the hard and shelly epimeral pieces of the body-segments are not properly developed (as they are in the common lobster and other active *swimming* long-tailed forms), and the lobes of the tail are in like manner rudimentary. Such changes I cannot but conceive to have been the result of long habit, arising from the disuse of the organs of a part of the body, causing first their gradual reduction in size, and finally resulting in their abortion. The two new species of *Thalassinidæ* I have to notice belong to the genus *Callianassa*, hitherto characteristic of the Maestricht Chalk, and found also living in our own seas. We are now able to take it back to the Lower Greensand on the one hand, and link together the Cretaceous and Recent periods by a species in the Eocene beds of Hempstead, Isle of Wight. I have named the first *Callianassa Neocomiensis*, from the Greensand, Colin Glen, Belfast (Pl. II. fig. 5), and the second *Callianassa Batei* (after Mr. C. Spence Bate), from Hempstead Upper Marine series, Isle of Wight. (Plate II. fig. 4.)

This is a genus which should be looked out for by collectors of Upper-Chalk fossils in Norwich.

The Plates exhibited are intended for the second part of my Monograph on the fossil Merostomata, which now awaits its turn of publication. I wish to add a word here in favour of the Palæontographical Society, as deserving of support, as a means of enabling authors writing upon special branches of Palæontology to secure the publication of their researches. If more subscribers would only come forward in its aid, more authors would be enabled to make their work known, and much time would be saved. The last volume issued is an illustration of what they give for their annual guinea subscription*.

Casts of the largest of the Palæozoic Crustacea have already been prepared and coloured, and copies sent to Liverpool, Dublin, Oxford, Cambridge, Edinburgh, Glasgow, Norwich, and elsewhere, for the Museums of those cities.

EXPLANATION OF PLATE II.

Fig. 1. *Cyclus radialis*, Phillips, sp. From the Carboniferous Limestone of Bolland, Lancashire, and Visé, Belgium. Enlarged five times the natural size.
Fig. 2. *Cyclus Rankini*, sp. nov. From the Coal-shales, Carluke, Scotland. Magnified five times.
Fig. 3. *Penæus Sharpii*, sp. nov. Lower Lias, Northampton. A fourth less than the natural size (the outlined parts are restorations).
Fig. 4. *Callianassa Batei*, sp. nov. Upper Marine series, Hempstead, Isle of Wight. Natural size.
Fig. 5. *Callianassa Neocomiensis*, sp. nov. Greensand, Colin Glen, Belfast. Natural size.

First Report on the British Fossil Corals.

By P. Martin Duncan, *M.B. Lond., F.R.S., F.G.S., Sec. Geol. Soc.*

This Report consists of notes of observations made upon the Coral-faunæ described by MM. Milne-Edwards and Jules Haime in the monograph of the 'British Fossil Corals' (Palæontographical Society, 1850), of descriptions of new and unpublished species, of notices of species published by me in 1867 and 1868, and of examinations into the affinities of the forms and their geological positions.

* The last volume issued contained 45 Plates (9 of which were double quarto) and 238 4to pages of text.

The fossil Corals of the Crag, Brockenhurst beds, Eocene deposits, Upper and Lower White Chalk strata, Upper Greensand and Red Chalk rock of Hunstanton are considered, and also those of the Rhætic beds and of the great Liassic series.

The fossil Corals of the Lias have been described by me and published in two parts by the Palæontographical Society during the last twelve months. This great fauna, with the exception of one species, is new to Great Britain, and has been illustrated in seventeen plates.

The fossil Corals of the Red Chalk of Hunstanton have just been lithographed in one plate; and those from the interesting Tertiary deposit at Brockenhurst have been already published and illustrated (1866).

The Report dwells fully upon these three new faunæ. The species described by MM. Milne-Edwards and Jules Haime, from the strata whose Corals are noticed here, are forty-three in number.

I am glad to add notices of 115 species new to Great Britain, twenty-five of the species having been described in the Coral-faunæ of the Continent.

LIST.

New Eocene species.....	12	Described elsewhere	2
„ Brockenhurst	11	„ „	2
„ Upper Chalk	10	„ „	1
„ Upper Greensand ..	4	„ „	2
„ Hunstanton Red rock	2	„ „	2
Middle Lias.....	2	„ „	0
Zone of Amm. raricostatus „ „ Bucklandi..	10	„ „	2
„ „ angulatus ..	37	„ „	13
„ „ planorbis..	2	„ „	1
Total new species....	90		25
	25		
	115		

Species described by MM. Milne-Edwards and Jules Haime, 43. Total species, 158.

The labour of passing so many forms under review, and of superintending twenty-six plates published by the Palæontographical Society, two plates in the Philosophical Transactions, and one in the Journal of the Geological Society, may perhaps be explanatory of the impossibility of my concluding the Report on the Cretaceous Coral-fauna.

The new species from the Gault, however, have been lithographed but not published; but those from the Upper Greensand and Neocomian have not yet been drawn.

There remains for a future Report the description of the fossil Corals of the Gault, Lower Greensand, and of the Oolitic rocks.

The vast Coral-remains of the Palæozoic age have not been alluded to in this Report; and although I have had the advantage of Mr. Thomson's valuable skill in producing sections of Carboniferous corals, and also of investigating large series of Devonian and Silurian forms, I can only assert that, before any satisfactory communication on these early Zoantharia can be written, much time must be occupied and much labour be undergone *.

* The Grant of £50 for reporting on the British Fossil Corals has been spent.

REPORT.

The researches of Darwin, Dana, and others have been so long before the scientific world, that the external physical conditions accompanying Coral-life are universally well understood. The physico-chemical changes which take place in dead corals and influence their future fossil condition have been described; and it is most reasonable to assert that the representatives of the existing Coral-faunæ flourished under the same kind of conditions, and were subjected to the same prefossil incidents and changes.

Corals are either aggregated in reefs or distributed sparely over the sea-bottom. In the strata of nearly every formation, somewhere or other, aggregations of corals are found, either in great banks, or as distinct reefs hanging on to the older rocks; moreover sparely distributed solitary or simple forms are universal.

In the Caribbean Sea, the Indo-Pacific, the Great Ocean, the China seas, aggregations occur and the species flourish in comparatively shallow water. In the deep water from 50 to 200 fathoms, between reefs, simple and sparely distributed species occur; and in other seas, where there are no reefs, the sea-bottom from about 50 to 200 fathoms supports larger or smaller simple and a few compound forms.

The Mediterranean, the Atlantic off the Spanish coast, the Bay of Biscay, the South-west British sea, and especially the seas between Unst and Norway are characterized by numerous simple Madreporaria and a few compound forms.

This geographical and bathymetrical distribution must influence us in reasoning geologically upon the presence of corals in strata; and a tropical climate must not be of necessity inferred from the discovery even of fine specimens.

Corals cannot migrate except by the floating away of their ova; and very slight alterations in the very definite physical conditions destroy the parent stock as well as the ova. It is not surprising therefore to find the species very much restricted in their vertical range in strata. Recent species vary greatly under slight modifications of the sea-depth, force of wave, and purity of sea-water; and it is found that corresponding variations occurred in every age, the minute structural differences repeated over and over again in specimens from the same deposits having clearly a genetic relation to a definite type. As there are now geographical provinces of corals differing in genera, species, and in physical peculiarity, so in every formation down to the Lower Silurian there are evidences of areas characterized by reefs or by simple and solitary species, and the species of distant localities were, as now, different, peculiar, and occasionally identical. From those early days there have been opportunities for the migration of distant species by their ova; and it is found that the fossil species peculiar to a certain geological horizon in one part of the world are often represented by closely allied species, varieties, or identical forms in higher or lower horizons in other parts. Some few forms are very persistent; and those which have lasted through the Tertiary ages into the present have a great geographical range, just as those which had a great vertical range in older deposits had also a great horizontal area.

It is necessary, in considering the relative ages and contemporaneity of coral species, to remember that a coral reef on the side of a precipitous submerged mountain-top had its débris carried down the abyss for ages, and that this is enormous in amount.

It must be remembered that in the course of time the distance between

the bottom of the reef and the top of the detritus will decrease very sensibly, and that any gradual elevation of the reef above the sea, producing its destruction, would be accompanied by a more rapid descent of débris. In after ages the upper and stony deposit would perchance be considered of different age from the marly and fine sediment below. Again, deep seas creeping over littoral areas and then over the land during the gradual subsidence of great areas would bring simple corals over littoral and terrestrial remains, the species all being really contemporaneous. On the other hand, a long-continued subsidence would equally tend to the increase of the reef and of the deep-water sediment. After the lowering of the area had been destructive to the reef, and no more detritus could fall, the usual ooze of the deep sea would gradually invade all. These suggestions will perhaps render the occurrence of large coralliferous deposits in certain strata only, in large areas of formations, more comprehensible, and will tend to the belief that when coralliferous deposits occur at the base of a great series of uncoralliferous strata (and this is often the case) the idea of contemporaneity is not overcome by the evident succession of the deposits.

The relation between such faunæ as the St.-Cassian and South Wales Lower Lias of the zone of *Ammonites angulatus* is evident; but the intermediate faunæ of Azzarola and of the lowest zones of the Lias on the Continent are less closely allied to the Welsh fauna. Again, the fauna of the Welsh Lower Lias is more closely allied to the Lower Oolitic Coral-fauna of England than are the Coral-faunæ of the zones of *A. Bucklandi*, *A. raricostatus*, and of the Middle and Upper Lias.

How interesting is the affinity between the Coral-fauna of Gosau and the Miocene Coral-fauna of the Caribbean area! yet the British Chalk hardly represents any part of the Gosau fauna, and our Eocene fauna has no resemblance to it. These considerations tend to prove how vast and complicated the gradual migrations must have been, even of animals which could only live under very definite and limited conditions, how really contemporaneous were the species entombed in vast consecutive deposits, how complicated the relations of the fauna have ever been, and how clearly the absence of corals from strata does not prove their absence in adjoining and equivalent areas. The notion that successive new creations of corals followed repeated destructions of faunæ is not supported by a single fact; on the contrary, all the evidence disproves it. The amount of individual variation, of gradual structural changes, and of decided variation amongst the Madreporaria is not without significance; and the examination of large series of forms from all parts of the world, and from consecutive formations, impresses the belief in the continuous evolution of new forms by variation from the old during the whole of the Coral ages.

Fossil Corals from the Crag.

The following authors have written upon this subject:—Searles Wood, Ann. & Mag. Nat. Hist. 1844, vol. xiii. p. 12. Lonsdale, Searles Wood's Catalogue, Ann. & Mag. Nat. Hist. 1844. Milne-Edwards and Jules Haime, "Mém. sur les Astræides," Comptes Rendus de l'Acad. des Sciences, vol. xxvii. p. 496 (1868); "Monog. des Turbinolides," Ann. des Sciences Naturelles, 3rd ser. vol. ix. (1848); Hist. Nat. des Corall. 1857, Paris. R. C. Taylor, Mag. Nat. Hist. 1830, vol. iii. p. 272. G. de Fromentel, 'Introd. à l'Etude des Polyp. Foss.' 1858.

The Sclerodermic Zoantharia, or true Madreporaria, are rarely found in any of the Crags. Bryozoa abound, and thus gave the term "Coralline" to

the Crag. As a general rule, the most preservable and commonest of the true corals are not found in recent seas with Bryozoa; but certain forms inhabiting the sea-bottom from the lowest spring-tide level to 200 or more fathoms are brought up by the dredge with Bryozoa. These forms are strongly represented in the Crag Coral-fauna.

List of Crag Species.

Sphenotrochus intermedius, *Münster*, sp.
Flabellum Woodii, *Ed. & H.*
Cryptangia Woodii, *Ed. & H.*
Balanophyllia calyculus, *Wood.*

Sphenotrochus intermedius is found in the Coralline Crag and in the Red Crag of England, and it has been found in the Antwerp Crag. The genus still exists, and is represented in the south-western and western British and Irish seas.

Sphenotrochus M'Andrewanus, Ed. & H., the *Turbinolia Milletiana* of William Thompson, from Cornwall and Arran, is closely allied to the Crag species; and it is very evident, from the variability of these simple corals, that *Sphenotrochus Milletianus* (Defrance, sp.) of the Anjou and Touraine Miocene, *Sphenotrochus intermedius*, and *Sphenotrochus M'Andrewanus* have descended from one type, and that they have been slightly modified to meet the changes in the external conditions in the later Tertiary and recent seas. Probably these Crag and recent species should be considered varieties of the Miocene form. My researches in the Australian Tertiary Coral-fauna have brought two species of *Sphenotrochus* to light; but they are only remotely allied to the British species.

The alliance between *Flabellum Woodii* and *F. Roissyanum* of Dax and Malaga, and *F. cristatum* of the Bolderberg, is not close; and the affinity between the British Crag species and the living *F. anthophyllum*, Ehrenberg, of the Mediterranean and Spanish coast, and perhaps from our north-east seas, is slight. *Flabellum Woodii* is closely allied to *F. subturbinatum*, Ed. and H., of the Miocene of Plaisance, and *F. Gallapagense*, from the Gallapagos Miocene. *F. Woodii* is found in the Coralline Crag.

Cryptangia Woodii, Ed. & H.—This genus is extinct, and the second species of it is a form very like the Crag species; it is from the Faluns, and, like the Crag species, is imbedded in a Cellepore. The septal arrangement of the species is rather abnormal, and there is an evident tendency to revert to some old type in which the quaternary arrangement prevailed. The genus is closely allied to *Rhizangia* and to *Cylicia*. The first of these is extinct, and flourished in the Lower Chalk of Gosau, in the Eocene, and in the Miocene; and the last is recent, its species living in the South-African and Australian seas.

Balanophyllia calyculus, Wood, is represented in the Southern British seas by *B. regia*, Gosse, to which it is closely allied. The Mediterranean species is not closely allied; and the same may be said for the Cape-of-Good-Hope *B. capensis*, Verrill, and the Miocene *B. cylindrica*. The species is found in the Red Crag, and the specimens are usually very badly preserved about the calice. The genus is fully noticed in the report on the Fossil Corals of the Brockenhurst beds.

It will thus appear that three out of the four genera of Crag corals are represented in the existing seas of our coasts by more or less closely allied species. One genus is extinct.

The fine *Stephanophyllia Nysti* of the Black Crag of Antwerp is not found in the British Crags.

Judging from the conditions surrounding the existing species and their allies, it might be asserted that no very great bathymetrical or climatal changes have taken place between the deposit of the Crag and the present time. The intervention of a long glacial period is not proved by the study of the corals. But doubtless during that period migration to deep water or to the south occurred. When the cold period was succeeded by more temperate times a return of the fauna took place; and it must be remembered that two opportunities at least were thus given for variation in form.

Fossil Corals from Brockenhurst.

Lower Oligocene.

Before 1866 no species of corals were known to exist in any beds between the top of the Barton series of the Eocene and the base of the "Crag." I published in that year, in the Supplement to the British Fossil Corals, Palæontographical Society's vol. for 1865, descriptions of thirteen species of corals from Brockenhurst in Hampshire. The species were, with the exception of two, new to science, and indicated very different external conditions to those prevailing at the time of the deposition of the Bracklesham and Barton corals. Moreover the two species which had been described from foreign sources also indicated a very different state of things from those favourable to the life of the tiny simple *Turbinoliæ* of the London Clay and of the Barton series.

