LXII. *On the Composition of Chalk Rocks and Chalk Marl by invisible Organic Bodies: from the Observations of Dr. Ehrenberg*. By* Thomas Weaver, *Esq., F.R.S., F.G.S., M.R.I.A., &c. &c.†*

THE remarkable discoveries effected, and the new light thrown on geology by the indefatigable researches of Dr. Ehrenberg, during several years past, through the medium of the microscope, particularly in respect of the Infusoria and Polythalamia tribes, highly instructive and interesting as they must be to all naturalists, are especially so to the geologist, since they open to him a large field of inquiry, eminently deserving of cultivation. To draw attention to this subject, which involves no less than an investigation as to what extent minute organic bodies, invisible to the naked eye, may have contributed to the production of all limestone formations, whether of an origin posterior or anterior to the epoch of the chalk, descending thus in the series to the primary limestones, it appeared to me that a sketch taken from a portion of the labours of Dr. Ehrenberg might be not only useful, but especially acceptable to such geologists as may not be conversant with the language of the original. I propose then, in the first instance, to advert briefly to the earlier researches of Dr. Ehrenberg concerning the Coral tribes in general, and those of the Red Sea in particular‡; and in the second, to present such extracts from the Memoir, the title of which stands at the head of this paper§, as may answer the purpose of a general view.

At the instigation of the Royal Academy of Sciences of Berlin‖, Dr. Ehrenberg and his friend, the late Dr. Hemprich,

* Communicated by the Author.

† With an Appendix touching the researches of M. Alcide d'Orbigny.

‡ See in the Abhand. der König. Acad. d. Wissenschaften zu Berlin for the year 1832:—

1. Contributions to the physiological knowledge of the Coral animals in general, and in particular of those of the Red Sea, with an attempt to classify them according to their physiological distinctions; read 3rd March, 1831, with additions printed 1st Dec. 1833, pp. 225–380.

2. On the Nature and Structure of the Coral Banks of the Red Sea, read 22nd March 1832; revised and printed in Feb. 1834, pp. 381–432.

§ *Ueber die Bildung der Kreidefelsen und des Kreidemergels durch unsichtbare Organismen*, in the Transactions of the Royal Academy of Sciences of Berlin, for the year 1838, read 20th Dec. 1838, and 18th Feb. 1839, pp. 59–149.

‖ See the Report read to the Academy by M. Alr. von Humboldt on the Travels of Doctors Ehrenberg and Hemprich through Egypt, Dongola, Syria, Arabia, and the Eastern declivity of the highlands of Abyssinia, in the years 1820–1825, conveying a clear idea of the arduous and extraordinary labours of those gentlemen in all branches of Natural History: Berlin, 1826. Dr. Hemprich fell a sacrifice to his exertions in Abyssinia, on the 30th of June, 1825.

visited the Red Sea during a period of eighteen months, namely, nine months from the year 1823 to 1824, and an equal number in 1825, having been nearly twelve months of the time on board ship, in which interval they passed over nearly the whole extent of that sea, saw many of its islands and coral banks, and landed with a view to special examination on forty-eight different points of the two coasts; but the whole number of islands and special points of the coast seen by them amounts to about 150, independently of the long coast of Sinai in Arabia, which they examined in continuity. In these laborious efforts, attended with extreme danger, they collected 110 species of Coral animals, being nearly three times as many as had been found or described by all former observers, namely, by Shaw, Forskâl and Savigny, and later by Rüppel.

To determine the subjects of that collection with the greater precision, it became necessary to undertake a review of the whole class of the Coral animals, and the more so as Dr. Ehrenberg found that his own observations were frequently in collision with the systematic distinctions that have prevailed up to the present time. In this review the author has especially compared the four most recent extensive systems, namely, of Schweigger in 1820, Rapp in 1829, Cuvier in 1830, and Blainville likewise in 1830, which may be said to embody the judgment of the present generation upon the labours of earlier periods, and to comprise the sum of existing knowledge in this department of natural history. He has in particular turned his attention to the work of Blainville *, since it contains the greatest number of new details, having been enriched by the latest manuscript observations and drawings of Quoy and Gaimard, the result of their second voyage round the world with Capt. D'Urville. In these newer works, the labours of Lamarck having been critically employed, the author was relieved from the necessity of noticing them in a special manner.

The attempt to reconcile the observed discrepancies led the author to separate the Coral animals into two organic natural groups, which are well marked and distinct from each other, and which he named *Anthozoa* (Flower-animals) and *Bryozoa* (Moss-animals). In the course of these researches the author found that the whole group of the Anthozoa, which consist of the proper (single-mouthed) coral animals, and which had been gradually distributed under more than 158 generic names, including even heterogeneous animals and plants, might, according to his own observations of their correspondence in

* *Dictionnaire des Sciences Naturelles*, 1830.

affinity and relations of structure and development, be reduced to eighty-six genera, but which number might perhaps be still further diminished, as a few genera might be classed as sub-genera. The Anthozoa he has divided into two orders, *Zoocorallia* (Animal-corals) and *Phytocorallia* (Plant-corals). In the Memoir is given a systematic description of the Orders, Tribes, Families, Genera and Species of the Anthozoa, while further details are reserved for the author's work, entitled, *Symbolæ Physicæ*. The subjoined Table will show the general arrangement, extending to the genera.

Anthozoa.

Ore ventriculoque distinctis, tubo cibario anoque discreto nullis, corpore intus radiatim lamelloso. (Vibratio nulla, gemmæ et spontanea divisio frequentissimæ.)

Ordo I.—Zoocorallia.

