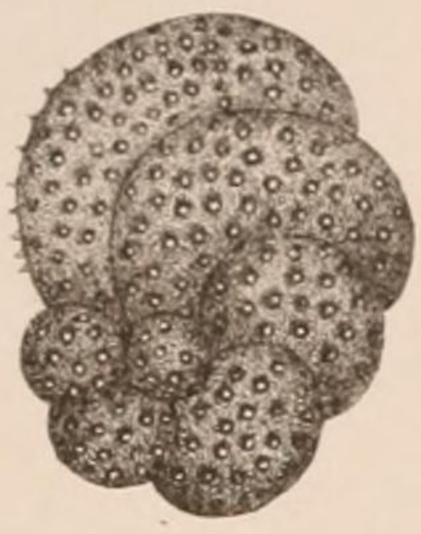

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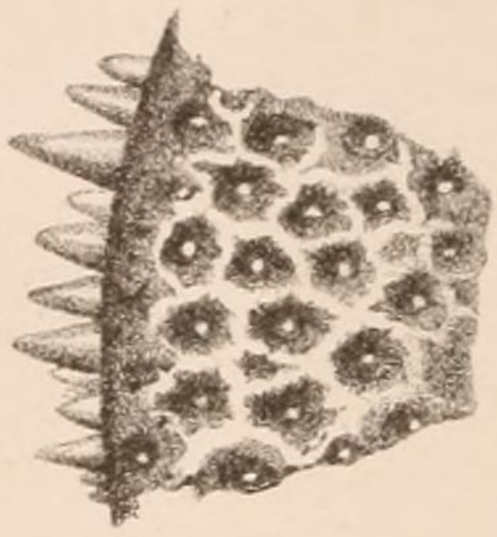

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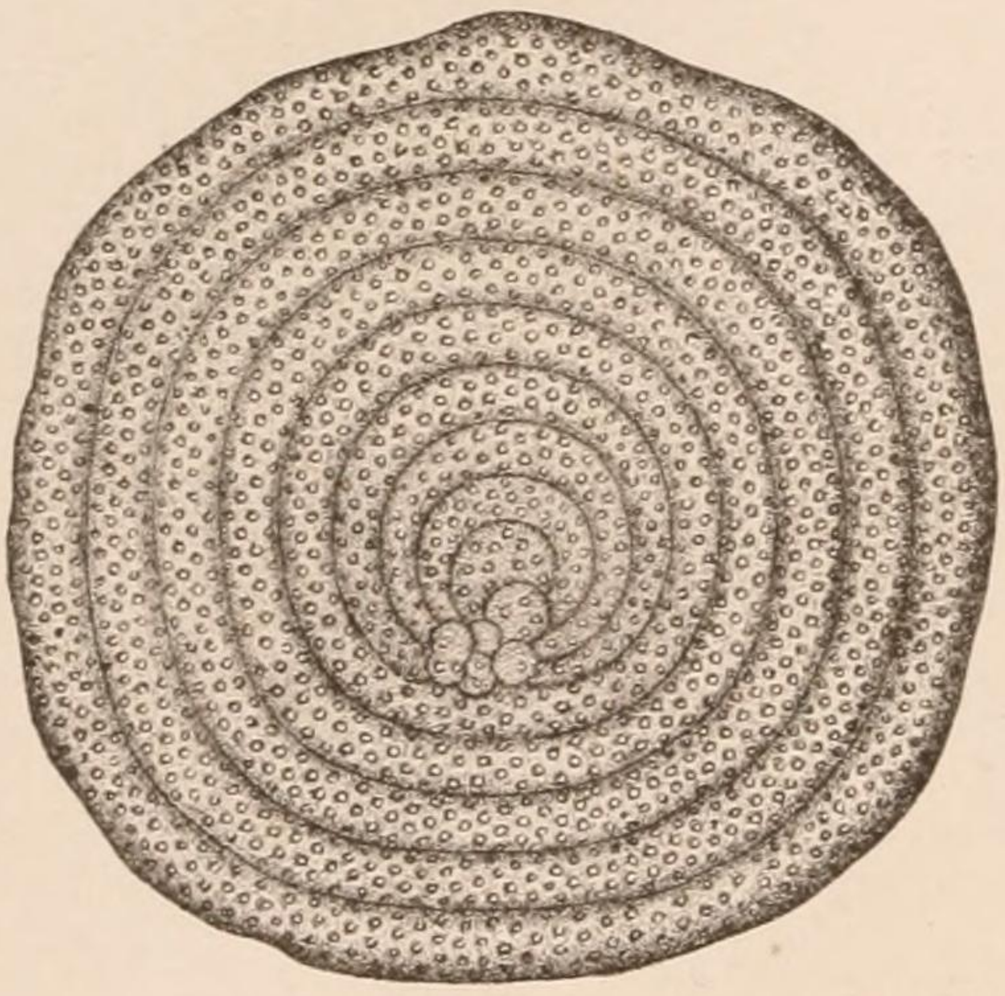