The facies of the whole collection was clearly intermediate between the Eocene and the Falunian coral-faunæ. The species were collected from beds which are distinctly represented in White Cliff Bay, and which belong to the Middle Headon series.

Overlying freshwater remains (the Lower Headon), it is evident that great marine and terrestrial changes had occurred subsequently to the estuarine conditions prevailing towards the end of the deposition of the Barton series. The genera of the corals discovered at Brockenhurst prove that the conditions inseparable from a coral-reef succeeded those favourable to the development of estuarine and freshwater species of mollusca. The existing species of such genera as *Madrepora* and *Solenastræa* are reef-dwellers, and *Axopora* and *Litharæa* are represented in modern reefs by *Pocillopora* and *Porites*. Such genera as *Balanophyllia* and *Lobopsammia* were and are dwellers in from 20 to 100 or more fathoms, and are found in the deeper water, close to the reefs. A corresponding succession occurs in North Germany, and deep seams of fossil wood are covered with marine deposits of the same relative age as the marine bed at Brockenhurst. Both the marine deposits are covered with greater or less depths of sands and gravels. The molluscan fauna of Brockenhurst has much in common with those of the North German Lower Oligocene deposits superimposed on the fossil-wood seams of Magdeburg, Bernsberg, Aschersleben, Egeln, Helmstedt, and Latdorf; and the British as well as the German deposits are moreover the equivalents of the "Tongrien Inférieur."

The palæontology of the deposits has been sufficiently studied to determine the necessity of their separation in classificatory geology from the Eocene and Miocene formations. As yet no satisfactory alliances have been determined to exist between the Oligocene coral-fauna of North Germany and that of Brockenhurst. But inasmuch as the mollusca are closely allied, there is a great probability of the deep-water, oceanic, and reef tracts having been to the west of the North German littoral tracts.

List of the Species.

1. Solenastræa cellulosa, *Duncan.*
2. —— Kœneni, *Duncan.*
3. —— Reussi, *Duncan.*
4. —— gemmans, *Duncan.*
5. Beyrichi, *Duncan.*
6. —— granulata, *Duncan.*
7. Balanophyllia granulata, *Duncan.*
8. Lobopsammia cariosa, *Goldfuss*, sp.
9. Axopora Michelini, *Duncan.*
10. Litharæa Brockenhursti, *Duncan.*
11. Madrepora Anglica, *Duncan.*
12. —— Römeri, *Duncan.*
13. —— Solanderi, *Defrance.*

The species of the genus *Solenastræa* from Brockenhurst form a very interesting series, which might almost be made a subgenus. The high septal number in conjunction with the highly inclined endotheca and the defective columella characterize the group. The species described by Reuss from the Castelgomberto district, and those from Ghent and Touraine by MM. Milne-Edwards and Jules Haime, are very distinct from the Brockenhurst species. Those I have published in my 'West-Indian Fossil Corals,' and a species noticed by Michelotti and Duchassaing, from St. Thomas's, are equally remotely allied to the British forms.

The recent *Solenastrææ* are world-wide—the Red Sea, the Indian Ocean, and the Caribbean Sea being their favourite localities.

The *Madreporæ* from Brockenhurst are very interesting species, for fossil forms of the genus are very rare. *Madrepora Solanderi*, Defrance, was known as a form from Anvert and Valmondois; but it appears to me that the correct geological age of the deposit whence it and another coral (also common to the Brockenhurst, viz. *Lobopsammia cariosa*) came is not free from doubt. It is not improbable that they are true Oligocene corals, especially as the last-named species is identical with *Lobopsammia dilatata*, Römer, from Latdorf.

Madrepora Anglica is a grand form, with a great trunk and short branches, equalling in size any of the most luxuriant recent species. It is allied to *Madrepora crassa*, Ed. & H., from the Pacific and Southern oceans. The genus comprehends nearly 100 species now flourishing; but the fossil forms are only eight in number. The recent species are found, for the most part, in the boiling surf of the reef, in every part of the globe where the conditions for reefs exist.

Axopora is a genus which has absorbed the genus *Holarcæa*. The species have very rudimentary septa, enormous columellæ, well developed tabulæ, and a reticulate cœnenchyma. The species are found in the Eocene of Great Britain and France, and at Brockenhurst, and they are all closely allied.

Litharæa Brockenhursti is remotely allied to the species from the Bracklesham beds and the French and the Javan tertiaries. The genus is extinct; but the Brockenhurst species, although not the latest in geological age, points to *Goniophora*, a large recent genus of Pacific and Red-Sea corals.

The species of *Balanophyllia* from Brockenhurst, like that from Bracklesham, has no epitheca, but its large base, distinct costæ, and very granular surface render it easily distinguishable. Reuss, F. Römer, and Philippi have described species from the Lower Marine Sand of Weinheim and Latdorf; but they are not closely allied to the species under consideration.

As the genus is present in the whole of the Cainozoic coralliferous beds of Great Britain, and is represented in the existing South British and Mediterranean seas, the following Table may be useful concerning its divisions.

BALANOPHYLLIA.

Subgenus 1. Corallites with broad bases.

Balanophyllia desmophyllum, *Lonsdale*, sp.	Bracklesham.	Eocene.
—— geniculata, *D'Archiac*, sp.	Port des Basques.	,,
—— tenuistriata, *Ed. & H.*	Paris basin.	,,
—— granulata, *Duncan*	Brockenhurst.	Oligocene.
—— cylindrica, *Michelotti*, sp.	Turin and Verona.	Miocene.
—— subcylindrica, *Philippi*, sp.	Sicily.	,,
—— Italica, *Michelin*, sp.	Astesan.	Pliocene (recent).
—— calyculus, *Wood*	Crag.	Pliocene.
—— capensis, *Verrill*	Cape of Good Hope.	Recent.
—— verrucaria, *Pallas*, sp.	Mediterranean.	,,
—— Cumingii, *Ed. & H.*	Philippines.	,,
—— regia, *Gosse*	South Britain.	,,
—— Bairdiana, *Ed. & H.*	Unknown.	,,

Subgenus 2. Corallites more or less pedicellate.

—— Gravesi, *Michelin*, sp.	Henouville (Oise).	Eocene.
—— sinuata, —— inæquidens, —— fascicularis, *Reuss*	Weinheim.	Oligocene.
—— prælonga, *Michelotti*, sp.	Turin.	Miocene.
—— Australiensis, *Duncan*	South Australia.	Miocene?
—— ineplaris, *Seguenza*	Sicily.	Pliocene.

Fossil Corals from the British Eocene Formation.

The following authors have written upon this subject:—Fleming, 'Hist. of British Animals,' 1828. Milne-Edwards and Jules Haime, *op. cit.* Lonsdale, in Dixon's 'Geology of Sussex.' J. de Carle Sowerby, Trans. Geol. Soc. vol. v. p. 136 (1834). J. S. Bowerbank, Mag. Nat. Hist. 1840. Wetherell, Trans. Geol. Soc. 2nd ser. vol. v. (1834).

The labours of these naturalists and palæontologists were collected in the great monograph of the 'British Fossil Corals' by

M. Milne-Edwards and Jules Haime, and by P. Martin Duncan, Supp. Mon. Brit. Foss. Corals, Palæontograph. Soc. 1866, part 1, Tertiary.

In the monograph last named in the list, thirteen species were added to those noticed in the previously published monograph by MM. Milne-Edwards and Jules Haime. The following is a complete summary of the Eocene species.

1. Turbinolia sulcata, *Lamarck.*
2. —— Dixoni, *Ed. & H.*
3. —— Bowerbankii, *Ed. & H.*
4. —— Fredericiana, *Ed. & H.*
5. —— humilis, *Ed. & H.*
6. —— minor, *Ed. & H.*
7. —— firma, *Ed. & H.*
8. —— Prestwichii, *Ed. & H.*
9. —— affinis, *Duncan.*
10. —— exarata, *Duncan.*
11. —— Forbesi, *Duncan.*
12. Leptocyathus elegans, *Ed. & H.*
13. Trochocyathus sinuosus, *Brongniart*, sp.
14. —— Austeni, *Duncan.*
15. Trochocyathus insignis, *Duncan.*
16. Paracyathus crassus, *Ed. & H.*
17. —— caryophyllus, *Lamarck*, sp.
18. —— brevis, *Lamarck*, sp,
19. —— Haimei, *Duncan.*
20. —— cylindricus, *Duncan.*
21. Dasmia Sowerbyi, *Ed. & H.*
22. Oculina conferta, *Ed. & H.*
23. —— incrustans, *Duncan.*
24. —— Wetherelli, *Duncan.*
25. Diplohelia papillosa, *Ed. & H.*
26. Stylocœnia emarciata, *Lamarck*, sp.
27. —— monticularia, *Schweigger*, sp.
28. Astrocœnia pulchella, *Ed. & H.*

29. Stephanophyllia discoides, *Ed. & H.*
30. Balanophyllia desmophyllum, *Lonsdale*, sp.
31. Dendrophyllia elegans, *Duncan.*
32. —— dendrophylloides, *Lonsdale.*
33. Stereopsammia humilis, *Ed. & H.*
34. Dendracis Lonsdalei, *Duncan.*
35. Porites panicea, *Lonsdale.*
36. Litharæa Websteri, *Bowerbank*, sp.
37. Axopora Forbesi, *Duncan.*
38. —— Parisiensis, *Michelin.*

Notice of the Species.

Turbinolia sulcata, Lamarck, is found in the Eocene deposits at Grignon, Hauteville, and Ghent, and is not found, I believe, in higher beds than the Bracklesham in England. The other species are purely British. *T. Prestwichii*, Ed. & H., is probably the oldest form, and *T. sulcata* and *T. Dixoni* are next in age. The remaining species come from the Barton beds. With the exception of the occurrence of *T. sulcata* in the Parisian Eocene, there is little to connect these Turbinoliæ with others. The genus is not represented in the great Nummulitic coral-fauna of the South of France, the North of Italy, or of Sindh. A species is found in the Eocene of Alabama; and three species, characterized by very bad specimens, were determined from forms found in the Lower Oligocene deposits of Germany. The genus is extinct.

The genus *Leptocyathus* is one of those artificial groups which surround the great genus *Trochocyathus*. It is closely allied to *Stephanocyathus*, Seguenza; and indeed the only distinction between these two genera is the distribution of the pali before certain septa. Doubtless some further information will enable those interested in the classification of the Zoantharia to make the genera *Leptocyathus* and *Stephanocyathus* mere subgenera of *Trochocyathus*. *L. elegans* is a very beautiful form; and the structure of its base is a curious instance of symmetry and simplicity of structure, producing in a coral which doubtless was a dweller in deepish water and on an oozy bottom, great perfection of ornamentation.

There is a second species, *L. Atalayensis*, D'Archiac, sp., from the Eocene of Biarritz; but there is some doubt about its genus.

The *Trochocyathi* of the British Eocene are insignificant species of the great genus which is so fully represented in the Sindhian and European Nummulitic series. I have noticed in my 'Supplement to the British Fossil Corals,' Part I., that it is doubtful if *T. sinuosus* was ever found in England, and I have described two new species.

One of these, *T. Austeni*, Duncan, is the representative in the Bracklesham deposits of *T. elongatus*, Ed. & H., of the Eocene of Quartier-du-Vit (Basses Alpes); but *T. insignis*, Duncan, so readily distinguishable by its costal ornamentation and wavy spino-granulose septa, is very solitary as regards its affinities. The *Trochocyathi* commenced in the Jurassic period, culminated in the Miocene, and are extinct, being represented by the *Caryophylliæ* of the Pliocene and recent coral-faunæ.

There are several genera of perforate corals in the British Eocene. Four genera of these belong to the *Eupsammidæ*, one to the *Turbinarinæ*, and two to the *Poritidæ*.

The Eupsammian genera are:—

Stephanophyllia.	Dendrophyllia.
Balanophyllia.	Stereopsammia.

The *Stephanophylliæ* are Cyclolitoid *Eupsammidæ*, and range from the White Chalk to the Pliocene.

The Cretaceous species form a group readily distinguished from the Ter-

tiary forms; and these have a calicular and columellary structure which forms them into a subgroup.

The Eocene species is distantly allied to *S. elegans* from the Miocene of Tortona. The genus is extinct.

The *Balanophyllia*, from the Bracklesham beds, is readily distinguished from the Crag species by its having no epitheca. This is one of the oldest species of the genus, whose species are found also in the Paris Eocene, and in the Nummulitic strata of Port-des-Basques. The recent species are British, South African, and Pacific (20 to 80 fathoms).

The new species, *Dendrophyllia elegans*, nobis, is one of the most beautiful corals ever discovered. The elegant branching and gemmation, the graceful costal curvature and granulation, and the symmetrical repetition of the septal cycles render the coral an object of great interest. Its nearest ally is *D. gracilis*, Ed. & H., of the Chinese seas, a dweller in twenty-five fathoms water. The Miocene and Pliocene species of the genus are well marked; and the recent species are found in the Mediterranean Sea, in the sea off Cadiz and Madeira, and in the Chinese, Pacific, and Australian seas. The most vigorous species are from Cadiz and Madeira, *Dendrophyllia ramea* living there in twenty-five to eighty fathoms.

Stereopsammia is a genus with only one species; and this was determined from the study of a very good compound corallum in the Bracklesham beds. It is interesting to note that a genus appeared in the Upper Sicilian Tertiaries (and has many species in the Australian, New-Zealand, and Chinese seas, besides some off Panama and in the Pacific coral-sea, &c.) which is closely allied to *Stereopsammia*, for its only distinction is the existence of a columella in its species. Both the genera are very erratic members of their subfamily, for the peculiar Eupsammian direction of the septa is not noticed either in *Stereopsammia* or in *Cœnopsammia*.

The aporose condition of the lower part of the corallites of *Stereopsammia*, and their perforated calicular ends, taken into consideration with the peculiarity of the septal direction, prove that the genus links the *Eupsammineæ* amongst the perforate corals with the Aporosa.

The genus *Dendracis* has hitherto been little known. MM. Milne-Edwards and Jules Haime described the first species, out of the *Madrepora Gervilii* of Defrance, from the Hauteville beds; but no species was known to be of British growth. Whilst examining the Dixon collection in the British Museum, I found a species, *D. Lonsdalei*, nobis. Very recently Reusshas described:—*D. seriata*, Castelgomberto; *D. mammillosa*, Castelgomberto; *D. Haidingeri*, Oberburg and Java; and *D. nodosa*, Oberburg. D'Achiardi has also described a species from the Castelgomberto district.

Lonsdale was correct in his diagnosis of his *Porites panicea*; and it is a most interesting species, for it is a true *Porites* and a perforate coral. The form has its septa less spiculate and more lamellate than is usual in the *Porites*, moreover the cœnenchyma is very decided. This Eocene species has thus characteristics of the genera *Porites*, *Astræopora*, and *Litharæa*.

Reuss has described *Porites nummulitica*, Oberburg; *P. minuta*, Castelgomberto; *P. incrassata*, Java, tertiary. This last species is closely allied to *Porites panicea*.

Some years since, I described a *Porites* from the Lower (Hippurite) Limestone of Jamaica. Our knowledge of the genus, therefore, extends from the Lower Chalk to the present day. The Miocene forms and the recent are the most numerous. *Astræopora panicea*, Ed. & H., must give way to the original species, *Porites panicea*, Lonsdale. The *Astræoporæ* flourished in the Castel-

gomberto deposits. The genera *Axopora* and *Litharæa* have been noticed in the report on the Brockenhurst corals. The first genus represented the *Milleporidæ* in the Eocene.

