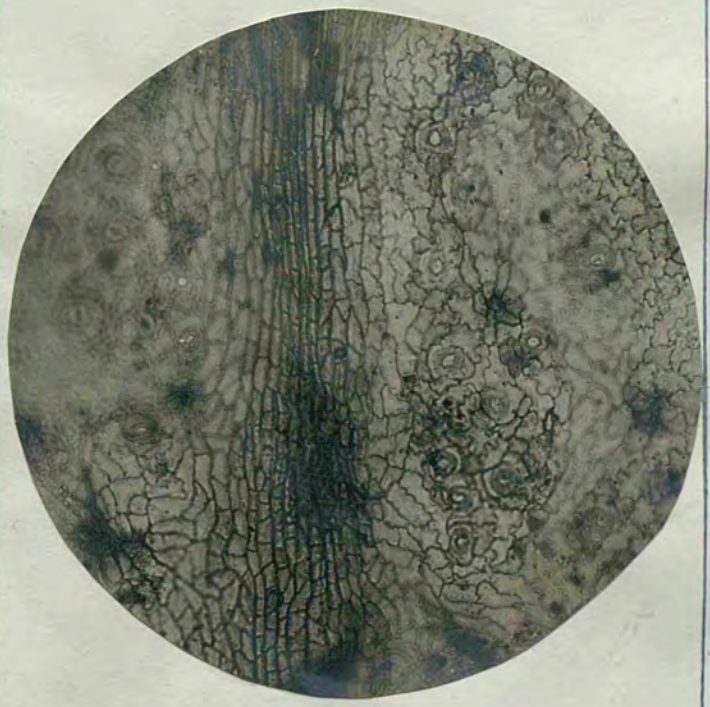
Figure 4.

Fossil Epidermis

Plate II.

Figure 5.

Figure 6.



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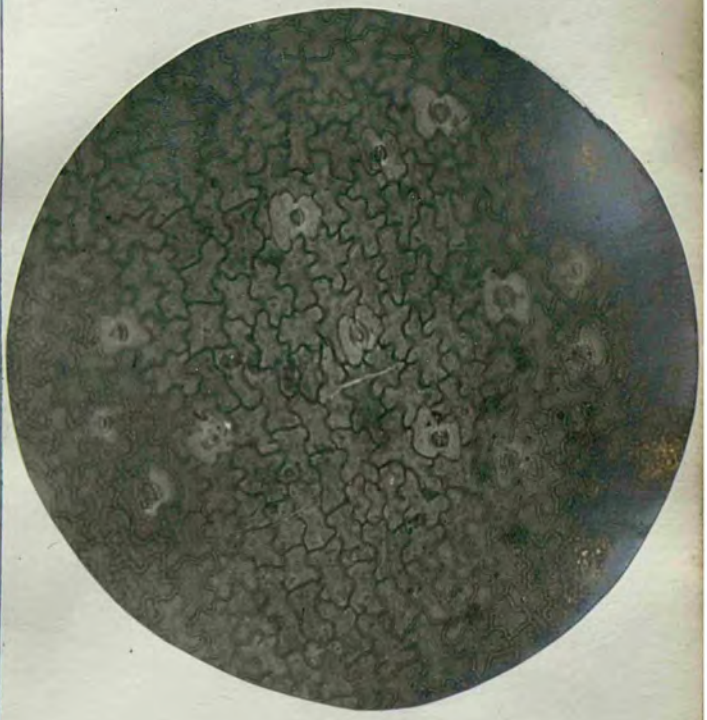


Figure 8.

Fossil Epidermis

Plate III.