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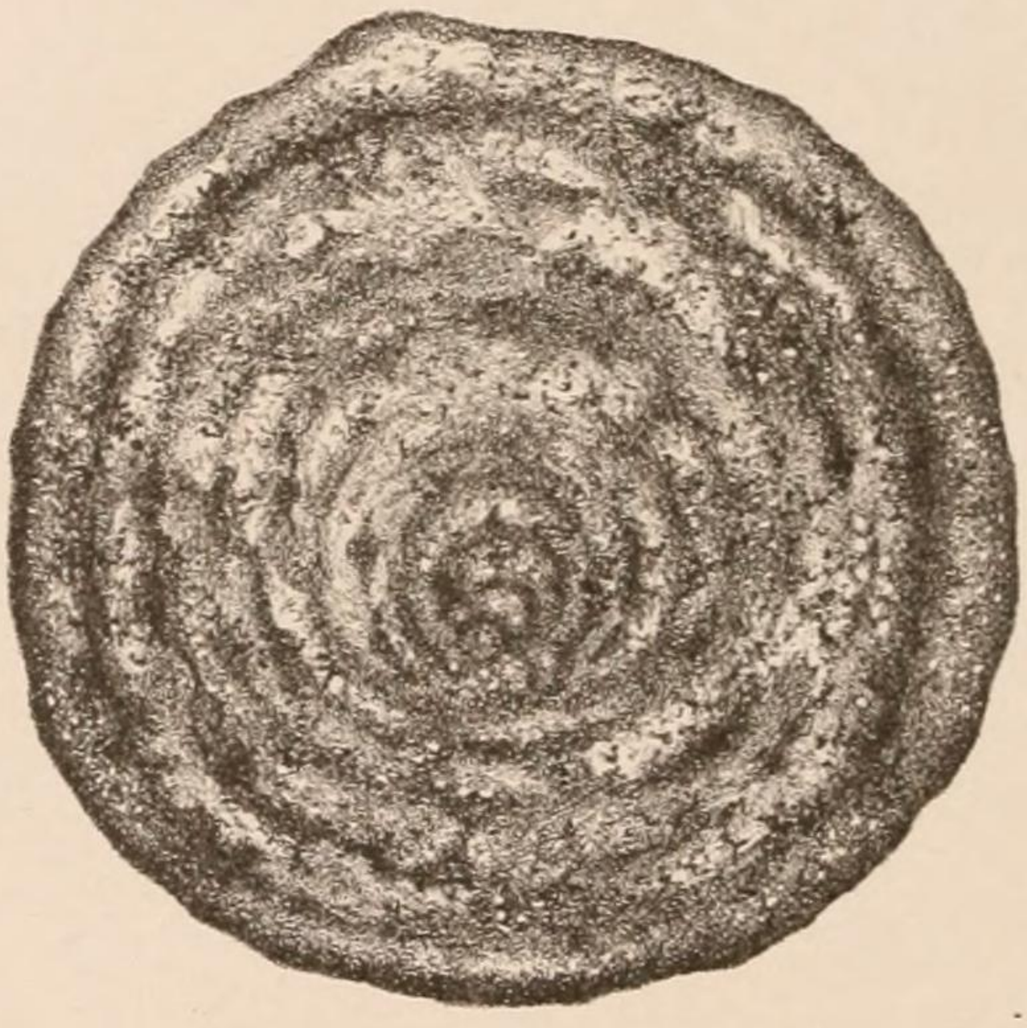

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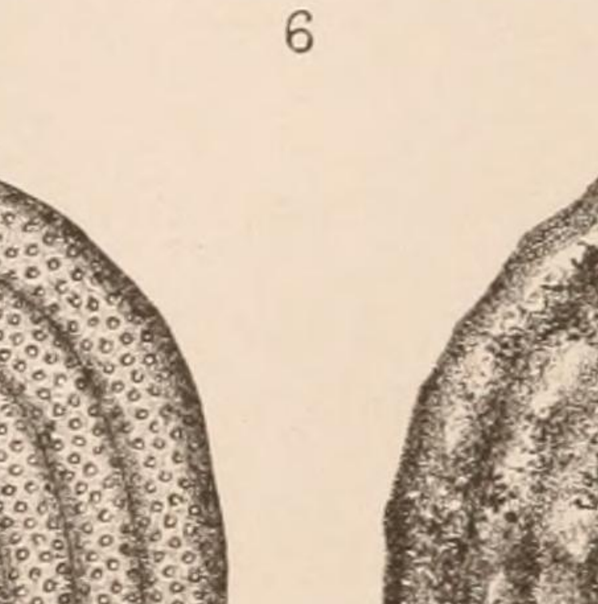

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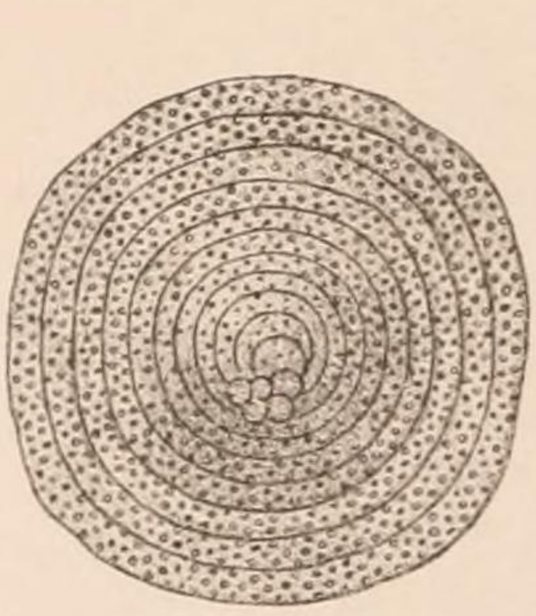

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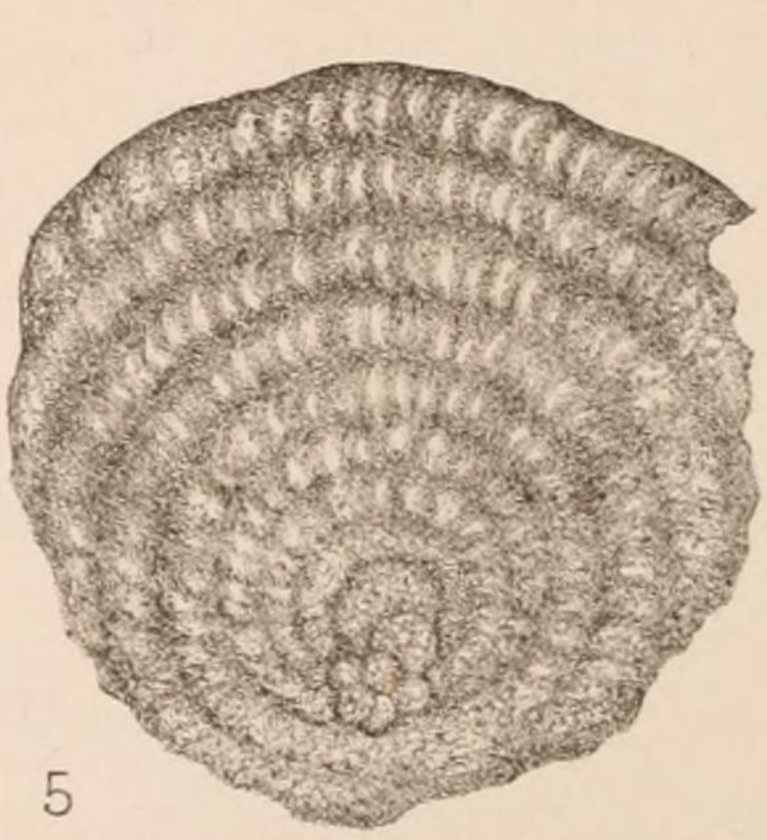

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J.A.Lovegrove del. West.Newman lith.

Cycloloculina.

JOURNAL

OF THE

ROYAL MICROSCOPICAL SOCIETY.

OCTOBER, 1908.

TRANSACTIONS OF THE SOCIETY.