The five species of *Paracyathus* from the British Eocene are :—

Paracyathus crassus, *Ed. & H.*
—— caryophyllus, *Lonsdale*, sp.
—— brevis, *Ed. & H.*
Paracyathus Haimei, *Duncan.*
—— cylindricus, *Duncan.*

P. caryophyllus is found in the Jamaican Eocene, and is closely allied to *P. cylindricus*. *P. crassus* and *P. Haimei* are also allied.

It is doubtful whether the genus should be considered more than a subgenus of the great genus *Trochocyathus*. There are recent species in the Mediterranean and in the West Indies. They are found at a depth of from fifteen to eighty fathoms.

M. de Fromentel has described a species of the extraordinary Eocene genus *Dasmia*, from the Neocomian of St. Dizier. The genus stands by itself, unless the opinion of MM. Milne-Edwards and Jules Haime be admitted to be correct, viz. that each lamina is a septum. To carry this opinion further would place the genus amongst the *Eupsammidæ*.

The *Oculinidæ* are represented in the British Eocene by two genera and four species.

Oculina conferta, *Ed. & H.*
—— incrustans, *Duncan.*
Oculina Wetherelli, *Duncan.*
Diplohelia papillosa, *Ed. & H.*

The three species of *Oculina* belong to a subdivision of the genus in which the calices are distributed without order, the costal striæ being rudimentary or absent. *Oculina conferta* has some analogy with *Oculina Halensis*, Duncan, from the nummulitic limestone of Sindh; but the Sindhian coral has its calices arranged in a serial order. The genus flourished in the Miocene and Pliocene periods, and is represented in almost every coralliferous sea by species living either in tolerably deep water or at a very great depth.

Diplohelia is an extinct genus, and characterizes Tertiary deposits. There is a species, *D. raristella*, Defrance, sp., in the Eocene of Paris and Biarritz. In the corresponding deposits of Lacken there is *D. multistellata*, Galeotti, sp. The Miocene species from the Sicilian Tertiaries have lately been described by Seguenza; and *D. reflexa*, Michelotti, sp., is from Superga. The great development of the columella in *Diplohelia* separates the genus from its nearest ally *Astrohelia*, whose species are Miocene forms from the Faluns and from Maryland. The transition between the genera is through *Astrohelia Lesueuri*, Ed. & H., from the American Walnut-Hill Miocene. This species has a small, lax, and spongy columella, and its closest affinity is with the *Diplohelia* with costal striæ. M. Milne-Edwards remarks that *Astrohelia* (thus united with *Diplohelia*) is a passage from between the *Oculinidæ* and the *Astræidæ*, particularly in relation to the *Cladangiæ*, a Miocene genus. The affinity between *Cladangia* and the recent *Astranginæ* is evident.

The genera *Stylocœnia* and *Astrocœnia* have been removed from the *Eusmilinæ* to the *Astræinæ* in consequence of the discovery that their septa are dentate.

Stylocœnia emarciata has an immense geological range. It characterizes the Eocene of Jamaica, Sindh, Italy, France, and England.

S. monticularia is common to the French and British Eocene beds. (See remarks on the genus in the report on the fossil corals of the Lias.)

Astrocœnia is a very important secondary genus; its peculiarities are fully discussed in the Report on the Fossil Corals of the Lias. There are three species in the Eocene, but only one is British. Reuss has lately described

two species from the Castelgomberto district. The genus became extinct in the Miocene age.

The smaller Heliastræans and Astræans appear to represent these genera in the recent coral-faunæ.

It may be assumed, from our knowledge of the habits of the representatives of the Eocene species in the existing seas, that the bulk of the fauna lived on oozy sea-bottoms, at a depth of from 10 to 100 fathoms. Such a sea (as regards its depth, bottom, and magnitude, but not as regards its temperature) as has been dredged off Unst, or the Southern China Sea, where there are no reefs, might resemble that which contained the old *Turbinoliæ*, *Trochocyathi*, *Paracyathi*, *Oculinæ*, *Stephanophylliæ*, *Balanophylliæ*, *Dendrophylliæ*, and *Stereopsammiæ*.

The genera *Stylocœnia*, *Astrocœnia*, *Dendracis*, *Porites*, *Litharœa*, and *Axopora* were probably located on small reefs, or in shallower water than the others. The fauna, as a whole, is insignificant, and bears a very feeble relation to the magnificent Eocene Coral-fauna of Castelgomberto, the South of France, and Sindh. These were the coral-tracts of the period, and were full of great reefs, whose corals are represented now-a-days by large and quickly growing species.

The immense break between the Upper Chalk and the British coralliferous Eocene deposits is proved by the total difference of their coral-faunæ.

The scanty relationship between the British Eocene and Lower Oligocene coral-faunæ has already been noticed. Part of the British Eocene coral-fauna is represented by species now living in the British, Spanish, and Mediterranean seas, and the rest by species in the Pacific and East-Indian oceans. The slight affinity between the British Eocene and the recent West-Indian coral-faunæ is therefore worthy of notice.

Fossil Corals from the Upper and Lower White Chalk of Great Britain.

The following authors have written upon this subject:—MM. Milne-Edwards and Jules Haime, *op. cit.* Lonsdale in Dixon's 'Geology of Sussex.' Parkinson, 'Organic Remains of a Former World.' Mantell, 'Geology of Sussex,' and Trans. Geol. Soc. 2nd ser. vol. iii. Fleming, 'British Animals,' 1828. Phillips's 'Illustrations of the Geology of Yorkshire,' pt. 1, 1829. S. Woodward, 'Synopt. Tab. Brit. Org. Remains,' 1830. R. C. Taylor in Mag. Nat. Hist. vol. iii. p. 271 (1830).

MM. Milne-Edwards and Jules Haime noticed and described nine species from these formations. One of these species had been previously described by Mantell, and another by Reuss; but seven species were added to our British fauna through the industry of the great French zoophytologists.

During the last few months I have thoroughly examined the specimens offered to me, and those which had been studied by MM. Milne-Edwards and Jules Haime, Lonsdale, and Mantell. I can add ten new species to the list of the corals from the White Chalk, and five good varieties of formerly known species. It is necessary also to admit a species of Mr. Lonsdale's, and to uppress one of MM. Milne-Edwards and Jules Haime.

Corals from the Upper and Lower White Chalk.

1. Caryophyllia cylindracea, *Reuss*, sp.*
2. —— Lonsdalei, *Duncan*†.
3. —— Tennanti, *Duncan*†.
4. Onchotrochus serpentinus. *Duncan* †.
5. Trochosmilia laxa, *Ed. & H.*, sp. and varieties 1, 2, 3 ‡.

* Synonym *Cyathina lævigata.*
† Species not hitherto described.
‡ Varieties or subspecies not hitherto described.

6. Trochosmilia cornucopiæ, *Duncan**.
7. —— Wiltshiri, *Duncan**.
8. —— Woodwardi, *Duncan**.
9. —— granulata, *Duncan**.
10. —— cylindracea, *Duncan**.
11. Parasmilia centralis, *Mantell*, sp., varieties 1, 2.
12. —— cylindrica, *Ed. & H.*
13. Parasmilia Fittoni, *Ed. & H.*†
14. —— serpentina, *Ed. & H.*
15. —— monilis, *Duncan**.
16. —— granulata, *Duncan**.
17. Diblasus Gravensis, *Lonsdale.*
18. Synhelia Sharpeana, *Ed. & H.*‡
19. Stephanophyllia Bowerbanki, *Ed. & H.*‡

The list of species presents a remarkable assemblage of forms. The *Caryophylliæ* are represented in existing seas, especially in from low spring-tide level to 80 or 100 fathoms, in the West Indies, the Mediterranean, and in the south-east and north-east British seas. They are, with one exception (the *Caryophyllia Smythi*), always dwellers in many fathoms; and this coral is evidently a littoral variety of *C. borealis*. The *Oculinidæ* of the present day are usually found under the same conditions as the *Caryophylliæ*; and doubtless the *Parasmiliæ* and *Trochosmiliæ* were dwellers in from 10 to 100 fathoms.

There are no forms which indicate shallow waters, or anything like a reef. The fauna is essentially a deep-sea one.

The continental development of Cretaceous corals is very remarkable; and the horizon of Gosau and Martigues, probably that of our Lower White Chalk and part of the Upper Greensand, is characterized by the reef species. A more decided equivalency between the higher horizons of the Upper Chalk of the continent and the Norfolk beds has been established by the discovery of some of the species now noticed for the first time.

Family TURBINOLIDÆ.

Division Caryophyllaceæ.

MM. Milne-Edwards and Jules Haime adopted for a coral from the Upper Chalk the name of *Cyathina lævigata*. They published this name in their "Monog. des Turlinolides," Ann. des Sciences Nat. 3rd series, vol. ix. p. 20 (1848), and in their "Monograph of the Corals of the Upper Chalk," Pal. Soc. 1850. Lonsdale named the same coral *Monocarya centralis*, Dixon, 'Geol. of Sussex,' 1850, and probably *Monocarya cultrata* also.

In 1850 D'Orbigny (Prodr. de Paléont. t. ii. p. 275, 1850) gave the coral the specific name *cylindracea*, it having become evident that Reuss was the primary discoverer of the species in 1846. In his 'Kreideformation,' p. 61, pl. 14, figs. 23–30, Reuss gives the name *Anthophyllium cylindraceum*. The genus of the coral is evidently *Caryophyllia*, in the sense adopted by Charles Stokes in 1828.

MM. Milne-Edwards and Jules Haime, having all this information before them, very properly determined the generic and specific names to be *Caryophyllia cylindracea*, Reuss, sp., in their 'Hist. Nat. des Corall.' vol. ii. p. 18.

This species is very polymorphic, and the pali of some specimens are very like the outer terminations of the columellary structures in some *Parasmiliæ*. Very frequently it is hardly possible to determine which are the pali and which the ends of the columellary fasciculi. Moreover in some specimens the base is small and the costæ reach low down; whilst in others the base is normal and large, the costæ being abnormal from their length. There is a

* Species not hitherto described.

† See the remarks on the propriety of absorbing *P. Mantelli*.

M. de Fromentel has described *Caryophyllia decameris*, from Southfleet. Much experience in these species inclines me to believe the decameral arrangement he speaks of to be a monstrosity. His species has but one specimen.

‡ Lower Chalk.

new species of this genus in the Dunstable chalk, and another in the chalk of Sussex. There are thus three species of *Caryophyllia* in the Upper Chalk of England:—

1. Caryophyllia cylindracea, *Reuss*, sp.
2. —— Lonsdalei, *Duncan*.
3. Caryophyllia Tennanti, *Duncan*.

Caryophyllia Lonsdalei, Duncan.

The corallum has a large and incrusting base, and the stem is cylindro-conical and straight. There is a slight curve near the base. The calice is circular, small, not very open, and moderately deep. The columella is small, and is terminated by rod-shaped processes. The septa are slightly exsert, the primary especially. There are three complete cycles; and the septa of the higher orders of the fourth cycle are not developed in every system. The primary, secondary, and tertiary septa are very much alike. They have a wavy inner edge and are granulated. The pali are situated before the tertiary septa, and are knob-shaped, and rather flat from side to side. The costæ are nearly equal at the calicular margin, and pass downwards as flat, band-like prominences, separated by shallow intercostal grooves. They are continued to the base, but are hidden midway by an epithecal growth.

Height of the corallum $\frac{5}{6}$ inch. Breadth of the calice $\frac{1}{3}$ inch.

Locality. Dunstable.

In the collection of the Rev. T. Wiltshire.

This species is readily distinguished by its costæ, and is more closely allied to *C. cylindracea* than to any other form.

Caryophyllia Tennanti, Duncan.

The corallum has a large base, a curved cylindrical stem, and an inclined elliptical calice. It is short in relation to its broad base. The calice is open and shallow. The columella is small, and terminates in twelve knob-shaped endings to the fasciculi. The septa are unequal, and there are five incomplete cycles. The laminæ are marked with curved lines of granules, are wavy and unequal. The pali are longer than the columellary processes, are wavy, flattened, and curved. The costæ are subequal in the upper third, but are not seen below.

Height $1\frac{1}{3}$ inch. Length of calice $\frac{5}{6}$ inch.

Locality. Sussex, Upper Chalk.

In the collection of Professor Tennant, F.G.S.

This species connects the Tertiary and recent *Caryophylliæ* with those of the Cretaceous system.

Division Turbinoliaceæ.

Gen. nov. Onchotrochus.

The corallum is simple, tall, slender, rather hook-shaped or clavate, and presents evidence of irregular growth.

There is no endotheca. The costæ are rudimentary, and there is no columella. The septa are few in number. The epitheca is pellicular and striated.

The genus is somewhat allied to *Smilotrochus*, *Stylotrochus*, and very distantly to *Flabellum*.

Onchotrochus serpentinus, Duncan.

The corallum is tubulate, curved superiorly, and straight, and tapering inferiorly. There is a sudden diminution in the diameter of the upper part of the corallum. The costæ are quite rudimentary. The epitheca is marked with fine transverse striations. The septa are continuous with what appear to be rudimentary intercostal spaces. The laminæ are twelve in number;

they project into the circular calice, but are not exsert. A section proves that they are very stout even low down in the corallum.

Length of corallum 1 inch. Diameter of the calice $\frac{1}{6}$ inch.

Locality. Charlton, Kent.

In the collection of the Rev. T. Wiltshire.

This species is mimetic of *Parasmilia serpentina*, Ed. & H., from the same geological horizon, just as *Thecosmilia cylindrica* is of *Parasmilia cylindrica*. The *Stylotrochi* of the Cambridge Upper Greensand are closely allied to the Upper-Cretaceous form.

Family ASTRÆIDÆ.

Genus Trochosmilia.

Subgenus *Cœlosmilia*.

It is a great question whether *Cœlosmilia* can stand as a genus. It is impossible to separate its species from those of *Trochosmilia* by an external examination; and sections prove that there is no columella and a very scanty endotheca. Still there is an endotheca; and the visceral cavity is not open from top to bottom, as in the *Turbinolidæ*. It is true that there is a facies common to the *Cœlosmiliæ*, and that they are a natural group; but in fact they would not differ from a well-known *Trochosmilia* with scanty endotheca, were there such a species. On studying the genus *Trochosmilia*, it will be noticed that many of its species have never been described with reference to their endotheca. Many were determined from one or two specimens, and sections of the majority have not been taken. Now *Trochosmilia sulcata*, Ed. & H., has very little endotheca; it is a species from the Gault, and the *Cœlosmiliæ* are all from the Upper Cretaceous, Eocene, and recent coral-faunæ. In placing *Cœlosmilia* as a subgenus, but included in *Trochosmilia*, it must be admitted that the classification becomes simpler and more natural. Since MM. Milne-Edwards and Jules Haime published their 'Hist. Nat. des Coralliaires' some new species of *Cœlosmilia* have been published or described. The known species were as follows:—

1. Cœlosmilia poculum, *Ed. & H.* Recent.
2. —— Faujasi, *Ed. & H.* White Chalk.
3. —— punctata, *Ed. & H.* White Chalk.
4. —— laxa, *Ed. & H.* Norwich Chalk.
5. —— Edwardsi, *D'Orb.* Sezanne.
6. Cœlosmilia Atlantica, *D'Orb.* Tuber Creek, New Jersey.
7. —— excavata, *Hag.*, sp.
8. —— radiata, *Quenstedt.* Natheim.