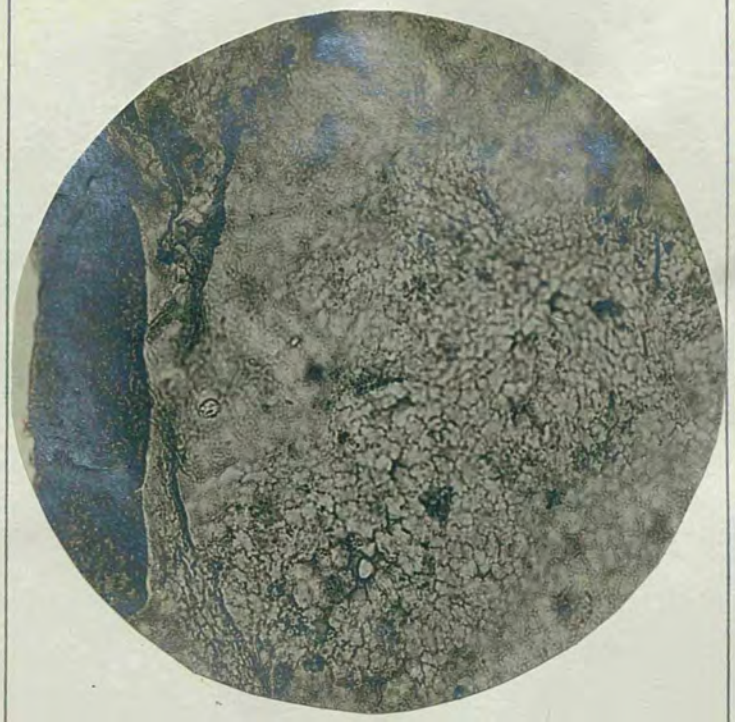
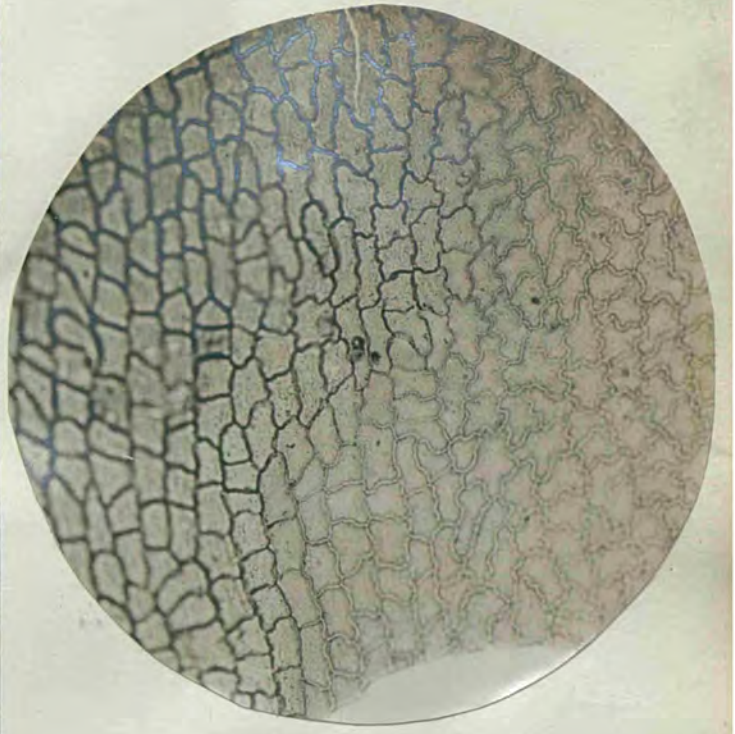


Figure 9.



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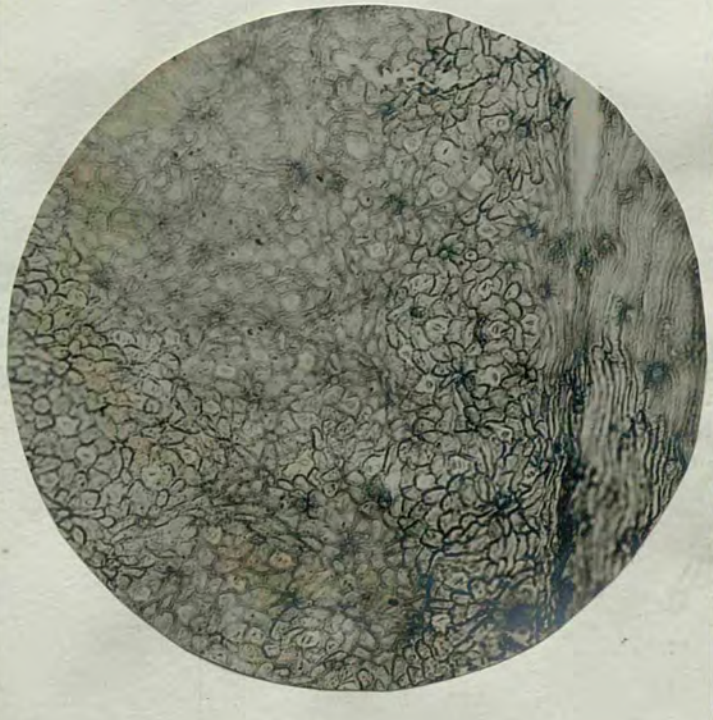