XV.—*On Cycloloculina, a New Generic Type of the Foraminifera.*

With a Preliminary Study of the Foraminiferous Deposits and Shore-sands of Selsey Bill.

By Edward Heron-Allen, F.L.S. F.R.M.S.,
and Arthur Earland.

(*Read June* 17, 1908.)

Plate XII.

Introductory Note by Edward Heron-Allen.

I opine that if there might be a special heaven for Rhizopodists, it would be one whose leading feature would be a calm sea, in the surface waters of which a record number of living, pelagic Foraminifera might be gathered in the terminal bottle of a common tow-net. If this may be postulated as the Walhalla of the student

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EXPLANATION OF PLATE XII.

Fig. 1.—*Cycloloculina annulata* sp. n. 1st or discorbine stage. × 96. Balsam mount.
,, 2.—Ditto. 2nd or pavonine stage. × 60. Balsam mount.
,, 3.—Ditto. 3rd or annular stage. × 48. Balsam mount.
,, 4.—Ditto. 3rd or annular stage. × 48. Coarse specimen. Opaque mount.
,, 5.—Ditto. 3rd or annular stage (fragment). × 48. Hyaline specimen. Opaque mount. To show the crenulated surface of chambers.
,, 6.—Ditto. Detail showing spines on septal face of chamber. × 290.
,, 7.—Ditto. Detail showing areolated structure round the tubuli. × 290.
,, 8.—*Cycloloculina polygyra* sp. n. 3rd or annular stage. × 48. Balsam mount.

of the Foraminifera, his Niffelheim may certainly be found in the material which, for the past year, has occupied my leisure moments, and the appellate jurisdiction of my friend and collaborator, Arthur Earland. I refer to the material which may be scraped at any time, between tide-marks, from the surface of the shore sand of Selsey Bill, which extends from the point of the Bill north-westwards, through Bracklesham Bay, to the brackish waters of Chichester Harbour, opposite Hayling Island and the Isle of Wight. When first I suggested devoting my attention to this material to Mr. F. W. Millett, he returned me a highly characteristic answer, and one which would have seriously damped the ardour of a beginner. He said: "The specimens of Foraminifera are interesting, but I cannot quite see how you are to make a useful monograph out of this jumble of fossils washed out of uncertain beds from unknown localities."

In the beginning I found Mr. Earland at one with him, but as I continued doggedly upon the quest, Mr. Earland came round to my view that this is, perhaps, the most remarkable and suggestive foraminiferous deposit to be found in the British Islands. The completed study of the Foraminifera of the locality, we hope to lay before the Society at a future date, but it has seemed good to us to introduce the subject, with a paper upon a most interesting form continually recurrent in the material, which, at first, we were disposed to regard as a new species of *Planorbulina*, but which we have gradually been forced to recognise as a new genus, for which we propose the generic name of *Cycloloculina*, and which we have the honour to lay before you in two species, named respectively *Cycloloculina annulata* and *C. polygyra*.

It will not be impertinent to the consideration of the genus to devote a few moments to the history of its discovery. Selsey Bill is the peninsula resembling, as it were, an "uvula" dependent from the extreme south-west of Sussex, a few miles only from the borders of Hampshire; and there is probably no locality upon the coast lines of Great Britain which has attracted in a greater degree the earnest attention of geologists. It may be said at once that the whole of the district under consideration, forms part of the most noteworthy of the raised beaches which occupied the attention of Professor Prestwich, and were so learnedly and lucidly described and discussed by him in the 'Quarterly Journal' of the Geological Society in 1892.* For the purpose of this paper, the geological interest of this shore commences at Bracklesham Farm, which is situate just beyond the western boundary of the Geological Survey's Map, Sheet 332, and opposite which lies the great bank of Eocene fossils which is exposed at low tide, and is composed of agglome-

* This raised beach extends from Brighton on the east, to Portsmouth on the west, and includes the whole district south of a line drawn from Portslade through Arundel to Havant (Postscript, No. 11).

rated masses of *Cardita* (*Venericardia*) *planicosta* and *acuticosta*, digging through which, one finds an equally rich bed of the large *Cyprœa tuberculosa*. This bed reappears on the eastern side of the Bill, opposite the now reclaimed Pagham Harbour, where cockles have been gathered from time immemorial, and have achieved a reputation to which testimony was borne by Izaak Walton, who records that there are four good things in Sussex, "a Selsey cockle, a Chichester lobster, an Arundel mullet, and an Amberley trout."* Proceeding south-eastwards, we arrive at the *Turritella* beds of Earnley, beds which dip under the peninsula, and (like the *Cardita* beds) reappear on the eastern side of the Bill, opposite Park Farm. Further on, just before we reach Thorney Farm, we find the shore, at low tide, literally strewn with the little disks of *Nummulites lævigatus*, whilst, opposite Thorney Farm, we find Eocene deposits at the extreme limit of low tides in which the gigantic shells, often two feet in length, of *Cerithium giganteum* are not uncommon. The next, and, to us, a most interesting deposit, is found immediately in front of Medmerry Farm, now ruined by the encroachment of the sea, where a spit of Post-Pliocene mud (a Pleistocene, or Post-Tertiary deposit), runs out to sea, which can easily be examined at spring tides, and is extraordinarily rich in fossil Foraminifera. The question as to whether these are *in situ*, or derived, or partly derived and partly *in situ*, we must leave for discussion when we present to the Society the completed results of our work upon the Selsey shore sands. Between Medmerry Farm and the Thorney Coastguard Station, a high bank of recent shingle, heaped up against the Raised Beach and the Coombe Rock, Mr. Clement Reid's section of which (Postscript No. 9, p. 355) has been so often reproduced in works and papers dealing with Tertiary and Post-Tertiary deposits, keeps the sea (not always successfully) from inundating the low-lying marshes that lie between the disused oyster beds of Medmerry Farm and the Windmill, which, at this point, forms a feature of the landscape. "Passing Thorney Coastguard Station" (we quote, for the sake of convenience, from Mr. Clement Reid's 'Memoir' upon the Sheet No. 332, Postscript No. 13), "we reach the highest Eocene deposits represented in the Selsey peninsula. These consist of clays and sandy rock-beds full of Foraminifera, such as *Nummulina variolaria*, and *Alveolina subulosa*, etc.† The Mixon

* The Complete Angler. By I. Walton and C. Cotton. London, 1653, Chap. IV. Third Day.