The new species are;—

10. Cœlosmilia elliptica, *Reuss.* Castelgomberto.
11. —— Javana, *Duncan*, MS. Java.
12. —— cornucopiæ, *Duncan.* Trimmingham chalk.
13. —— Wiltshiri, *Duncan.* Norwich Chalk.
14. Cœlosmilia Woodwardi, *Duncan.* White Chalk, England.
15. —— granulata, *Duncan.* White Chalk, England.
16. —— cylindrica, *Duncan.* White Chalk, England.

The species *cornucopiæ*, *Wiltshiri*, *Woodwardi*, *granulata*, and *cylindrica* are new to British palæontology, and are very characteristic of the Upper Chalk.

I have discovered three well-marked varieties of *C. laxa*.

An analysis of the species produces the following results:—

1. The species *Atlantica*, *punctata*, *Edwardsi*, *excavata*, and *radiata* either pertain to other species, or are really indeterminable.

2. The species whose septal arrangement shows more cycles than four, or some septa of the fifth cycle, are:—

Cœlosmilia poculum.	Cœlosmilia Wiltshiri.
—— Faujasi.	—— Woodwardi.
—— Javana.	—— elliptica.
—— cornucopiæ.	

3. The species whose septal arrangement shows three cycles, or four cycles, or some septa of the fourth cycle, are :—

Cœlosmilia granulata.	Cœlosmilia laxa.
—— cylindrica.	

4. The species with large bases and with more than four cycles are :—

Cœlosmilia poculum.	Cœlosmilia elliptica.

5. The species with a large base and with more than three cycles of septa, but not more than four, is

Cœlosmilia cylindrica.

Having scanty endothecæ with wide bases :—

The costæ hardly prominent, replaced inferiorly by granules, 5 cycles, corallum straight	Trochosmilia (C.) poculum, *Ed. & H.*
The costæ cristiform, superiorly with intermediate costæ, corallum curved	—— (C.) elliptica, *Reuss*, sp.
The costæ very distinct, flat, wide, intercostal spaces linear, 4 cycles, corallum cylindrical...	—— (C.) cylindrica, *Duncan.*

With pedicel, or a small trace of former attachment, 5 cycles :—

The costæ throughout indistinct, plane, and unequal.	Trochosmilia (C.) Faujasi, *Ed. & H.*
The costæ alternately large and small, subcristiform above, crossed by ornamentation	—— (C.) Javana, *Duncan.*
The costæ subcristiform throughout, subequal above...	—— (C.) cornucopiæ ,,
The costæ very distant, distinct and subcristiform, smaller, much ornamented	—— (C.) Wiltshiri, ,,
The costæ long, the principal cristiform, many smaller between them, corallum long and cornute.....	—— (C.) Woodwardi, ,,

Four cycles or part of the fourth :—

The costæ well marked, distant, very granular, intercostal spaces very granular and strongly marked, corallum curved	—— (C.) granulata ,,
The costæ distant, distinct, and cross-marked in intercostal spaces	—— (C.) laxa, *Ed. & H.*

Trochosmilia (*Cœlosmilia*) *laxa*, Ed. & H.

In examining good specimens of this species I found the fourth cycle of septa to be present. Its laminæ are small, but decidedly visible; consequently the calice, as drawn by MM. Milne-Edwards and Jules Haime, 'Monog. Brit. Foss. Corals,' pt. 1. tab. viii. fig. 4*c*, is incorrect. The following description will apply to the three varieties of the species.

Variety 1. The corallum is conico-cylindrical and straight. The costæ are intensely granular inferiorly, and two large costæ are separated by three smaller. Near the calice the larger costæ have a wavy cristiform ridge upon them, the intermediate costæ being very granular, with chevron patterns, or they may be moniliform. At the calicular margin the costæ are nearly flat and granular. The fourth cycle of septa is distinct.

Variety 2. Inferiorly, in structure as *variety* 1. Superiorly the principal costæ are very cristiform, and well marked with a secondary ridge. The chevron pattern of the intermediate costæ are very distinct.

Variety 3. Costæ inferiorly wavy and sparely granular. Superiorly the costæ are subcristiform and plain, the continuity of the crests being defective. The intermediate are broken and moniliform, and here and there chevroned.

Trochosmilia (*Cœlosmilia*) *cornucopiæ*, Duncan.

The corallum is strongly curved in the plane of the smaller axis, and it is compressed superiorly, and is finely pedunculate. The growth-rings and swellings are moderately developed. The costæ are subequal above and cristate, and unequal inferiorly. The septa are numerous and very unequal. There are five cycles of septa, and six systems. The primary septa are very exsert, and the secondary ones less so. The septa of the fifth cycle are very small. The calice is elliptical and the fossa very deep, the larger septa joining those opposite at its bottom. There are traces of epitheca.

Height 1 inch. Breadth of calice $\frac{5}{6}$ inch. Length of calice 1 inch. Depth of fossa $\frac{5}{6}$ inch.

Locality. Trimmingham, Upper Chalk.

In the collection of the Rev. T. Wiltshire, F.G.S. &c.

Trochosmilia (*Cœlosmilia*) *Wiltshiri*, Duncan.

The corallum is tall, finely pedicellate, and is not compressed. The growth-rings are distinct. The costæ are very distinct and unequal, and they reach from base to calice. The smaller intermediate costæ are ornamented with chevrons and horizontal lines. The larger costæ have a secondary crest upon their free surface. The septa are unequal, slender, and not crowded. The calice is circular. There are five cycles of septa, but the fifth is incomplete in some systems. The primary septa are large, slightly exsert, and extend far inwards. The calicular margin is very thin, and the fossa is deep.

Height $1\frac{2}{3}$ inch. Diameter of calice $\frac{2}{3}$ inch.

Locality. Norwich, Upper Chalk.

In the collection of the Rev. T. Wiltshire, F.G.S. &c.

Trochosmilia (*Cœlosmilia*) *Woodwardi*, Duncan.

The corallum is tall, cornute, slightly pedicellate and narrow. The growth-markings are distinct. The costæ are distinct from base to calice. Two large suberistiform and very distinct costæ bound three intermediate small and more or less moniliform costæ. Sets of these costæ occur around the corallum. The septa are crowded, wavy, and unequal; many unite laterally, and the largest reach far into the axial space. The calice is circular, and the wall is very thin.

Height 2 inches. Breadth of calice $\frac{5}{6}$ inch.

Locality. Chalk of South of England.

In the British Museum, Dixon Collection.

Trochosmilia (*Cœlosmilia*) *granulata*, Duncan.

The corallum is tall and slightly curved; it has a long pedicel with a very distinct base. The corallum is slightly compressed, and bulges here and there. The costæ are well marked, distant, subequal, and intensely granular. The larger costæ are more distinct inferiorly and midway than close to the calicular margin; they are cristiform in some places, notched by chevron-shaped ornamentation in others, and occasionally sharply pointed or absent. The spaces between the larger costæ are wide, faintly convex, and are marked longitudinally by small costæ, and transversely by wavy or chevroned ornamentation. The whole external surface of the corallum is very granular. The calicular wall is very thin, and the calice is elliptical. There are three perfect cycles of septa, and some orders of the fourth cycle in some of the systems. The septa are wide apart, slightly exsert, unequal, and slender; they do not reach far inwards at once, but dip downwards with a gentle curve. In a section the inner margin of the lower septa is wavy. The endotheca is scanty.

Height $1\frac{2}{3}$ inch. Length of calice $\frac{5}{6}$ inch. Breadth $\frac{2}{3}$ inch.
Locality. Norwich, and Chalk of South of England.
In the British Museum, Dixon Collection.

Trochosmilia (*Cœlosmilia*) *cylindrica*, Duncan.

The corallum is tall, cylindrical, and very slightly bent. The calicular opening is smaller in diameter than the rest of the corallum. The costæ are nearly equal, broad, slightly crowded, and are separated by shallow, narrow and undulating intercostal grooves. The costæ are profusely ornamented with transverse ridges, straight, curved, or angular, and with large granules. The calicular edge is very thin, and the broad convex costæ are continuous with slender unequal septa. The primary are exsert, and the laminæ of the higher orders are very small. There is no columella, the larger septa uniting by a few short attachments from their inner margins. The endotheca is scanty.

Height several inches. Breadth of the calice $\frac{5}{6}$ inch.
Locality. Norwich, Upper Chalk.
In the collection of the Rev. T. Wiltshire, F.G.S. &c.

The subgenus *Cœlosmilia* is thus represented in the British chalk by one species formerly known, by three varieties of it, and by five new species:—

1. Trochosmilia (Cœlosmilia) laxa, *Ed. & H.*
   —— (——) ——, vars. 1, 2, 3, *Duncan.*
2. —— (——) cornucopiæ, *Duncan.*
3. —— (——) Wiltshiri, *Duncan.*
4. Trochosmilia (Cœlosmilia) Woodwardi, *Duncan.*
5. —— (——) granulata, *Duncan.*
6. —— (——) cylindrica, *Duncan.*

These *Trochosmiliæ*, with a slight amount of endotheca (and what there is of it is generally low down), are very characteristic of the Upper Chalk; and their presence suggests that the Upper Chalk of Norwich and Trimmingham is, from the evidence of its corals, as well as from the proofs already adduced from its Mollusca, on a higher horizon than the Upper Chalk (usually so called) in the south-eastern district. The coral evidence brings the Norfolk chalk closer in relation with the Faxoe, Rugen, and Ciply deposits†.

The affinity between *Trochosmilia* (*C.*) *cornucopiæ* and *Cœlosmilia excavata*, Hag., sp., a doubtful form, but well drawn by Quenstedt, is evident. It is from Rugen and Moen. *T. Wiltshiri* and the species *Faujasi*, from Ciply, are also closely allied.

The depth of the space between the calicular margin and the top of the upper dissepiment in these species indicates that the animal had great mesenteric, ovarian, perigastric, and water systems. They were probably very rapid growers. The wall is merged into the costal system, which is strengthened by a most unusual cross-bar and cristiform ornamentation; and this development, which is almost epithecal, is complementary to the defective endotheca.

Family ASTRÆIDÆ.

Division TROCHOSMILIA.

Genus PARASMILIA.

MM. Milne-Edwards and Jules Haime described five species of this genus from the Upper Chalk, viz.:—

1. Parasmilia centralis, *Mantell*, sp.
2. —— Mantelli, *Ed. & H.*
3. —— cylindrica, *Ed. & H.*
4. Parasmilia Fittoni, *Ed. & H.*
5. —— serpentina, *Ed. & H.*

† With regard to the depth at which *Oculinidæ* and simple corals can live, it has been discovered by Dr. Carpenter and Prof. Wyville Thompson that they exist at a depth of 530 fathoms.

P. cylindrica and *serpentina* are readily distinguished by their external shape; but, owing to the polymorphic character of *P. centralis*, it is by no means easy to separate it from *P. Mantelli* and *P. Fittoni*.

Parasmilia Mantelli, Ed. & H., was determined from one specimen alone, and it is clearly united to *P. centralis* by *P. Gravesana*, Ed. & Haime, of the White Chalk of Châlons-sur-Marne and Beauvais (Oise). This species I have found in England; and having had many specimens of *P. centralis* with costæ like those of *P. Mantelli* in some parts of the corallum, and normal costæ in others, I consider *P. Mantelli* a variety of *P. Gravesana*, and that this last species is a variety of *P. centralis*, a good subspecies.

Parasmilia Fittoni, Ed. & H., has a large columella and a definite structural distinction in its tertiary costæ from *P. centralis*.

The new forms I have noticed with the older are shown in the following list:—

1. Parasmilia centralis, *Mantell*, sp.
   —— ——, var. Mantelli.
   —— ——, subspecies Gravesana, *Ed. & H.*
2. —— Fittoni, *Ed. & H.*
3. Parasmilia cylindrica, *Ed. & H.*
4. —— serpentina, *Duncan.*
5. —— monilis, *Duncan.*
6. —— granulata, *Duncan.*

Parasmilia monilis, Duncan.

The corallum is long, much curved, and distorted. It is more or less cylindrical above and contracted here and there. Inferiorly it is pedunculate, the peduncle being small, curved, and long. The costæ are nearly equal on the peduncle; there they are rather subcristiform, a secondary crest being on the costæ; and in the intercostal spaces there is either a faint ridge or a moniliform series of granules. The calice is often smaller than the body, and the wall is very thin. The septa are small; and there are four cycles, the last cycle being rudimentary. The columella is small.

The height varies from $\frac{1}{4}$ inch to 2 inches, and the diameter from $\frac{1}{2}$ to $\frac{2}{3}$ inch.

Locality. Gravesend.

In the collection of the Rev. T. Wiltshire, F.G.S.

Parasmilia granulata, Duncan.

The corallum is tall, nearly straight, finely pedunculate, and cylindro-conical. The calice is very large, widely open, deep, and has a thin margin. The columella is well developed. The septa are barely exsert, reach but slightly inwards, but pass downwards at once. They are very unequal, alternately large and small, and there are four complete cycles and part of the fifth. The costæ are subequal near the calice, and the broadest are continuous with the smallest septa. On the body the costæ are subcristiform and in sets of four. On the pedicel they are very granular and very distinct.

Height $1\frac{1}{2}$ inch. Breadth of calice $\frac{1}{2}$ inch.

In the British Museum, Dixon Collection.

This species was included by Lonsdale in his genus *Monocarya*, and was termed *M. centralis*. *Parasmilia* has the priority as a genus; and the species is evidently not *P. centralis*. The position of the genus *Parasmilia* is somewhat like that of *Cœlosmilia*; but MM. Milne-Edwards and Jules Haime have created the genus *Cylicosmilia* for *Parasmiliæ* with abundant endotheca. Now in careful sections I have found that *P. centralis* and its varieties have endothecal dissepiments reaching close to the calicular fossa. The genus must therefore absorb *Cylicosmilia*; and *C. Altavilensis*, Defrance, sp., of the Eocene of Hauteville must become *Parasmilia Altavilensis*, Defrance, sp. Reuss has described an Eocene *Parasmilia* from Monte Grumi which is closely allied to the *centralis* series.

(Order ZOANTHARIA APOROSA.)

Family OCULINIDÆ.

Genus Diblasus, Lonsdale.

This genus was established by Lonsdale in Dixon's 'Geol. of Sussex,' 1850, and was described by the learned zoophytologist with all that critical acumen which characterizes him, pp. 248 to 254, pl. 18. figs. 14 to 28.

MM. Milne-Edwards and Jules Haime, whilst they acknowledge the genus to be "voisin des Synhelia" (Hist. Nat. des Corall. vol. ii. p. 115), do not give it a place in their classification. I have therefore carefully studied and drawn the specimens from the Dixon Collection in the British Museum, and have great pleasure in doing justice to Mr. Lonsdale, by inserting his genus with slight alterations to meet the present terminology.

Genus *Diblasus*, Lonsdale (amended).

The corallum is incrusting, very irregular in shape; the calices are wide apart and projecting; the intercalicular tissue is costulate. The septa are unequal. There are no pali. The columella is formed by the junction of the larger septa, and does not exist as a separate structure. Gemmation marginal and intercalicinal. The genus is evidently not closely allied to *Synhelia*; for it has no palular or true columellary structures. It approaches the genus *Astrohelia*, which is a transition genus bringing the *Oculinidæ* in relation with the *Astræinæ* through the *Cladangiæ* (Milne-Edwards and Jules Haime, 'Hist. Nat. des Corall.' vol. ii. p. 111).