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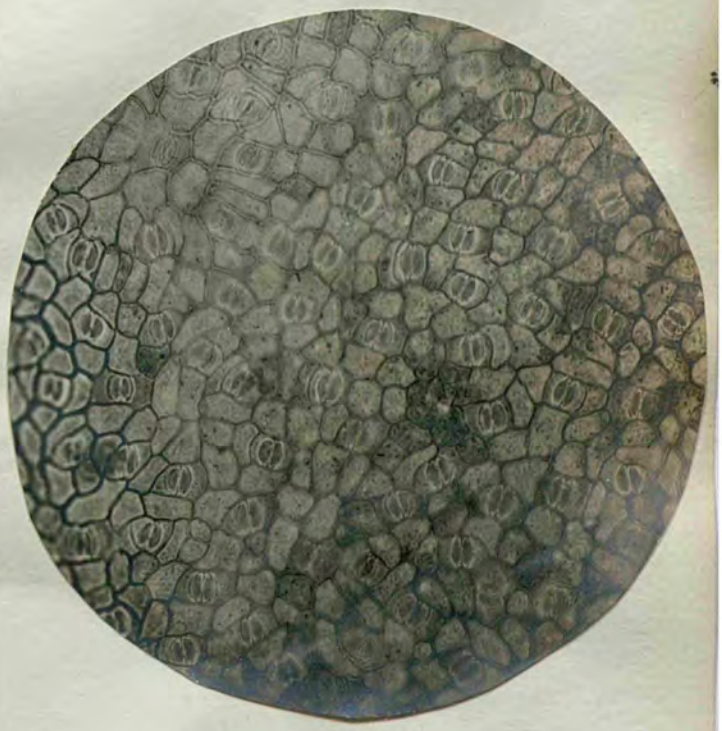

Figure 12.

Fossil Epidermis

Plate IV.

Figure 13.

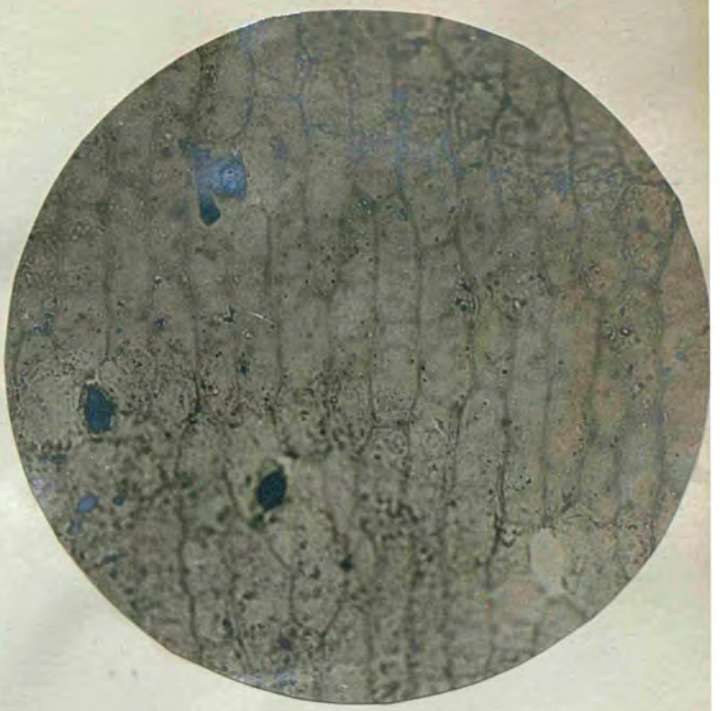

Figure 14.

Figure 15.

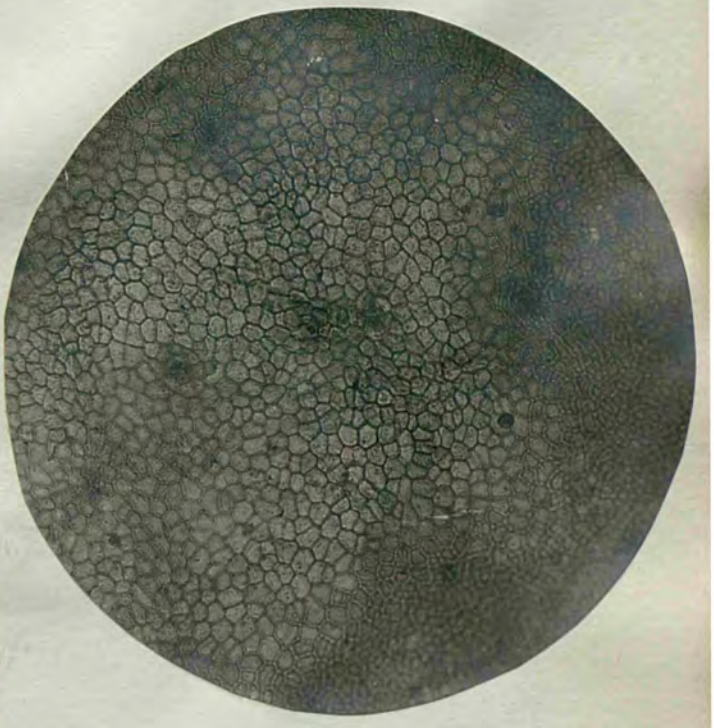

Figure 16.

Fossil Epidermis