† It must be borne in mind that the locality identified in the early geological memoirs as "Thorney Coastguard Station" is very misleading. The erosion of the coast having practically washed away the old Thorney Coastguard Station, the name has been transferred to the newer Coastguard Station two miles south-east, so that in any memoir prior to 1863 Thorney Coastguard Station means Bracklesham Bay, whilst in later memoirs (as, for instance, Mr. Reid's Geological Memoir, Postscript, No 13) "Thorney" means the Coastguard Station heretofore known as "Danners," which is at the end of West Street, Selsey.

Rocks opposite Selsey yield the *Alveolina* limestone, of which so much of the village is built. It is no longer quarried, as its removal led to a more rapid wasting of the coast." The whole of these Tertiary and Post-Tertiary deposits (which will receive our careful consideration when the time arrives for presenting our completed work to the Society) are overlaid by the Coombe Rock and brick-earths which Mr. Clement Reid has made the subject of significant study and observation (Postscript, Nos. 6 and 9); and, as we pursue our way round the Bill, we meet again, cropping out upon the eastern coast, the *Nummulite* bed, and the *Cardita* and *Turritella* beds, before we reach the broad expanse of marsh clay, overlaid with recent shingle, that shelves from Pagham harbour into the sea, just beyond the long spit of heaped-up shingle that stretches seaward opposite Park Farm. It must be borne in mind that the coast of Selsey Bill has been, and is, subject to a degree of annual erosion, unsurpassed on the British coasts. It was our intention to show, by means of a map, the old coast-lines as shown upon survey maps, dating from 1570 until the present time ; but we have been unable to complete this work for the present occasion (for which, perhaps, it would have been premature), but the map will be completed in this particular for the illustration of our later paper. By that time, also, we shall have completed a series of carefully measured sections which we are preparing, showing the strata of the brick earth, torrent gravels, marine gravels, and drift all over the Selsey peninsula. And, with a view to giving more complete data for the micro-geologist, we shall present an analysis of some thirty-six samples of strata, reaching from the 16-foot level to the 100-foot level, taken from two artesian borings that I have made through this Coombe rock and the underlying strata in the centre of Selsey village in a fruitless search for an underground water supply.

I little knew when, as a new settler in Selsey at the commencement of 1907, I determined to make a systematic study of the Foraminifera of the Selsey shore-sand—fired by Arthur Earland's exhaustive study of the Foraminifera of Bognor (Postscript, No. 17) and my own earlier and desultory studies of the same sand, and of that at Littlehampton—what I was undertaking. It seemed to me that, to arrive at a complete catalogue of the species to be found between tide-marks, all that was necessary was to make an extended gathering and wash, float, and elutriate the contained forms. Accordingly, in the course of some half-dozen walks at low tide from the foreshore of the extreme point, slightly to the east of the Marine Hotel, up to Bracklesham Bay (Thorney Farm), a distance of about $2\frac{1}{2}$ miles, I collected exactly 1000 cubic centimetres of foraminiferal scrapings, which, after treatment, gave the following results :—

	c.cm.
Coarse siftings left on the $\frac{1}{30}$-in. sieve	22·5
Pure Foraminifera (skimmed from the surface) ..	5·0
Floatings left on the $\frac{1}{90}$-in. sieve	24·5
,, ,, $\frac{1}{180}$-in. silk	9·5
Elutriated material left on the $\frac{1}{30}$-in. sieve ..	6·0
,, ,, ,, $\frac{1}{90}$-in. sieve ..	63·0
,, ,, ,, $\frac{1}{180}$-in. silk ..	15·5
Residue	854·0
	1000·0

Within a year of the incipience of the task of examining the material, I had compiled a catalogue of over 200 species, both recent and fossil, but very soon upon the query slide I found I had three or four discoidal shells of a highly friable nature, in very imperfect condition, that I had never seen before. I submitted them to my collaborator in this paper, who recognised as a fact, what I had by that time tentatively advanced, viz. that the shell was, at any rate, a new species, perhaps related to the *Planorbilina costellata* or *flabellum* of Terquem.*

Once, however, mounted in balsam, we recognised that we were dealing with a Foraminifer, not only new as regards species, but having an entirely new plan of growth and development, and consequently a new genus. The determination and description of the shell is as follows :

Précis of Origin.

The specimens on which the genus is founded are fossils, and were found in company with many other fossil Foraminifera derived from Secondary and Tertiary strata. A large proportion of the fossils are such as would occur in Tertiary beds of the period of the "Calcaire Grossier" (Eocene), and it is therefore probable that the specimens have their origin in the submarine denudation of strata which are not exposed above low-water mark. It is hoped to settle this point by dredging in the neighbourhood, but in the meantime it is thought desirable to publish this description of the most interesting form yet met with in the gatherings.

Family IX. **Rotaliidæ**.

Sub-family 2, Rotalinæ.

Genus, *Cycloloculina* Heron-Allen and Earland.

Definition of the Genus.—Test free (or perhaps sometimes adherent in the later stage of growth), complanate, discoidal, con-

* Les Foraminifères de l'Éocène des Environs de Paris. By M. O. Terquem, Mém. Soc. Géol. de France, sér. 3, ii. (1882).

sisting of three distinct series of chambers arranged in one plane representing three distinct life-periods, of each of which we have been fortunate enough to secure perfect and typical examples. These three life-periods are as follows :—

1. An initial series of seven or eight chambers arranged in one plane in a compressed and evolute spiral, all the chambers being visible on both faces of the test. The chambers grow rapidly in thickness, so that a young shell at the period of the completion of this first or "Discorbine" stage of growth is somewhat wedge-shaped in vertical section.

2. An intermediate or "Pavonine" stage, consisting of two or three chambers, which, rapidly increasing in width (as opposed to depth, which from the completion of the first or Discorbine stage remains pretty constant during the remaining growth), overlap and infold the initial or Discorbine series.

3. A final series of narrow annular chambers arranged concentrically round the earlier stages.

The completed test is usually symmetrical and roughly circular in outline, but is sometimes more or less irregular both in outline and in superficial appearance, as though it had grown in contact with an irregular surface. No attached specimens have, however, been found as yet.

The test is distinctly and somewhat coarsely perforated. As the test increases in growth and age, the walls become thickened by a deposit of shell substance between the tubuli, and the surface then assumes a rough, or areolated appearance, distinctly visible in balsam mounts, due to the cup-shaped depressions left round the perforations (plate XII. fig. 7). The edges of these cups appear to have been produced into minute spines, which are especially noticeable round the perforations on the oral faces of the chambers, where they have been included and protected from injury by the growth of the succeeding chambers (plate XII. fig. 6).