Diblasus Grevensis, Lonsdale.

The corallum is very irregular in shape and size. The calices project, and are irregular in their projection and size. The costæ are granular, equal, subequal, and unequal in different parts of the same corallum. The septa are in three cycles, and are unequal and dentate; the primary reach those opposite, and form a rudimentary columella; they are crowded, and are granular laterally. Diameter of usual-sized calices $\frac{1}{6}$ inch.

Locality. Gravesend Chalk.

In the British Museum, Dixon Collection.

The condition in which the specimens of this species is found is very remarkable: the inside of nearly every calice has been worn away, so that the mural edges of the septa are all that remains of them; the perfect calices appear to have shrunk from the surrounding cœnenchyma; and in many places the costæ have been worn off.

Lower Chalk.

There are several specimens of corals from the Lower Chalk; but I have not been able to identify them, on account of their fragmentary condition. *Onchotrochus serpentinus* is a Lower-Chalk form.

Fossil Corals from the Upper Greensand.

The following authors have written on this subject:—W. H. Smith, 'Strata identified by Organic Fossils,' 1816. Godwin-Austen, Trans. Geol. Soc. 2nd Series, vol. vi. p. 452. Morris, 'Cat. of British Fossils,' p. 46 (1843). MM. Milne-Edwards and Jules Haime, *op. cit.*

The scanty Coral-fauna of this deposit was described by MM. Milne-Edwards and Jules Haime; and although some years have elapsed since the publication of the first part of the 'British Fossil Corals' (Pal. Soc.), and the beds have been well searched, very few additions can be made to the list of fossils.

The following is a list of the published species (1850).

1. Peplosmilia Austeni, *Ed. & H.*
2. Trochosmilia tuberosa, *Ed. & H.*
3. Parastræa stricta, *Ed. & H.*
4. Micrabacia coronula, *Goldfuss*, sp.

In their 'Hist. Nat. des Corall.' vol. ii., MM. Milne-Edwards and Jules Haime make some alterations in the synonyms of the genera, and add a species to the list. They do not give any further information respecting some doubtful species noticed by Messrs. Godwin-Austen and Prof. Morris.

Their amended list is as follows.

1. Peplosmilia Austeni, *Ed. & H.*
2. Smilotrochus tuberosus, *Ed. & H.*
3. —— Austeni, *Ed. & H.*
4. Favia striata, *Ed. & H.*
5. Micrabacia coronula, *Goldfuss*, sp.

Specimens belonging to the following species have been submitted to me.

1. Onchotrochus Carteri, *Duncan.*
2. Smilotrochus elongatus, *Duncan.*
3. —— angulatus, *Duncan.*
4. Cyathophora monticularia, *D'Orbigny.*
5. Favia minutissima, *Duncan.*
6. Thamnastræa superposita, *Michelin.*

Trochosmilia tuberosa, Ed. & H., was found to be without endotheca, and therefore to be of necessity included amongst the *Turbinolidæ*. The genus *Smilotrochus* was determined in order to receive the species.

Genus Smilotrochus, Ed. & H.

The corallum is simple, straight, cuneiform, free, and without trace of former adhesion. There is no columella, the wall is naked and costulate. There is no epitheca, and the simple costæ are distinct from the base to the calice.

This is the simplest form of Aporose Zoantharia; and its structures are confined to a wall, septa, and costæ. *Flabellum* has an epitheca in addition, and *Stylotrochus* of De Fromentel is a *Smilotrochus* with a styliform columella, the septa uniting also by their thickened internal margins. *Onchotrochus*, nobis, has a pellicular epitheca, no columella; but, like *Stylotrochus*, the septa are united internally.

1. *Smilotrochus tuberosus*, Ed. & H.
Trochosmilia tuberosa, *Ed. & H.*
Turbinolia compressa? *Morris.*

This species with five cycles of septa was described in the 'Monog. of the Brit. Foss. Corals,' Upper Greensand, Milne-Edward and Jules Haime (Pal. Soc.).

2. *Smilotrochus Austeni*, Ed. & H.

This species is described in the 'Hist. Nat. des Corall.' vol. ii. p. 71.

The corallum is regularly cuneiform, very compressed below, and slightly elongate. The calice is elliptical, the summit of the larger axis rounded; forty-eight costæ, subequal, straight, fine, and granular.

Height of the corallum about $\frac{1}{3}$ inch.

Locality. Farringdon.

MM. Milne-Edwards and Jules Haime do not mention where the specimen is.

3. *Smilotrochus elongatus*, Duncan.

The corallum is tall, straight, and nearly cylindrical. The columellary space is large. The septa are fine and unequal, especially in length; there are four cycles of septa.

Height about an inch.

Locality. Upper Greensand of Cambridgeshire.

In the collection of James Carter, Esq.

4. *Smilotrochus angulatus*, Duncan.

The corallum is conical, hexagonal, slightly curved at its very fine inferior extremity. It is broad superiorly, and has six prominent angles, and is compressed slightly. The septa are fine, unequal, and each plane between the angles has a system of four cycles. The columellary space is large.

Height $\frac{3}{4}$ inch. Breadth $\frac{1}{2}$ inch.

Locality. Upper Greensand of Cambridge.

In the collection of James Carter, Esq.

Genus Onchotrochus.

Numerous specimens of a species of this genus are in the possession of James Carter, Esq. and the Rev. T. Wiltshire. The species has great resemblance to the lower part of *Onchotrochus serpentinus*, nobis. A careful examination of sections and calices proves that there is no columella, that the inner ends of the septa produce a false one, and that the styloid appearance is due to fossilization.

Onchotrochus Carteri, Duncan.

In the young corallum there is a flat and round expansion at the base, by which it was attached to foreign substances; but this is lost as growth proceeds. The corallum is either straight or slightly curved, is tall, very slender, conico-cylindrical, clavate, and enlarged here and there. Unworn specimens are more or less angular in transverse outline. The costæ are angular projections, extend from base to calice, are subequal, wide apart, and are connected and covered with a fine pellicular epitheca, which readily disappears. Growth-markings very common. The calice is circular and shallow. The septa are short at the wall, and wedge-shaped; they are rounded inferiorly, and do not extend far inwards. There are twelve septa, and they are subequal. The septa in sections often appear equal, and their inner ends are joined, and the axial space is filled up by a deposit of coral-structure. But the reverse is the case occasionally, and the irregularity of the septa may be well seen. The septa are continuous with the costæ.

Height $\frac{1}{3}$–$\frac{2}{3}$–1 inch. Diameter of calice $\frac{1}{12}$ inch.

Locality. Cambridge Greensand.

In the collection of James Carter, Esq. and Rev. T. Wiltshire.

The discovery of better specimens may perhaps lead M. de Fromentel to consider his *Stylotrochus*, which so resembles this form, to be of the same genus.

Genus Cyathophora, *Michelin.*

This genus has the usual characters of compound Astræinæ; but the dissepiments act as tabulæ, and shut in the calice below, just as in some of the Liassic *Isastrææ*. There is no columella*. Curved dissepiments are not noticed; and the family of the genus must remain unsettled, for the minute structure is clearly tabulate. The genus flourished in the Lower and Middle Oolites; and the only Cretaceous species is that under consideration, and which has been described by D'Orbigny from the Craie Tuffen, Les Martigues —*Cyathophora monticularia*, D'Orb., sp.

The septa are rather thick. There are three cycles, but the third is often deficient in one or two systems.

Locality. Haldon.

In the collection of the Geological Society.

* See remarks on Liassic *Isastrææ*.

Genus Favia.

This genus has absorbed the *Parastrææ*, so that *P. stricta* has become *Favia stricta*.

Favia minutissima, Duncan.

The corallum is incrusting, gibbous, and small. The calices are very small, close, and with very scanty intercorallite tissue. There are twelve septa, and the costæ are continuous.

Diameter of the calices under $\frac{1}{12}$ inch.

Locality. Haldon.

In the collection of the Geological Society.

This is the smallest of the *Faviæ*.

Genus Thamnastræa.

Thamnastræa superposita, Michelin, sp.

MM. Milne-Edwards and Jules Haime thus notice this species (Hist. Nat. des Corall. vol. ii. p. 559):—

"M. Michelin's specimen is very young. It is encircled by a strongly folded epitheca, which is formed of two layers. No columella is distinguishable. The septa are tolerably strong and unequal. There are three cycles, with the rudiments of a fourth in one or two systems."

The superposition of the calices is remarkable; and I cannot but place a coral found in the Irish Upper Greensand by Ralph Tate, Esq., F.G.S., in this species.

Locality. Ireland, Upper Greensand.

In the collection of R. Tate, Esq., F.G.S. &c.

Fossil Corals from the Red Chalk of Hunstanton.

The Red Chalk of Hunstanton contains several forms of Madreporaria. The small fauna has this peculiarity; its species belong to the group of Fungidæ without exception. The specimens are small, usually much worn at the calicular end, and are readily distinguished by their mammiliform appearance and white colour.

There are no compound Fungidæ in the Red Chalk, but such small, simple forms as would now characterize the presence of physical conditions unfavourable for coral-life. The recent simple Fungidæ are found at all depths; vast numbers of them are to be collected in the Gosau Lower Chalk; a few existed in the Upper Greensand and the Neocomian, and are found in the existing coral-fauna; none are found in the West-Indian seas, whilst the Red Sea, Pacific, and Indian oceans abound with them. It is probable that peculiar conditions are necessary for their development.

List of species in the Red Chalk of Hunstanton.

1. Micrabacia coronula, *Goldfuss*, sp.
   —— ——, var. major.
2. Cyclolites polymorpha, *Goldfuss*, sp.
3. Podoseris mammilliformis, *Duncan*.
4. —— elongata, *Duncan*.

Family FUNGIDÆ.

Subfamily Fungiæ.

Genus Micrabacia.

There are specimens of a small form of *Micrabacia coronula*, Goldfuss, sp., and of a large variety, in the red rock; the species is well known in the Upper Greensand of England, and in the Chalk of Essex. There is another

species, which is hardly distinguishable from *M. coronula*, in the Neocomian of Caussols (var.).

The variety of the species in the red rock rather resembles the Neocomian species in its diameter and flatness. The genus had a very short vertical range, and was represented in later times by the *Stephanophyllicæ*.

Subfamily Lophoserinæ.

Genus Cyclolites.

This genus almost characterized the geological horizon of the Craie-Tuffeau of Gosau, the Ile d'Aix, les Martigues, Vaucluse, Corbières, Uchaux, &c. A few species are found in the White Chalk, in the Eocene, and Miocene. There are some doubtful Neocomian species; and the genus is extinct.

Cyclolites polymorpha, Goldfuss, sp.

The corallum is very irregular in shape, generally subelliptical, and not very tall. The highest point of the calice is subcentral, and the central fossula is very variable in its place. The septa are very numerous, thin, close, flexuous, crenulate, and larger in front.

The solitary specimen of this form is small, but the fossula and septa are tolerably distinct.

Genus Podoseris, *Duncan*.

The corallum has a large concave base, by which it is attached to foreign bodies. The epitheca commences at the basal margin, and is stout and reaches the calicular margin. The height of the corallum varies. The calice is generally smaller than the base, and is convex. The septa are numerous and unequal, the largest reaching the rudimentary columella. The central fossula is circular and small. The costæ are seen when the epitheca is worn; they are distinct, connected by synapticulæ, and are straight.

The genus has been created to admit *Micrabacicæ* with adherent bases and more or less of a peduncle.

Podoseris mammilliformis, Duncan.

The corallum is short, straight, and broad. The base is concave, and is either larger than the calice, or there is a constriction immediately above it, and it is slightly smaller than the calice. The calice is round, convex, depressed in the centre, and is bounded inferiorly by the epitheca. The laminæ are stout, unequal, curved superiorly, and often join. There are five cycles in six systems, the last cycle being very rudimentary. The synapticulæ are numerous. The costæ are straight and subequal, and are smaller than the septa. The ornamentation of the septal and costal apparatus varies; and there may be an almost moniliform series of enlargements on the septa, or they may be plain. The columella is formed principally by the ends of the longest septa. The height of the corallum appears to be determined by the growth of the body between the base and the calice.

Height of the corallum $\frac{1}{4}$ inch. Breadth of calicular margin $\frac{1}{3}$ inch.
Height $\frac{1}{6}$ inch. Breadth of calicular margin $\frac{1}{4}$ inch.
Height $\frac{1}{2}$ inch. Breadth of calicular margin $\frac{11}{30}$ inch.

Monstrosities are often found amongst specimens of this species.

Podoseris elongata, Duncan.

The corallum is tall, a broad circular and slightly concave base, a long conico-cylindrical stem, and a small calice much narrower than the base. The epitheca is in bands. The costæ are alternately large and very small, somewhat distant, wavy, and united by synapticulæ, many of which are oblique.

The septa frequently unite by their axial ends to each other, the short to the long. There appear to be five cycles of septa. The base of the corallum has a cellular tissue, probably from the fossilization of some body to which it was adherent.

Height $\frac{5}{6}$ inch. Breadth of base $\frac{1}{2}$ inch. Breadth of calice $\frac{1}{4}$ inch.

The shape of this species is most unusual.

These corals are all in the collection of the Rev. T. Wiltshire, F.G.S.

It is evident that the coral evidence places the Red rock in the Upper-Greensand horizon.

Corals from the Lias.

When MM. Milne-Edwards and Jules Haime wrote their 'Monograph of the British Fossil Corals' (Pal. Soc.), only one good species was known as Liassic. There was a great palæontological break between the coral-faunæ of the Inferior Oolite and of the Mountain-limestone. The distinction between the Palæozoic and Jurassic coral-faunæ was so great that any student of the Mesozoic Zoantharia appeared to enter another Madreporarian world when the Carboniferous forms were presented to his notice. On leaving the study of the *Montlivaltiæ*, *Thecosmiliæ*, *Isastrææ*, and other familiar Secondary genera, and entering upon the investigation of such genera as *Cyathophyllum*, *Lithostrotion*, *Lonsdalia*, and *Amplexus*, a new classificatory philosophy had to be comprehended, and it required much experience in the habit of determining species before the foreshadowing of the Secondary forms could be appreciated in the Palæozoic. The break was produced by the very uncoralliferous nature of the Permian strata, the absence of any corals from the Trias in this country, and the solitary species from the Lias.

Of late years the distinction between the Palæozoic and Oolitic coral-faunæ of continental Europe has been lessened by the careful study by Laube and Reuss of the Triassic coralliferous limestones, and by De Fromentel, Ferry, Terquem, Piette, and Stoppani of the corals of the *Avicula-contorta* zone, and of the strata sometimes called Infralias, in which *Ammonites planorbis* and *A. angulatus* are found. The Palæozoic genera said to be found in the Muschelkalk and in the St.-Cassian beds were proved by Laube to be Secondary, and the small coral-fauna of the Lias below the zone of *Ammonites Bucklandi* (*bisulcatus*) was determined to be decidedly Jurassic in its affinities. The break was thus narrowed; but it was nevertheless very great; for the absence of any satisfactory assemblage of forms in the Permian formation and in the Muschelkalk rendered the aspect of the Carboniferous specific group very foreign to the student of the lowest Mesozoic corals.

Some recent discoveries of Permian corals in North America do not help to diminish this break.