The continual deposition of this shell-substance causes the older shells to assume a crenulate, or even warty, superficial appearance, which masks the sutural lines. The plan of growth then becomes very obscure, but is still readily observable in balsam mounts.

Aperture.—There is no special oral aperture in any of the stages of growth. The only communication between the successive chambers consists of the ordinary tubuli, which are equally distributed over the septal face of the chambers, as well as over the outer sides. The septal tubuli do not differ in any way from the other perforations.

This absence of special aperture is one of the most marked features of the genus, and has no parallel in the perforate Foraminifera outside the Tinoporinæ, of which sub-family the absence of a special aperture is a characteristic feature.

The genus *Cycloloculina* will be placed in the second sub-family

Rotalinæ of Brady's ninth family, the Rotaliidæ, and between the genera *Discorbina* and *Planorbulina*, which are its nearest allies, although the absence of special aperture might lead one to suppose that its affinities were with the Tinoporinæ. The earliest chambers however, which are on the Discorbine plan of growth, mark its affinity to that genus. It differs from *Planorbulina*, to which it bears a superficial resemblance externally, in the construction and arrangement of its later chambers, and in the absence of definite oral apertures. In *Planorbulina* the chambers succeeding the early spiral portion are arranged in more or less concentric order, but the method of arrangement rapidly becomes obscure, and one portion of the periphery often grows more rapidly than another, owing to the accretion of chamberlets. *Planorbulina*, moreover, is more or less an adherent form, and the later chambers grow to some extent over their predecessors, so that the initial spiral portion is only visible on the under, or attached, surface of the test. This overlapping reaches its fullest development in *P. accrvalis* (Brady), in which the chamberlets are irregularly heaped together.

In *Planorbulina*, moreover, the oral apertures are very well defined, consisting of minute arched slits, with everted lip, placed

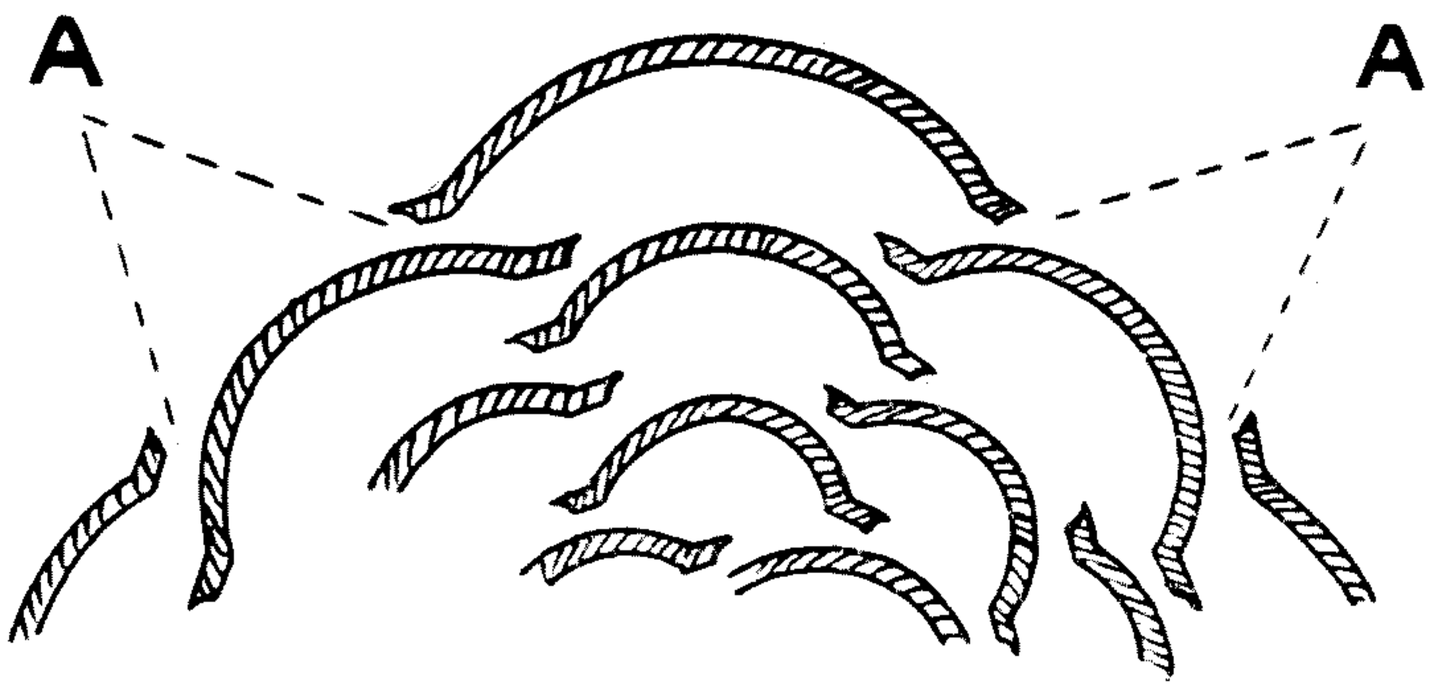

Fig. 138.—Diagrammatic Section of a Portion of *Planorbulina*.
A, oral apertures.

on each side of the chamberlet at the points of attachment to the previous whorl.

Our type bears a somewhat superficial resemblance to a species which was described by d'Orbigny under the name of *Planorbulina vermiculata*, but which was transferred by Brady to the genus *Pulvinulina* on grounds which do not appear very convincing to us. It may be noted that Brady assigns Terquem's *Planorbulina Eocæna* to this species, but we think incorrectly, as specimens which are undoubtedly referable to Terquem's species are of frequent occurrence at Bognor and Selsey, and they bear but little resemblance to *Pulvinulina* (*Planorbulina*) *vermiculata*, of which we have excellent specimens from the Mediterranean.

The undivided tubular chambers which are the characteristic feature of the genus *Cycloloculina*, have no parallel in the Foraminifera. D'Orbigny's second order, the Cyclostega, was

created to include those forms in which the test was discoidal and composed of concentric segments, but in *Orbitolites*, and its isomorph *Cycloclypeus*, these annular chambers are subdivided by partitions into chamberlets, as is also the case in *Orbiculina*, which in its variety *compressa* (*O. compressa* d'Orbigny), bears a remarkable resemblance to our form.

Terquem in his celebrated monograph * figures and describes several abnormal *Planorbulinæ*, most of which occur among the Selsey fossils. One of his species, viz. *Planorbulina flabellum* (Terquem),† bears a strong resemblance to the Pavonine stage of *Cycloloculina*, and is indeed probably referable to this genus, though apparently not to either of the Selsey types. Terquem's figure differs from our form in the shape of the later chambers, which are arcuate instead of being tubular and of horseshoe form.

Terquem's figure does not, however, tally very accurately with his description of the species, which is stated to be very variable in shape and in the number of chambers. In this respect it differs again from our form, in which the chambers are remarkably constant in shape and nearly always ten in number, up to the completion of the Pavonine stage.

Cycloloculina annulata sp. n. Plate XII. figs. 1–7.

Definition of Species.—Test free, complanate, discoidal, consisting of the three series of chambers arranged more or less irregularly in one plane. Peripheral edges of the chambers rounded. The entire surface of the shell, including the peripheral edge, somewhat coarsely perforate. No aperture to the test other than these perforations, which represent the sole means of communication between the successive chambers of the test.

The surface of the test varies greatly in individual specimens. It is occasionally almost smooth, clear, and distinctly hyaline, and in these specimens, which are always regularly complanate, the peculiar arrangement of the chambers is tolerably apparent even when the shell is viewed as an opaque object, the concentric sutural furrows being clearly marked. In the majority of specimens, however, the test is irregularly complanate, and the surface is so distorted by the irregular crenulated growth of the chambers, and so roughened by the depositions of secondary shell deposit round the edges of the perforations, that the sutural furrows are only visible at intervals. The real structure of the test is thus masked, and such specimens might easily be overlooked or regarded as abnormal *Planorbulinæ* of the "*larvata*" group. The transference of these thick and coarsely built specimens to balsam is, however,

* Les Foraminifères de l'Éocène des Environs de Paris. By M. O. Terquem, Mém. Soc. Géol. de France, ser. 3, ii. (1882).

† Tom. cit., p. 92, pl. xi. fig. 19.

sufficient to disclose their identity with the smooth and regular specimens which possibly represent individuals which had lived in deeper and more undisturbed water, or under conditions less favourable for exuberance of shell growth.

A series of radial crinkles or undulations, which are more noticeable in the thin-walled specimens than in the coarser shells, might at first sight give the impression that the annular chambers are divided by radial partitions into small chamberlets; but these markings are purely superficial, and the examination of numerous balsam specimens has proved that the tubular chambers are undivided throughout (plate XII. fig. 5).

Mode of Growth.—The initial or "Discorbine" stage commences with a primordial chamber, which is followed by about six other chambers, crescentiform in shape, and arranged as in *Discorbina biconcava* (Parker and Jones), to which species the shell, at the completion of its first stage, bears some resemblance (plate XII. fig. 1). With the seventh chamber, the second, or "Pavonine," stage may be said to commence. Owing to its great breadth, as compared with its diameter, it commences that overlapping of the preceding chambers, which, continually increasing in the eighth and ninth chambers, usually reaches its culminating point in the tenth chamber, which completely infolds all its predecessors, its opposite extremities meeting at the base of the shell. The test, which had been more or less fan-shaped, or, rather, Pavonine (peacock-tail shape) at the eighth and ninth chambers, is now practically circular, only a slight flattening at the base showing where the encircling edges of the tenth chamber have met (plate XII. fig. 2).

The third, or "Annular" stage of growth, now begins, and the animal adds several tube-like undivided chambers, each of which completely surrounds all its predecessors (plate XII. figs. 3, 4). The number of these chambers varies considerably. The largest specimen which we have found shows six of these concentric annular chambers. The specimen is imperfect, but it probably marks the approximate limit of growth, as the average number of annular chambers in the third stage does not exceed four.

From the ninth or tenth chamber to the completion of the shell, there is but little variation in the diameter of the tube-like chambers, the average diameter of the chambers being about 0·05 mm. This means that the tubes, though very nearly circular in section, are rather broader than they are deep.

In the next species, however—*Cycloloculina polygyra*—the variation is in the other direction, the depth being, if anything, greater than the breadth.

One abnormal specimen was found in which the shell showed signs of fracture and repair during the third stage of the animal's life. A considerable piece of the test has been broken away,

and the gap filled up, not by the restoration of the broken annular chambers, but by the insertion of irregular chamberlets, which fill the space and complete the circular outline of the shell.

The species varies considerably in size, but the following measurements may be taken as approximating to an average of the various stages:—"Discorbine" stage: length, 0·26 mm.; breadth, 0·20 mm. "Pavonine" stage: length, 0·5 mm.; breadth, 0·6 mm. Adult, or "Annular" stage: diameter, 1–1·1 mm. The concentric annuli average 0·05 mm. in diameter.

The thickness of the specimens is approximately the same in all stages of growth after the first few chambers, and an average for a moderately flat specimen would be 0·046 mm.

Cycloloculina polygyra sp. n. Plate XII. fig. 8.

Definition of Species.—Test free, complanate, discoidal, consisting of the three series of chambers arranged symmetrically in one plane. Peripheral edge nearly square. Perforations finer than in the type, and without any secondary deposit of shell substance between the pores. Sutural lines either very slightly depressed, or flush, or even slightly limbate. Number of chambers in the first two stages, usually eight. Average number of chambers in the third, or "Annular" stage, about five. The annular chambers increase regularly in diameter, instead of remaining of practically constant diameter, as in *C. annulata*, and this gradual increase gives a false impression of a closely coiled spiral, whence our specific name "*polygyra*." As the thickness of the test is practically the same in all stages, it follows that the internal section of the chambers varies at different stages of growth, the early chambers being almost ribbon-like, while the later ones are nearly square in section.

The species is founded on certain specimens which are found associated with *C. annulata* in several of the gatherings. It is of very infrequent occurrence as compared with the type, and all the specimens hitherto found are adults. There is, however, no doubt from their structure, that the test passes through the same three stages as does *C. annulata*, from which it differs in several essential features.

The chief differences are:—

A. In size, the species is considerably smaller than *C. annulata*. Our largest specimen of *C. polygyra* measures 0·5–0·6 mm. in diameter, which is less than the average size of *C. annulata*. The shell is altogether smaller, neater, and more finished in appearance than the type.

B. The peripheral edge is square, not rounded, as in *C. annulata*, and the sutural lines are only slightly depressed, and sometimes flush or limbate.

C. The secondary shell deposit between the perforations is entirely wanting, and the test, consequently, never acquires the coarse and weathered appearance which marks many specimens of *C. annulata*.

D. The annular chambers vary in diameter and in sectional shape.

The genus being thus established, and its two distinctive species having been determined by the examination of recurrent specimens, we had reached a point at which it became imperative that some organised effort should be made to determine the exact locality, if not the precise geological stratum, from which this interesting fossil is derived. We therefore made the following series of gatherings of a strictly localised character, taking whenever possible, not only a sample of the shore-sand, but of the rocks and other deposits exposed at low spring tides, and of the sea-floor by means of dredging.