The practical geologist will readily appreciate the vast physical changes which intervened between the Mountain-limestone and the *Avicula-contorta* beds in this country. The depth of the Permian magnesian and sandy deposits and of the Bunter on the Continent and its limestone (Muschelkalk), and that of the Keuper and its St.-Cassian and Kössen strata, will strike all who know that corals are the rarest of specimens in this pile of deposits; so that when the admirable condition of preservation of the Carboniferous corals and of those from the Lower Lias is considered, the imperfection of the record appears to be immense.

The earliest evidences of the existence of Secondary corals in this country are the casts of simple forms, probably of *Montlivaltiæ* from the *Avicula-contorta* beds, and the casts and corallites of *Montlivaltiæ* and the *Thecosmiliæ* from the

true White Lias. As the balance of the Palæontological evidence is in favour of these beds being younger than the Trias, they must be considered the feebly coralliferous strata of the Rhætic strata, or of the Infralias, or Lower Lias, according to the taste of the student of dogmatic systematic geology. The deposits containing *Avicula contorta* in England, Wales, and Ireland are not of that physical and mineralogical character which attends coralliferous sediments; and the assemblage of other organisms is not that which usually accompanies coral life.

A cast of a *Montlivaltia* was discovered in the *Avicula-contorta* zone, by Charles Moore, F.G.S.; and it is therefore an interesting fossil; for, except the few Permian specimens, there are no corals known in Great Britain between this cast and the Madreporaria of the Carboniferous.

Throughout Europe the strata containing *Avicula contorta* are generally uncoralliferous; but the great deposits at Azzarola have an old coral-bank. These were the coral-reef areas of the period, just as the Gosau and Martigues were the coral-reef areas of the Lower Chalk, and as the Dax and Caribbean strata were the coral-reef areas of the Miocene.

The White Lias of Great Britain and Ireland is a local deposit which is intercalated between the beds containing *Avicula contorta* and those constituting the zone of *Ammonites planorbis* (or its equivalent Ammonite, such as *A. Burgundiæ*). It is absent on the continent, the *Ammonites planorbis* (or its equivalent deposit) succeeding the beds with *Avicula contorta*. The White Lias is very uncoralliferous; and I have never seen a perfect specimen of a Madreporarian from it. The White Lias of Watchet contains imperfect *Montlivaltiæ* and stunted conico-cylindrical *Thecosmiliæ*. A cast of a Thecosmilian from Sparksfield resembles that of a species found in the deposits above the White Lias in the zone of *Ammonites-planorbis* and *A. angulatus*.

A large *Montlivaltia* from the White Lias near Leamington has an elliptical calice; but it is not possible to give it a specific determination. A cast of a multiseptate discoidal *Montlivaltia* is found at Punt Hill, Warwickshire; it resembles that of *Montlivaltia Haimei*, Chapuis et Dewalque. Corals of this type are common in the *Ammonites-planorbis* beds of the east of France and Luxembourg, but they do not appear to have existed in England until the zone of *Ammonites angulatus*. This species, having a range from the east of France to the west of England and Ireland, is very variable in its form and in some structural details.

It is evident from an examination of the Mollusca of the White Lias, that it was a deposit not likely to have corals located in it. The stunted *Thecosmiliæ* and discoid *Montlivaltiæ* have no congeners now existing; but many genera of simple corals of tubular form are frequenters of the sea-bottom from 100 fathoms to the lowest spring-tide range.

The coral-fauna of this deposit is unimportant, and even that of the next series of beds, those containing *Ammonites planorbis*, is small; but when the strata in which *Ammonites angulatus* existed was examined, a large and very varied assemblage of species, indicating old coral-reefs, as well as deep-water conditions, was proved to exist. In South Wales a reef hung on to the Mountain-limestone coast; and in the North of Ireland, as well as in the Lincolnshire area, sublittoral and deep-water forms flourished. Changes occurred in the physical geography of these areas, and an arenaceous series of deposits containing *Gryphæa incurva* and *Ammonites Bucklandi* succeeded the Welsh deposits just mentioned, and the deeper sea-beds of the east and west. The alteration in the sea-depth due to the lowering of these areas produced not only an alteration in the mineralogy of the strata, but great

modifications in the faunæ, especially as regards the corals. The arenaceous limestones situated upon the coralliferous dolomitic limestones of the old Welsh reef contain a feeble coral assemblage, and present no evidence of the existence of coral reefs. A great number of Mollusca are found in the deposits; some existed during the deposition of both, and others were limited in their range to one or the other; but the bathymetrical changes gave the corals no chance, and doubtless the reef species died out, their ova finding no resting place on that particular area.

The zones which succeeded *Ammonites Bucklandi* appear to have been unfavourable to certain forms of corals, especially to those which collect together in vast tracts, forming varieties of reefs. The modern representatives of the species found in the Liassic strata above the zone of *Ammonites angulatus* indicate deep water (30 to 100 fathoms). Where the reefs of the period were is certainly not determinable.

The corals of the Middle and Upper Lias are very rare.

The corals contained in the Liassic strata of Britain, France, Germany, and Italy have a very decided community of facies; at the same time it is evident that some portions of the Liassic coral-fauna resemble Triassic types, and that another portion is allied to the Oolitic.

This was to have been expected; for it is evident that the stunted *Thecosmiliæ* and the *Astrocœniæ* of the zone of *Ammonites angulatus* are the descendants of the equally stunted *Thecosmiliæ* and *Astrocœniæ* of the Triassic age. Moreover the descendants of the *Isastrææ* and of the larger *Montlivaltiæ* of the Lower and Middle Lias luxuriated in the Oolitic seas. The bulk, however, of the Liassic coral-fauna is characteristic of and special to the formation, and, as is the case in the other great series of strata, certain assemblages of species appear to characterize certain definite horizons. Yet not unexceptionably; for some species range into higher zones in certain areas, whilst others, which are confined to a definite horizon in one area, are found below and above the equivalents of the horizon in a distant locality. Thus a species which is only found in a particular bed, and is associated with a particular molluscan fauna in one locality, may be found associated with a molluscan fauna antecedent or subsequent in its recognized succession in another place.

The persistence of a species in a succession of deposits and its consecutive association with different groups of contemporaries and competitors is constantly observed in the Lias.

The groups of Madreporaria have a general relation to certain zones of life and to certain strata, besides very definite relations to others. It is not probable that corals and Ammonites had any close biological relations, but only those of a general nature; but corals were certainly *en rapport* with certain molluscan genera, especially with lithodomous groups; so that when corals of the Lias are said to belong to such and such a zone of *Ammonites*, it is to serve the purpose of the artificial but very necessary classificatory system of geology. If the Madreporaria are associated with certain Ammonite zones, it must be understood that it is only an approximative classification, and that the Ammonites and the Madreporaria may range higher than their supposed restricted zone, or not even be represented in certain portions of its area.

There are a few Triassic species in the Liassic coral-fauna, and the branching corals of the Sutton stone have generally a Triassic facies. The majority of the corals of the Lower Liassic strata are peculiarized by the imperfection of the septal arrangement, and by their epithecate wall. It may, in fact, be asserted that the so-called "rugose" characteristics of the greater part of the

Palæozoic coral-fauna had hardly left their hold upon Madreporarian life at the time when the Lower Liassic strata were deposited. No Palæozoic genus is represented in the Lias. The facies of the Lower Liassic Coral-fauna is produced by the multitude of branching *Thecosmiliæ*, stunted *Montlivaltiæ*, and small-caliced *Astrocœniæ*.

It is remarkable that neither Tabulate nor Perforate genera have been found in the Lias. The Tabulata must have been in existence during the Lias, for they are so fully represented in Palæozoic as well as in Cainozoic reefs.

Corals from the Zone of Ammonites planorbis.

There are some small *Thecosmiliæ* in the so-called Guinea beds at Binton and Wilmcote, which are doubtless the descendants of the *Thecosmiliæ* of the White Lias. One species passes up into the zone of *Ammonites angulatus* (*T. Terquemi*, Dunc.).

A very remarkable species of *Isastræa* is found in No. 3 bed of the Street section, associated with *Septastræa Haimei*, Wright.

This *Isastræa*, found so low in the secondary rocks, is especially interesting, on account of its possessing Latimæandræan characters, as well as true calicular gemmation close to the margin of the non-Latimæandræan calices.

Were certain portions of the corallum separated from others, two distinct genera would be made from them, according to the established rules of classification. The long serial calices without calicular buds are clearly *Latimæandræan*, and they grow in length by the gradual production of small septa amongst the others without a cyclical arrangement. In the non-serial calices the cyclical arrangement of the septa is not by any means perfect; and these calices differ from the non-serial calices of the *Latimæandrææ* of the Inferior Oolite by their calicular gemmation.

Modern research into the relation between the hard and soft parts of recent corals has proved that the tentacular and oral structures of serial calices differ greatly from those which increase by a more or less cyclical arrangement of the septa. Moreover, the Isastræan under consideration is rather an abnormal form, from the size of the septal dentations, and the great development of the endothecal dissepiments. These last close in the bottom of the calices, stretching across the fossa after the manner of tabulæ.

The earliest known *Isastrææ* are from the Triassic beds, and *I. Haueri*, Laube, from St. Cassian, is certainly like the species now under examination—Latimæandræan in some respects. These species are synthetic, and point out the origin of the *Latimæandrææ*, which in later times became prominent members of the Jurassic coral-faunæ.

It must be remembered that St.-Cassian species of *Thecosmilia* and other genera have been found in the beds higher in the geological scale than the No. 3 bed (Street section), and also that *Isastrææ*, perfect in their generic attributes, have been described from the St.-Cassian limestone. I have named the new form *Isastræa latimæandroidea*.

Septastræa Haimei, Wright, sp., is found with the last species. It has fissiparous calices, no definite cyclical arrangement of its septa, and a strongly developed endotheca. Its alliance to *Septastræa excavata*, De From., is evident; but this last species has a definite hexameral arrangement of its cycles, as well as frequent fissiparity.

Fissiparity is produced by two large septa stretching across the calicular fossa, joining and then developing small septa from their sides. The large septa form the walls which separate the newly formed calices.

This is the earliest species of the genus which has been found in this country; but *Septastræa Fromenteli*, Terquem et Piette, which belongs to the zone of *A. planorbis* of the west, has been found in the zone of *A. angulatus* in the east of England. It may have flourished in the zone of *A. planorbis* in the west, and evidently existed contemporaneously with *Septastræa Haimei*. These are the earliest forms of the genus, which has many Isastræan characters, which has its corallite walls rather imperfectly united, and which is reproduced by ova and by fissiparity. It is evidently related to a genus of St.-Cassian corals which, although not found in the zone of *Ammonites planorbis* in this country, is represented by two species (one a St.-Cassian type) in the zone of *Ammonites angulatus*, in Glamorganshire. The genus is *Elysastræa*, Laube, which will be noticed presently.

Septastrææ are not found in Great Britain later than the Lias; but species occur in the French Oolites and in the Miocene. The genus is extinct.

It was always an assemblage of variable forms, and the irregular septal arrangement of the species was the rule. This will be observed from the study of the following Table.

		Regular septal arrangement.	Variable species.	Irregular septal arrangement.
Earliest.....	Septastræa Haimei.....	..	1	1
	—— De Fromenteli	...	1	1
A. angulatus	—— De Fromenteli	...	1	1
	—— excavata	1	...	...
A. Bucklandi	—— Eveshami	...	1	1
Oolitic	—— explanata	...	...	1
	—— dispar.....	...	...	1
Miocene.....	—— Forbesi	1	...	...

There are thus three genera of corals represented in the British zone of *Ammonites planorbis*:—

Thecosmilia Terquemi, *Duncan*.
Isastræa latimæandroidea, *Duncan*.
Septastræa Haimei, *Wright*, sp.

And by inference those genera were in existence during the deposition of the sediments of the zone which lived in St.-Cassian times, and in the age of the zone of *Ammonites angulatus*—such genera, for instance, as *Montlivaltia*, *Elysastræa*, *Astrocœnia*, *Rhabdophyllia*.

The zone of *Ammonites planorbis* is very distinctly developed in France and in Luxembourg, and it succeeds without any White Lias intervening upon the beds with *Avicula contorta*. In England the zone is but feebly developed, and the upper part of the White Lias cannot be separated from it. The separation of the zones of *Ammonites planorbis* (or its equivalent) and *A. angulatus* is satisfactorily determined on the continent, but it is not to be arbitrarily asserted for Great Britain; and in both cases large percentages of species are common to the upper and lower zone.

Triassic fish pass upwards into the zone of *Ammonites angulatus* in the French area, and Triassic Madreporaria are found in the corresponding zone in Glamorganshire. *Avicula contorta* and an Astrocœnian are common to the Azzarola beds, the *Avicula-contorta* zone of Great Britain, and the zone of *A. angulatus*. The French zones of the Lower Lias contain Azzarolan species. It must be conceded that the White Lias was deposited during the age of *A. planorbis* or *A. Burgundiæ* of the French area, the deposits being contemporaneous in a general sense—that the Azzarola deposit of Lombardy

was developed whilst the sediments containing *Avicula contorta*, the fossils of the White Lias, and those of part of the zone of *Ammonites planorbis* were being formed in the north-west of Europe—that the fauna of the *A. planorbis* zone was extended westwards, and became more decidedly associated with that of the zone of *A. angulatus*—that the St.-Cassian fauna was represented more or less in the Azzarola deposits—that the European area was not subject to violent disturbances between the deposition of the Azzarola beds containing *Avicula contorta*, and the commencement of the age of *Gryphæa incurva*—that simple bathymetrical changes produced first local, and subsequently general modifications of the faunæ—that faunæ which appear to have been consecutive were really synchronous, and that the lifetime of the St.-Cassian, Azzarola, *Avicula-contorta*, and Lower-Lias faunæ was embraced in a less extensive period than has usually been admitted. It is of the greatest importance to the palæontologist that every objection to the arbitrary classification of systematists in geology should be fully stated; and it is very evident that the physical breaks in the Upper Trias, Rhætic, and Lower Liassic strata are not accompanied by such decided palæontological changes as might be believed to have taken place.

Corals from the Zone of Ammonites angulatus, *Schl.*

There are some highly fossiliferous beds in South Wales, the West of England, the county of Lincoln, and in the North of Ireland which have the homotaxis of the typical strata of the continental zone of *Ammonites angulatus*, viz. the Calcaire de Valogne, the Foie de Veau in the Côte d'Or, and the Grès Calcareux in the Duchy of Luxembourg. The strata whence the ablest French palæontologists of the present day derived the magnificent Lower-Liassic (Infraliassic of some) molluscan fauna are the evident equivalents biologically, and perhaps chronologically of the Sutton stone, the conglomeratic deposits at Brocastle, the coralliferous bed at Cowbridge (all being in Glamorganshire, and known so thoroughly, thanks to Charles Moore), the beds above the White Lias at Marton in Lincolnshire, and some deposits at Waterloo, Larne, in the North of Ireland.

The British and continental deposits contain large numbers of molluscan species in common, and not a few Madreporaria; but the British strata were soon proved to be very coralliferous, especially in the west.

The following is a list of the species of corals from the continental zone of *Ammonites angulatus*.

1. Montlivaltia Sinemuriensis, *D'Orb.*
2. —— dentata, *De From. et Ferry.*
3. —— Martini, *De From.*
4. —— Rhodana, *De From. et Ferry.*
5. —— discoidea, *Terq. et Piette.*
6. —— Haimei, *Chap. et Dew.*
7. —— Guettardi, *Chap. et Dew.*
8. —— polymorpha, *Terq. et Piette.*
9. —— denticulata, *De From. et Ferry.*
10. Thecosmilia Martini, *De From.*
11. Thecosmilia Michelini, *Terq. et Piette.*
12. —— coronata, *Terq. et Piette.*
13. Septastræa Fromenteli, *Terq. et Piette.*
14. —— excavata, *De From.*
15. Isastræa Condeaua, *Chap. et Dew.*
16. —— Sinemuriensis, *De From.*
17. Stylastræa Sinemuriensis, *De From.*
18. —— Martini, *De From.*
19. Astrocœnia Sinemuriensis, *D'Orb.*
20. —— clavellata, *Terq. et Piette.*

Probably some of the species of *Montlivaltia* will have to be absorbed by others; but this list, when added to the Table of British Corals from the zone of *Ammonites angulatus*, proves that, instead of the Lias being an uncoralliferous series, it was quite the contrary. The great development of coral life in the Azzarola series, the scanty remains of it in the Western and North-western European *Avicula-contorta* zones, and in the White Lias and in the zone of *Ammonites planorbis*, and the luxuriance of the species in the zone of

Ammonites angulatus in the westernmost Lower Lias are most significant facts; and the significance is not diminished when the paucity of the species of the zone of *Ammonites Bucklandi*, and their distinctness from those of *Ammonites angulatus*, is considered.

List of British Species from the zone of Ammonites angulatus.

1. Oppelismilia gemmans, *Duncan.* Ireland.
2. Montlivaltia Walliæ, *Duncan.* South Wales.
3. —— Murchisoniæ, *Duncan.* South Wales.
4. —— Ruperti, *Duncan.* England.
5. —— parasitica, *Duncan.* South Wales.
6. —— simplex, *Duncan.* South Wales.
7. —— brevis, *Duncan.* South Wales.
8. —— pedunculata, *Duncan.* South Wales.

b. 9. —— polymorpha, *Terq. et Piette.*

b. 10. —— Haimei, *Ch. et Dew.* England and Ireland.

11. —— Hibernica, *Duncan.* Ireland.
12. —— papillata, *Duncan.* England.

c. 13. —— Guettardi, *Blainville.* England.

14. Thecosmilia Suttonensis, *Duncan.* South Wales.
15. —— mirabilis, *Duncan.* South Wales.
16. —— serialis, *Duncan.* South Wales.
17. —— irregularis, *Duncan.* South Wales.
18. —— Terquemi, *Duncan.* South Wales.
19. —— affinis, *Duncan.* South Wales.
20. —— dentata, *Duncan.* South Wales.
21. —— plana, *Duncan.* South Wales.
22. —— Brodiei, *Duncan.* South Wales.

b. 23. —— Martini, *E. de From.* England.

b. 24. —— Michelini, *Terq. et Piette.* England.

a. 25. Rhabdophyllia rugosa, *Laube.* South Wales.

a. 26. Rhabdophyllia recondita, *Laube.* South Wales.

b. 27. —— Astrocœnia Sinemuriensis, *D'Orb.* South Wales.

28. —— gibbosa, *Duncan.* South Wales.
29. —— plana, *Duncan.* South Wales.
30. —— insignis, *Duncan.* South Wales.
31. —— reptans, *Duncan.* South Wales.
32. —— parasitica, *Duncan.* S. Wales.
33. —— pedunculata, *Duncan.* South Wales.
34. —— costata, *Duncan.* South Wales.
35. —— favoidea, *Duncan.* South Wales.
36. —— superba, *Duncan.* South Wales.
37. —— dendroidea, *Duncan.* South Wales.
38. —— minuta, *Duncan.* South Wales.
39. Cyathocœnia dendroidea, *Duncan.* South Wales.
40. —— incrustans, *Duncan.* South Wales.
41. —— costata, *Duncan.* South Wales.

a. 42. Elysastræa Fischeri, *Laube.* South Wales.

43. —— Moorei, *Duncan.* South Wales.

b. 44. Septastræa excavata, *E. de From.* South Wales.

c. 45. —— Fromenteli, *Terquem.* South Wales.

46. Latimæandra denticulata, *Duncan.* South Wales.

b. 47. Isastræa Sinemuriensis, *E. de From.* South Wales.

48. —— globosa, *Duncan.* South Wales.
49. —— Murchisoni, *Wright.* Skye.
50. —— Tomesii, *Duncan.* Worcestershire.

This large Coral-fauna is made up of—

Series 1.	Species ranging from the St.-Cassian beds	3
,, 2.	Species ranging from continental zones of *Ammonites angulatus*	7
,, 3.	Species from the Azzarola deposits	1
,, 4.	Species from the continental zone of *Ammonites planorbis*	2
,, 5.	Species peculiar to the British deposits.....	37
	Total.....	50

The first series comprehends—

Thecosmilia rugosa, *Laube*,
Rhabdophyllia recondita, *Laube*,
Elysastræa Fischeri, *Laube*,

species which are common to the white dolomitic limestone of Sutton in Glamorganshire, and the St.-Cassian beds.

These widely ranging forms link the distant formations together in the

same manner as the fish which are found in the Triassic strata and also in the French zone of *Ammonites angulatus*. Not only are these species of Madreporaria not rare, but they are accompanied in the Sutton stone by closely allied species, which of course are allied to the St.-Cassian types.

Thecosmilia Suttonensis, Duncan, and *T. serialis*, Duncan, are in structure and in their methods of reproduction similar to *Thecosmilia rugosa*, Laube, a St.-Cassian species. *Elysastræa Fischeri*, Laube, is accompanied by a closely allied species in the Glamorganshire beds; and the genus is remarkable for its obvious connexion with the early secondary *Astræidæ* with more or less united walls.

Rhabdophyllia is a genus closely allied to *Thecosmilia*, and as the forms included in these genera commence as simple corals, and become compound or serial during growth, it is obviously necessary to compare them in their young stage with the genus *Montlivaltia*. Thus MM. Milne-Edwards and Jules Haime say that *Thecosmiliæ* are compound *Montlivaltiæ*; and this opinion is rendered important when it is remembered that some *Montlivaltiæ* have calycinal gemmation, and thus approach the Thecosmilian type still more. *Montlivaltia* is a genus with species in the lowest coralliferous secondary rocks; so that there is a fair assumption to be made that from *Montlivaltia* descended *Thecosmilia* and *Rhabdophyllia*. The *Thecosmiliæ* of the Sutton stone are principally capitate forms; that is to say, they spring from a peduncle and divide suddenly (by gemmation or by fissiparity). Amongst the non-capitate forms is *Thecosmilia rugosa*; moreover one of the species common in the French zone of *Ammonites angulatus* is also fissiparous and non-capitate, viz. *Michelini*, Terq. et Piette. *Thecosmilia Suttonensis*, Duncan, has some resemblance to *Thecosmilia rugosa*, Laube, in its calice, but not in its fissiparity, and it is allied to *Thecosmilia serialis*, Duncan, in its short peduncle and capitate swelling. The origin of the corallites in *T. Suttonensis* by intercalycinal gemmation is very distinctive.

Thecosmilia serialis, Duncan, belongs to the stunted *Thecosmiliæ* so characteristic of the Triassic and Lower Liassic coralliferous strata. It is readily distinguished by the number of corallites springing from the peduncle, and by its long serial calices mixed with rounded ones.

The existence of corallites produced, in one individual, by lateral gemmation, calicinal gemmation, and fissiparity is as remarkable as is the restriction of other individuals of different species to one of these forms of reproduction.

It is necessary to bear in mind that there are these diverse methods of gemmation and increase in these early *Thecosmiliæ*, because the genera which are structurally allied, and doubtless genetically related, possess one or more of these methods.

Moreover it is remarkable that the feeble true wall, the strong epithecate wall, the strong endotheca, the irregular septal arrangement, and the absence of true costæ should have existed in these old secondary forms, linking them on to the Palæozoic Coral-fauna in these particulars, whilst in Oolitic times the wall, costæ, and septa became developed according to the Mesozoic type. The gradation of structure between the species of the genus in consecutive periods, however, is very palpable.

Thecosmilia Martini and *Michelini* belong to the second series*; they are closely allied to each other and to several British species; they are bush-

* The species of the 1st series are marked *a* in the list of the British species.
" " 2nd " " *b* " " "
" " 3rd " " *c* " " "

shaped, and have a great range. It would appear that the following Table gives a correct idea of the dispersion of the early *Thecosmiliæ*.

St.-Cassian types .. { Azzarola, species ... } → Species of the Luxembourg and French Zone of *A. angulatus*.
A. planorbis, species }
A. angulatus, species → Oolitic species.

The genus *Elysastræa* has its corallites separate and covered with an epitheca below, but united above at the calicular margin. The calicular part is clearly Isastræan, and the basal is Thecosmilian. Now bush-shaped *Thecosmiliæ*, such as *T. Michelini* and *T. Martini*, are noticed to become united by their walls in some individuals, and the walls of some species of genera closely allied to *Isastræa* are not united inferiorly.

The genus is clearly a transition, not only between *Thecosmilia* and *Isastræa*, but between several groups of genera. For instance,

Thecosmilia—Elysastræa—Isastræa—Latimæandræa.
Montlivaltia— *—Septastræa.*
—Prionastræa.

The earliest reliable *Isastrææ* are from St. Cassian; and several species are found with the St.-Cassian Elysastræan; but they are all erratic and rather abnormal forms. Thus *Isastræa Haueri*, Laube, and *I. splendida*, Laube, have a very irregular calicular development, and not one of the Liassic species ever attained that regularity of septal arrangement which characterizes the Oolitic Isastræans.

In the Sutton stone, at Brocastle, in Skye, and in the Worcestershire beds of *Ammonites angulatus*, there are the following *Isastrææ*.

Isastræa Sinemuriensis, *De From.* — Isastræa Murchisoni, *Wright*, sp.
—— globosa, *Duncan.* — —— Tomesii, *Duncan.*

I. Sinemuriensis { has deep calices, great irregularity of septal arrangement, 78 septa, sometimes no distinct cyclical arrangement.
I. globosa, { spherical, calices shallow, sometimes 36 septa, but no cyclical arrangement.
I. Murchisoni, { large, convex, flat, calices shallow; wall grows after the development of the contiguous calices; 40 or more septa; no cyclical arrangement.
I. Tomesii, { large, massive; wall thin; septa thin, with dissepiments between them visible; *not* 4 cycles.

The first of these species has a great range, and connects the St.-Cassian and Oolitic species with a high septal number.

The second belongs to a series comprising

I. Richardsoni, *Ed. & H.*, Inf. Oolite.
I. dissimilis, *Mich.*, sp. ,,

The third has evident affinities, from the structure of the wall, with *Elysastræa* and *Lepidophyllia*, and it is an unusual form.

The fourth resembles more or less *I. Bernardiana*, Ch. and Dew. Inf. Oolite.

It will be observed that these species have only a remote, but of course generic, affinity with the *Isastrææ* of the succeeding arenaceous deposits of the zone of *Ammonites Bucklandi*, but that their affinities with the species of the St.-Cassian and Inferior-Oolite coral-faunæ are decided.

They have only a generic relation to *Isastræa latimæandroidea*, Duncan, of the zone of *Ammonites planorbis*, as no serial calices are found in them.

There is a species of *Latimæandræa* in the British zone of *Ammonites angulatus*, *L. denticulata*, Duncan; its calices are very like the serial calices of *Isastræa latimæandroidea*.

I have already noticed that probably *Astrocœnia gibbosa*, nobis, is really a form from Azzarola, for the casts of both are very alike. Now there is an Astrocœnian in the St.-Cassian, *A. Oppeli*, Laube; it is unfortunately hardly specifically differentiated, but it is evidently closely allied to the *Astrocœnia* of the Sutton stone, as well as to *A. Sinemuriensis*, D'Orb., sp., from the French zone of *Ammonites angulatus*. This last species is also hardly sufficiently differentiated; but I have placed it amongst the British species provisionally.

There are eleven species of *Astrocœnia* special to the Welsh Lias, and the species just noticed. The genus was evidently flourishing in the St.-Cassian and Azzarolan times, and was singularly abundant in species amongst the Lower Liassic reefs at Sutton and Brocastle, to which the Mountain Limestone formed the support.

The Liassic *Astrocœniæ* occur as large and massive, small and dendroid, or as irregular and, sometimes, as incrusting forms. All the species are very irregular in their septal arrangements, and none of them present definite and clear cycles of septa.

Some of the species have the cœnenchyma between the calices irregularly ridged, so as to present the first traces of that cœnenchymal development which characterizes the genus *Stylocœnia*. The columella is very distinct in all the species, and the junction of the largest septa to it is marked in some forms by a paliform swelling; but there are no pali. The dentate condition of the septal edge is very marked. The size of the corallum, its shape and habit, the size of the calices, the character of the costæ, and the density, thickness, and ornamentation of the free portion of it appear to differ in various forms, and separate eleven new species from those already described.

The following is a scheme of the *Astrocœniæ* from the zone of *Ammonites angulatus*, at Sutton and Brocastle.

Astrocœnia.

Corallum	large	gibbous and tall	Astrocœnia gibbosa, *Duncan*.
		flat and short	—— plana, *Duncan*.
			—— insignis, *Duncan*.
		short and irregular outline	—— septans, *Duncan*.
	small	incrusting	—— parasitica, *Duncan*.
		pedunculate, with epitheca	—— pedunculata, *Duncan*.
		dendroid	—— dendroidea, *Duncan*.
		flat and narrow	—— superba, *Duncan*.
		globose	—— favoidea, *Duncan*.
		irregular	—— costata, *Duncan*.
		flat and semiincrusting	—— minuta, *Duncan*.

Corallum having the cœnenchyma	scanty	Astrocœnia favoidea.
		—— minuta.
	abundant	—— parasitica.
		—— dendroidea.
		—— superba.
		—— pedunculata.
		—— insignis.
	moderately developed	—— septans.
		—— costata.
		—— gibbosa.
		—— plana.

The surface of the cœnenchyma ...	ornamented...	and straight...	Astrocœnia insignis.
		„ spined ...	—— superba.
		„ wavy.....	—— costata.
			—— gibbosa.
	ridged		—— gibbosa.
			—— plana.
			—— minuta.
			—— reptans.
			—— dendroidea.
	plain		—— parasitica.
			—— pedunculata.
	rudimentary		—— favoidea.

Astrocœnia clavellata, Terq. et Piette, is found in the Luxembourg Lower Lias, but the zones above that of *Ammonites angulatus* in the Lias do not present, as yet, any species. The species is represented in the Oolites, and became extinct in the Falunian.

Cyathocœnia is a new genus, which I have suggested and published in order to admit forms which, had they been furnished with a columella, would have been classified as *Astrocœniæ*. There is a species in the zone of *Ammonites Bucklandi*. Some of the species are mimetic of the *Astrocœniæ*. The following is a scheme of the genus.

Cyathocœnia.

Cyathocœniæ with the corallum	branching, having costæ	C. dendroidea.
	incrusting, no costæ, cœnenchyma granular	C. incrustans.
	flat large costæ, and a deep calice	C. costata.
	globular, no costæ, cœnenchyma plain.....	C. globosa.