1. Shore-sand. From a small sand-bay, or pocket, in the shelter of the spit of shingle that runs out to sea opposite Park Farm, on the eastern side of the Bill. (It may be observed that this is the only spot on the eastern shore which is not covered at all states of the tide with a greater or lesser depth of shingle, derived apparently from the raised beach or Coombe Rock.)

2. Mud. A green plastic clay (? Tertiary) dredged in five fathoms outside the Mixon Rocks.

3. Rock detritus. The indurated and *Pholas*-bored Tertiary clay. Pebbles, and small boulders, dredged in five fathoms outside the Mixon Rocks, locally known as "The Clibs."

4. Rock detritus. The *Alveolina* limestone forming the Mixon Rocks proper, of which most of the old houses in Selsey are built. Dredged with Nos. 2 and 3.

5. Rock detritus. The muddy sand found in the pools under the boulders upon the highest point of the Mixon Rocks, piled round the Mixon Beacon and uncovered at low tide. This consists of the detritus of Nos. 2 and 3 mingled with recent Foraminifera.

6. Shore-sand. From the commencement of the "sands" opposite the Marine Hotel, extending slightly eastward towards the extreme point, off which are the Mixon Rocks.

7. Shore-sand. From the same point, extending about a quarter of a mile westward, opposite "The Bungalows."

8. Mud-deposit. Opposite Thorney (New) Coastguard Station, called by Mr. C. Reid the "Selsey Beds." A brown loamy (Pleistocene) mud, with much detritus of derived fossil Mollusca.

9. Mud-deposit. A Post-Tertiary estuarine clay, of deep indigo blue colour, about three feet thick, separating No. 8 at this point from No. 10.

10. Bracklesham Beds. The *Pholas*-bored Eocene belt that

surrounds the peninsula. Sample taken below Nos. 8 and 9, opposite Thorney Coastguard Station.

11. Shore-sand. From the sands midway between No. 7 and No. 12 above the "Selsey Beds" (No. 8).

12. Shore-sand. From the shore opposite the oyster-beds and Windmill, slightly north-west of the present Thorney Coastguard Station.

13. Shore-sand. From the shore opposite Medmerry Farm, between the Coombe Rock and the spit of Pleistocene mud described by Mr. C. Reid (Postscript, No. 9; also Nos. 8 and 10).

14. Mud-deposit. Dug from the Pleistocene mud ("Clibs") exposed at spring-tide (Laminarian zone) opposite Medmerry Farm.

15. Shore-sand. From the shore of Bracklesham Bay opposite Thorney Farm, and the now abandoned (old) Thorney Coastguard Station.

16. Eocene-sand. From the interior of large and perfect shells of *Cardita planicosta*, from a depth of two feet in the Bracklesham Beds, uncovered at low water of spring tides in Bracklesham Bay.

Besides the foregoing samples of material, we possess, and shall examine systematically in due course, the thirty-six Artesian-well samples of the strata of the Selsey peninsula to which reference has been made.

The presence of a large number of purely chalk Foraminifera in the Selsey shore-sand is accounted for by the continual throwing up and shattering upon the shingle, of hollow flints (Spongidæ) from the upper chalk (probably from the Isle of Wight), and a description of the contents of some of these will form a necessary termination to our completed study of the Foraminifera of the locality.

It will readily be gathered from a glance at the foregoing catalogue of material, that an exhaustive study of the Foraminifera of Selsey Bill must occupy all the leisure that we can devote to it for some years to come. Meanwhile we have made a preliminary and necessarily somewhat cursory examination of the twelve samples composing the above catalogue, with a view to ascertaining, as far as is at present possible, the precise origin of the genus *Cycloloculina*.

The result of such examination is as follows:—

1. Park Farm. Almost entirely the detritus of recent shells. A few *Nummulites*, but practically no Foraminifera, recent or fossil.

2. Mixon Mud. The coarse siftings gave *Nummulites* and *Alveolina Boscii* in quantity, with small Eocene Mollusca, often full of pyrites. The *Nummulites* frequently encrusted with Polyzoa (*Hydractinia*, etc.), showing that they have been washed out of the matrix for some time. Large casts, in glauconite and quartzose, of *Miliolina alveoliniformis*, *Biloculina*, *Discorbina* (? *parisiensis*). One

Cycloloculina was found among the finer siftings looking very much out of place, and probably washed by the current from the point of the Bill. A feature of the finer siftings were robust sponge-spicules and fragments of a gem-mineral not yet identified.

3. "Clibs." Principally *Nummulites*, with a disconcerting mixture of recent forms, evidently washed out of the *Pholas* borings.

4. *Alveolina* limestone. Large casts in yellowish silica of various *Miliolinæ*, and perhaps some large *Polymorphinæ*.

5. Under the Mixon Rocks. The same casts as in No. 4, with a large proportion of recent arenaceous forms (*Verneuilina polystropha* and *Haplophragmium canariense*, with large recent *Miliolinæ* (*Massilina secans*).

6. Opposite Marine Hotel. Suspending judgment as to the single test dredged in 5 fathoms (No. 2), *Cycloloculina* makes its first appearance here, where it is fairly plentiful.

7. Opposite "The Bungalows." Here *Cycloloculina* is an increasingly recurrent shell.

8. Selsey Beds. A brown clay, full of derived Eocene fossil Foraminifera, but no *Cycloloculina* found *in situ*.

9. Blue Band. No sign of *Cycloloculina*, but many Estuarine forms, such as *Nonionina*, *Trochammina*, etc., all filled with iron pyrites. This band is full of vegetable detritus and fragments of pyrites.

10. Bracklesham Beds. An Eocene clay, very rich in fossil Foraminifera, but no sign of *Cycloloculina* at present.

11. Above the Selsey Beds. Here *Cycloloculina* is more plentiful than anywhere else, the specimens being, for the most part, delicate and perfect.

12. Opposite the Oyster Beds. Here *Cycloloculina* is a recurrent form, though generally somewhat battered.

13. Opposite Medmerry Farm. Here *Cycloloculina* is about as common as in No. 12, but more battered as a rule.

14. Pleistocene mud deposit. In the first small lump of this mud which we washed we found a perfect *Cycloloculina annulata* and a perfect *C. polygyra*, but many hours' patient search since then have failed to produce a further specimen of either. The utmost care is taken to use clean sieves and new muslins, but until more specimens are washed out we must suspend judgment as to this sample.

15. From the shore of Bracklesham Bay. In this we have failed to find any trace of *Cycloloculina*. The gathering consists almost entirely of Eocene fossils, shell-detritus, with *Nummulites*, and a striking collection of large glauconite casts of Foraminifera, but few tests, either recent or fossil. We have, however, found in this sample several specimens of the rare *Polymorphina complanata* figured by d'Orbigny in his "Foraminifères fossiles du Bassin Tertiaire de Vienne" (Paris, 1846).

16. Interior of *Cardita*, Bracklesham. A green sandy clay in which we have found no trace of any Foraminifera whatever.

It will therefore be seen that within the time limits of our researches up to the present, the genus *Cycloloculina* is found as a derived fossil only, in the shore-sands of the western side of Selsey Bill, from the extreme point opposite the Marine Hotel, up to Mednerry Farm, growing more scarce as one proceeds north-westward. The shell is extremely delicate and friable, and we are of opinion that it is incapable of travelling far in a perfect condition, or of withstanding the wash of the tide for more than a short while. It is found by us in its best state in elutriated rough material, the process of washing appearing to damage it almost beyond recognition, whilst its weight renders it almost entirely absent from "floatings." It would appear therefore to be washed from some Post-Tertiary mud stratum near that which Mr. C. Reid has named the "Selsey Beds," where it occurs no doubt to-day as a derived fossil, having been washed there from some hitherto undiscovered soft band in the Eocene clays of the *Pholas*-bed which fringes the shore at this point. It appears furthermore to be one of Nature's failures, existing probably in great quantity *in situ* wherever it came into existence, but the exact geological stratum or deposit in which it had its origin is for the present purely conjectural, and must remain so until we can make a more extended and localised series of dredgings.

Note.—In the completing paper which we propose to lay before the Society shortly, we shall endeavour to trace the relationships between the sub-marine and the sub-aerial geology of the peninsula of Selsey, and, in giving a list of the Foraminifera both recent and fossil which we have identified in our gatherings, we shall make the attempt to ascribe to each species its correct, or at any rate probable, origin.

Postscript.

In the preparation of this paper it has been found necessary to consult many authorities, and we think it desirable to give the following list of works, in chronological order, to which we have had recourse for the purpose of verifying our researches into the origin of the Foraminifera of the Selsey peninsula.

1. **Trimmer**, J.—On the Agricultural Geology of England and Wales. Journ. Roy. Agric. Soc. England, xii. (1851) p. 445.
2. Godwin-Austen, R.—On the Newer Tertiary Deposits of the Sussex Coast. Quart. Journ. Geol. Soc., xiii. (1855) p. 40. (1857 Postponed Papers.)
3. Fisher, O.—On the Bracklesham Beds of the Isle of Wight Basin. Op. cit., xviii. (1861) p. 65.

4. Bell, A.—Contributions to the Fauna of the Upper Tertiaries. I: The "Mud-deposit" at Selsey, Sussex. Ann. Mag. Nat. Hist., series 4, No. 43 (1871) p. 45.
5. Wood, S. V.—The Newer Pliocene Period in England. Quart. Journ. Geol. Soc., xxxvi. (1880) p. 457 (part 1); and xxxviii. (1882) p. 667, (part 2).
6. Reid, C.—On the Origin of Dry-chalk Valleys and of Coombe Rock. Op. cit., xliii. (1887) p 364.
7. Gardner, J. S., H. Keeping, and H. W. Monckton.—The Upper Eocene, comprising the Berton and Upper Bagshot Formations. Op. cit., xliv. (1888) p. 578.
8. Bell, A.—Notes on some Post-Tertiary Marine Deposits on the South Coast of England. Op. cit., xlvii. (1891) p. 172.
9. Reid, C.—The Pleistocene Deposits of the Sussex Coast, and their Equivalents in other Districts. Op. cit., xlviii. (1892) p. 344.
10. Bell, A.—Notes on a Post-Tertiary Deposit in Sussex. Yorkshire Phil. Soc. Report for 1892, p. 58. (Reprinted York, 1893.) Supplementary Note (leaflet) by F. W. Millett, The Foraminifera of a Post-Tertiary Deposit in Sussex.
11. Prestwich, J.—The Raised Beaches and "Head" or Rubble-drift of the South of England: their relation to the Valley Drifts, and to the Glacial Period; and on a late Post-Glacial Submergence. Quart. Journ. Geol. Soc., xlviii. (1892) p. 263.
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13. Reid, C.—The Geology of the Country around Bognor (Explanation of Sheet 332, London, 1897). Memoirs Geological Survey, 1898.
14. Mill, Hugh Robert—A Fragment of the Geography of England: South-west Sussex. Reprinted from Geographical Journal, March and April, 1900
15. Reid, C.—The Geology of the Country near Chichester (Explanation of Sheet 317, London, 1903.) Memoirs Geological Survey, 1903.
16. Elsden, J. V., and W. Whitaker—Excursion to Selsey and Chichester. Proc. Geol. Assoc., xviii. (1904) p. 475.
17. Earland, A.—The Foraminifera of the Shore-sand at Bognor, Sussex. Journ. Quekett Micr. Club, series 2, ix. (1905) No. 57, p. 187.

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CONTAINING ITS TRANSACTIONS AND PROCEEDINGS

AND

A SUMMARY OF CURRENT RESEARCHES RELATING TO

ZOOLOGY AND BOTANY

(principally Invertebrata and Cryptogamia)

MICROSCOPY, &c.

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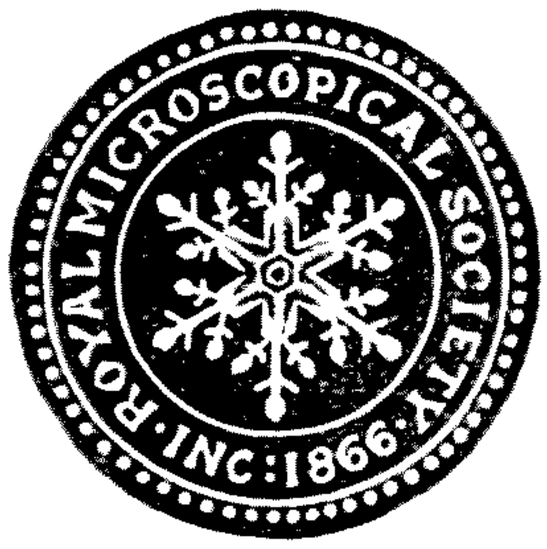

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