The gradation of structure in the genera just passed under our notice becomes more and more evident as such forms as those included under the genus *Cyathocœnia* are studied. In the early stage *Thecosmilia* cannot be distinguished from *Montlivaltia*; but gemmation from the calice, from the calicular wall, or from the wall ensued, or fissiparous division occurred, as the corals grew. There was an evident tendency in *Montlivaltia Walliæ*, Duncan, for instance, to reproduce by calicular gemmation; but in *Oppelismilia* distinct calicular budding occurred. Under these circumstances the genetic relations of the three genera *Thecosmilia*, *Montlivaltia*, and *Oppelismilia* are of the closest.

Now in bush-shaped *Thecosmiliæ* union often occurs between a bud from the wall and the parent stem. A section transverse to the line of growth shows, (1) low down, two corallites with their septa, walls, and epitheca perfect; but higher up the epitheca is not seen in a section, and the walls may be (2) slightly separate, or (3) quite fused, and they then appear as one lamella between the corallites.

(1) is what is observed in *Elysastræa*; (2) is the Septastræan peculiarity; (3) peculiarizes *Isastræa*.

The origin of *Latimæandræa* from *Isastræa* has already been noticed. In *Elysastræa* the epitheca and one wall become absorbed at the calicular margin. In *Cyathocœnia* the epitheca between the walls becomes cœnenchymal, and variously ornamented; whilst in *Astrocœnia* the same thing occurs besides the growth of a columella.

The following grouping of the genera is made with a view to assert that they had genetic relations with *Montlivaltia*, and that some Cainozoic types revert to more ancient.

Montlivaltia	Oppelismilia.		
	Thecosmilia.		
Thecosmilia with	gemmation from the wall	Elysastræa	Cyathocœnia.
		Phymastræa (*a*) ..	Astrocœnia.
		Solenastræa (*b*) ...	Thamnastræa.
		Heliastræa (*c*)	Isastræa.
			Prionastræa.
			Astræa.
			Metastræa.
	calicular gemmation	Lepidophyllia.	
	serial calices	Latimæandræa.	
	fissiparous development.....	Septastræa.	

a. An evident reversion to *Elysastræa* in a recent genus.

b. *Solenastræa* is a case of reversion to an ancestral *Thecosmilio-Elysastræa* type in the later Neozoic ages.

c. Has great probability of being a case of atavism with much modification of *Thecosmilia* and *Solenastræa*.

The *Montlivaltiæ* of the zone of *Ammonites angulatus* are remarkable for their septal regularity, the amount of dissepimental endotheca, the usually rudimentary condition of the true wall, and the development of the strong and compensating endotheca. These characteristics are observed in the St.-Cassian *Montlivaltiæ*, and in those which are found in the strata intervening between the *Ammonites-angulatus* and the St.-Cassian beds. These structural peculiarities, in a genus whose later Jurassic species have a perfect hexameral arrangement, a perfect wall, and moderate endotheca and epitheca, indicate the descent of the *Montlivaltiæ* from a Palæozoic stock. In *Montlivaltia Murchisoni*, Duncan, the wall and epitheca are united perfectly into one structure with the *intercostal spaces*, just as the septa of some simple Palæozoic corals are continuous, not with costæ, but with the intercostal spaces or their analogues.

M. parasitica is remarkable for its septal number; and *M. simplex* has distant and curved septa.

M. papillata, Duncan, *M. Hiberniæ*, Duncan, and *M. Haimei*, Chap. et Dew., are closely allied species; they are broad-based, pedunculate, short, and turbinate, and vary greatly. The last-named species ranges probably over the whole area of the zone of *Ammonites angulatus*.

Closely allied to *Montlivaltia* and *Thecosmilia* is the new genus *Oppelismilia*. Its Palæozoic aspect is distinct, the multiseptal and non-cyclical calice, the calicular budding, and the strong epitheca all refer it to bygone types.

These corals, from the Lias beneath the zone where *Gryphæa incurva* and *Ammonites Bucklandi* are abundant, indicate that, like the succeeding formations of the Chalk and the Oolite, the Lias was very coralliferous. Nothing marks the progress of palæontology more strongly than the ability of making this statement from well-ascertained data; for within a very few years the Lias was considered so muddy a deposit as to be obnoxious to coral life.

Now, with a great fauna, part of it indicating reef conditions and the rest moderately deep water, the Lower Lias will assume as great an importance to the zoophytologist as the Eocene. The Liassic coral-fauna reflects the Palæozoic as the Eocene foreshadows the Recent coral-fauna. Unfortunately the paucity of our information respecting the earliest Secondary coral-fauna, that of the Lower Trias, is so great that the Liassic species are still greatly removed from the original types.

Corals from the Zone of Ammonites Bucklandi (bisulcatus).

Corals are not numerous as regards their species in this zone, and the com-

monest species of the zone of *Ammonites angulatus* have not been found in any of its strata.

It is probable that *Thecosmilia Martini*, E. de From., which in France ranges from the beds containing *Ammonites Moreanus* into those in which *Ammonites bisulcatus* is found, has a corresponding vertical range in England. *Thecosmilia Michelini*, Terq. et Piette, appears to be present in the zone of *Ammonites bisulcatus*; but as yet only casts of its specimens, which resemble those of the species from Abbot's Wood in the zone of *Ammonites angulatus*, have been found. These casts, and some of *Thecosmilia Martini*, have been assigned to the genus *Cladophyllia*, but without sufficient reason. *Thecosmilia* is a large genus, and of course the species present individuals of all sizes; so that to give to small cylindroid *Th cosmiliæ* the generic appellation of *Cladophyllia* is unreasonable. In fact this last genus is but a subgenus of *Thecosmilia* at the best.

List of Species from this Zone.

1. Montlivaltia Guettardi, *Blainville.*
2. Septastræa Eveshami, *Duncan.*
3. Lepidophyllia Stricklandi, *Duncan.*
4. Isastræa endothecata, *Duncan.*
5. Isastræa insignis, *Duncan.*
6. —— Stricklandi, *Duncan.*
7. Cyathocœnia globosa, *Duncan.*

Septastræa Eveshami has very irregular calices; and when the wall has been worn away between them, a groove is seen indicating that separation of the corallites which I have already noticed to obtain in the *Elysastrææ*. The species is rather abnormal; for although fissiparity is common, still there is a disposition to serial increase.

The genus *Isastræa* has three well-marked species in this zone, and they are very distinct from those of the zone of *Ammonites angulatus*. In *Isastræa endothecata* the depth of the calices, the extraordinary development of the endotheca, and the great number and the irregularity of the septa are differential. *Isastræa Stricklandi* also has a great development of endotheca; for large plates of it cross the corallites, and shut in the calicular fossæ below, acting perfectly like tabulæ, just as in *Cyathaphora*. The septa are few in number; and no cyclical arrangement is to be noticed.

Isastræa insignis belongs to a section of the genus which comprises *I. Henocquei*, Ed. & H., from the Hettangian, *I. polygonalis*, Muschelkalk, and *I. Lonsdalei*, Ed. & H., from the Inferior Oolite.

A new genus, *Lepidophyllia*, has a species in this zone, and a very fine one in the zone of *Ammonites Jamesoni*: it is an interesting form, and presents some Rugose characteristics, such as a repeated calicular gemmation and an epithecate wall.

The only *Montlivaltia* I have seen from the zone of *Ammonites Bucklandi* has a lower horizon on the continent. Having thus a very considerable vertical and geographical range, the species is, of course, very variable, and many local varieties have been found, which are separated with difficulty from *Montlivaltia Haimei*. These flat multiseptate *Montlivaltiæ* are very characteristic of the Lower Lias. They have a representative in the zone of *Ammonites obtusus*, in the form of *M. patula*, Duncan, whose dentate septa are wonderful. Such septa began then to be the fashion; for in the next zone the *Montlivaltiæ* are famous for their grandly ornamented dentations.

Corals from the Zone of Ammonites raricostatus.

The *Montlivaltiæ* from Fenny Compton, Honeybourne, and Cheltenham belong to several species, and two of these are singularly polymorphic. Shape has not much to do with the specific diagnosis of some recent simple

corals; and it is necessary to assert this in collecting under one fossil species corals of very different external forms. The *Montlivaltiæ* from the zone of *Ammonites raricostatus* are common, and their mineral condition has been preservative of the minutest details: even the granulations on the minute septal dentations are preserved.

Dr. Wright collected and described a very remarkable series of corals from the Hippopodium and coral-beds of Marle Hill, Cheltenham, Honeybourne, and Fenny Compton, naming them *Thecocyathus rugosus*. The assemblage of forms thus named contains very varied specimens, the external shape especially being rarely alike in two or three instances. A careful examination of sections of most of the forms enabled me to place them all in the genus *Montlivaltia*. The absence of pali and the presence of short endothecal dissepiments proved that they could not belong to the genus *Thecocyathus*. But the general Montlivaltian characteristics have also the palæozoic peculiarities already noticed in considering the *Montlivaltiæ* of the zone of *Ammonites angulatus*. *Montlivaltia rugosa*, Wright, sp., will therefore take the place of *Thecocyathus rugosus*, Wright, MS.

Montlivaltia mucronata, Duncan, is a polymorphic species, remarkable for its elegance and ornamentation; some of its specimens are amongst the most beautiful of the *Madreporaria*. The study of a large collection enabled me to place some very different-looking forms in the same species, the intermediate varieties having been in my possession.

There is a decided affinity between these *Montlivaltiæ* and *M. Stuchburyi*, Ed. & H., of the Inferior Oolite. Moreover the *M. nummiformis*, Duncan, of this zone is related, if structural affinity be of value, to *M. lens*, E. & H., Inf. Oolite. *Montlivaltia radiata*, Duncan, is a very abnormal species, and retains the quadrate septal arrangement, which is fully represented in many Liassic species, but which is so characteristic of many Palæozoic forms. It must be remembered that such strange structural peculiarities in later forms may arise from atavism.

List of Corals from the Zones of the Lower Lias above the Zone of Ammonites Bucklandi.

Montlivaltia patula, *Duncan*.
—— rugosa, *Wright*, sp.
—— mucronata, *Duncan*.
Montlivaltia nummiformis, *Duncan*.
—— radiata, *Duncan*.

There are then twelve species in the Lower Lias above the zone of *Ammonites angulatus*, five of which are above the zone of *Ammonites Bucklandi*. It needs no care to decide that the fauna of the zone of *Ammonites angulatus* has little affinity with that of the other zones.

Corals from the Middle Lias.

1. *Lepidophyllia Hebridensis*, Duncan.
2. *Montlivaltia Victoriæ*, Duncan.

The first species is from the island of Pabba, and was collected by Dr. Wright; it forms a bed there, and was doubtless a rapid grower.

The genus has already been slightly noticed; its calicular gemmation and the growth of epitheca on the free wall of the corallites, where they grow higher than their neighbours, refer to an Elysastræan, Thecosmilian, and Septastræan series.

A great number of specimens of all sizes of a very polymorphic *Montlivaltia* have been found on the surface of the fields at Chemington, near Skipton, and in a watercourse or ditch section of the Middle Lias close by. *Ammonites*

Henleyi, *A. Chiltensis*, *Cardinia attenuata*, and *C. elongata* were found with the corals.

Montlivaltia Victoriæ, Duncan. This coral grows to a height of five inches, and may be two inches broad; it is the largest simple secondary form, and has the epithecal wall so peculiar to the Liassic *Montlivaltiæ*. Its septal number is very great, and the endotheca is highly developed. It is very variable in shape.

There are some fragmentary corals in the Marlstone, but their genera are doubtful; and the cast of a *Montlivaltia* was found by Mr. Charles Moore at Wells, but I cannot determine the species.

Corals from the Upper Lias.

The only species is that which was found years since, and which was described by MM. Milne-Edwards and Jules Haime, *Thecocyathus Moorei*, Ed. & H.

Total number of Species of Corals from the British Liassic Strata.

Lower Lias	64	species.
Middle Lias	2	„
Upper Lias	1	„
	67	species.

The descriptions and drawings of sixty-six of these species are in my 'Monograph of the Liassic Corals,' 1867, 1868, Pal. Soc.

The *Thecocyathus Moorei*, Ed. & H., was described and drawn in the 'Monog. Oolitic Corals,' by Milne-Edwards and Jules Haime, Pal. Soc.

Report of a Committee appointed to investigate Animal Substances with the Spectroscope. By E. Ray Lankester.

During the year attempts have been made to obtain a supply of Siphonostoma or *Sabellæ* for the purpose of investigating the derivatives of the body described by me last year as chlorocruorine; at present a sufficient supply has not been obtained. The absorption-spectrum of chlorocruorine from *Sabella*, however, has been carefully observed and recorded. The Sponge-chlorophyll has been investigated with the object of determining which of the two green and two yellow bodies, spoken of by Professor Stokes as being present in plants, is present in the sponge; and some interesting results appear likely to be obtained when the history of plant-chlorophyll is more fully known.

The feathers of twenty-two species of birds, mostly red, green, or blue, have been examined for absorption-spectra; none was obtained; but Prof. Church has discovered a red matter containing copper in the feathers of the Turacou; and to this body he gives the name turacin. The spectrum of this substance I have carefully examined and recorded. As stated by Prof. Church, it gives two absorption-bands, when in the feather, close to those of hæmoglobin, but readily separable from them, and by no means indicating anything like identity in the bodies, as Prof. Church appears to have thought.

A scheme with the chief solar lines and Sorby's standard interference lines

ruled in has been prepared for recording absorption-spectra. I have taken notes of many by this means, which is very useful. A more satisfactory means of measurement than Sorby's scale appears to be required, since the quartz plate cannot be readily obtained of the right thickness.

In a future Report I hope to give the results of observations which have now to be deferred.

Second Report of the Committee on the Condensation and Analysis of Tables of Steamship Performance.

At the Dundee meeting of the British Association in 1867, the Committee on the above-mentioned subject, consisting of John Scott Russell, Esq., F.R.S., William Fairbairn, Esq., LL.D., Thomas Hawksley, Esq., C.E., James R. Napier, Esq., F.R.S., and W. J. Macquorn Rankine, Esq., LL.D., was reappointed, for the purpose of continuing its duties as defined in the resolution by which it was originally appointed in 1866; and a sum of £100 was placed at its disposal. The Committee, as before, employed Mr. J. Quant, naval architect, as calculator, and have reason to be highly satisfied with the manner in which his duties have been performed.

The sum of £100 has been expended.

The contents of the Report now submitted to the Association are as follows:—

List of detailed tables whose condensed results appear in the present Report.

Condensed tables.

Analyzed tables, according to the method of Mr. Scott Russell.

Analyzed tables, according to the method of Professor Rankine, so far as that method is at present complete; that is to say, taking into account eddy-resistance depending on friction, and wave-resistance due to shortness of afterbody. Just at the commencement of the Meeting to which this Report is presented, Professor Rankine pointed out a hitherto neglected kind of wave-resistance, depending on a relation between speed and depth of immersion; but the data of observation necessary in order to determine its amount and laws have not yet been obtained.

In explanation of the distinction between "condensed" and "analyzed" tables, it has to be stated that the condensed tables contain nothing except quantities ascertained by measurement, observation, and experiment; while the analyzed tables contain certain functions of those quantities, which functions are connected with theoretical views as to the probable nature and laws of the actions that take place between the vessel and the water.

List of Detailed Tables whose condensed results appear in this Report.

The detailed tables whose condensed results appear in the present Report consist of those which were published in the Report of the British Association, 1863.

Table I.—Engineer's log of City of Dublin Steam Packet Company's Steamship 'Munster,' June and July, 1861.

No information as to draught of water or displacement is given.