Corpore aut omnino molli, aut Cephalopodum more intus lapidem generante (secernente nec excernente) hinc sæpe omnino libera et, præter formam, animalium characteres omnes perfectius servantia.

		Species. Of the Red Sea. Unproved.	Observed by himself.	Total living.	Fossil Genera.	Genera.
Tribus I. Zoocorallia Polyactinia.	Familia I. Actinina. Genera 9. Species living . 50. In the Red Sea 23.	...	16	29	...	1. Actinia.
		...	1	1	...	2. Metridium.
		...	1	1	...	3. Megalactis.
		1?	...	1?	...	4. Thalassianthus.
		...	1	10	...	5. Cribrina.
		...	1	3	...	6. Actinodendron.
		...	1	1	...	7. Epicladia.
		...	1	1	...	8. Heterodactyla.
		...	...	3	...	9. Lucernaria.
	Fam. II. Zoanthina. Genera 4. Fossil 2. Species living . 12. In the Red Sea 7.	...	2	3	...	10. Hughea.
		1	...	2	...	11. Zoanthus.
		1	1	4	...	12. Mammillifera.
		...	2	3	...	13. Palythoa.
		...	...	...	F.	Siphonia.
		...	...	...	F.	Lymnorea.
	Fam. III. Fungina. Genera 6. Fossil 5. Species living . 12. In the Red Sea 3.	...	1	3	F.	14. Fungia.
		...	1	5	...	15. Haliglossa.
		...	...	3	...	16. Polyphyllia.
		...	...	...	F.	17. Cyclolithas.
		1?	...	1?	F.	18. Turbinalia.
		...	...	...	F.	19. Trochopsis.
		...	...	...	F.	Diploctenium.

		Species.				
		Of the Red Sea.				
		Unproved.	Observed by himself.	Total living.	Fossil Genera.	Genera.
Tribus II. Zoocorallia Octactinia.	Fam. IV. Xenina.	...	3	3	...	20. Xenia.
	Genera 3.	...	3	3	...	21. Anthelia.
	Species living . 7.	...	...	1	...	22. Rhizoxenia.
	In the Red Sea 6.					
	Fam. V. Tubiporina.					
	Genus 1.					
	Species living . 3.	...	1	3	...	23. Tubipora.
	In the Red Sea 1.					
		...	1	1	...	24. Halcyonium.
	Fam. VI. Halcyonina.	...	5	12	...	25. Lobularia.
	Genera 6.	...	2	2	...	26. Ammothea.
	Species living 28.	...	2	4	...	27. Nephthya.
	In the Red Sea 13.	...	3	8	...	28. Sympodium.
		...	...	1	...	29. Cliona.
	Fam. VII. Pennatulina.					
	(α) Halisceptra.	...	...	4	...	30. Veretillum.
	Genera 4.	...	...	1	...	31. Pavonaria.
	Species living . 7.	...	...	1	...	32. Umbellularia.
	In the Red Sea 0.	...	...	1	...	33. Scirpearia.
	(β) Halipteria.					
	Genera 3. Fossil 1.	...	...	2	...	34. Renilla.
	Species living . 10.	...	...	3	F.?	35. Virgularia.
	In the Red Sea 0.	...	...	5	...	36. Pennatula.
Tribus III. Zoocorallia Oligactinia.	Fam. VIII. Hydrina.					
	Genera 2.	...	...	4	...	37. Hydra.
	Species living . 6.	...	...	2	...	38. Coryna.
	In the Red Sea 0.					
	Fam. IX. Tubularina.	...	...	4	...	39. Syncoryna.
	Genera 4.	...	...	3	...	40. Tubularia.
	Species living . 12.	...	...	4	...	41. Eudendrium.
	In the Red Sea 0.	...	...	1	...	42. Pennaria.
	Fam. X. Sertularina.					
	Genus 1.	1?	...	4	...	43. Sertularia.
	Species living . 4.					
	In the Red Sea 1.					
	Zoocorallia...	5	49	151	8	

ORDO II.—PHYTOCORALLIA.

Corpore aut lapideam aut corneam materiam adglutinantem secernente, ac dorso (solea) excernente ejusque ope semper adnato (Ostrearum more).

			Species. Of the Red Sea. Unproved.	Observed by himself.	Total living.	Fossil Genera.	Genera.
TRIBUS IV.	Phytocorallia Polyactinia.	Familia XI. OCELLINA.	...	...	2	...	44. Desmophyllum.
		Genera 14. Fossil 12.	...	...	3	...	45. Cyathina.
		Species living 41.	...	1	1	F.	46. Stephanocora.
		In the Red Sea 7.	...	...	3	F.	47. Monomyces.
			...	1	9	F.	48. Oculina.
			...	...	4	F.	49. Turbinaria.
			...	3	8	F.	50. Explanaria.
			...	...	6	F.	51. Cladocora.
			...	...	...	F.	52. Columnaria.
			...	1	1	F.	53. Strombodes.
			...	...	...	F.	54. Cyathophyllum.
			...	...	...	F.	55. Pterorrhiza.
			...	1	4	F.	56. Anthophyllum.
			...	...	...	F.	57. Stylina.
		Fam. XII. DÆDALINA.	1	2	7	...	58. Caryophyllia.
		(*a*) ASTRÆINA.	...	4	7	F.	59. Favia.
		Genera 4. Fossil 3.	...	8	14	F.	60. Astræa.
		Species living 28.	...	...	...	F.	61. Favosites.
		In the Red Sea 15.					
			...	2	7	F.	62. Mæandrina.
			...	2	12	F.	63. Manicina.
		(*β*) MÆANDRINA.	...	...	1	...	64. Merulina.
		Genera 7. Fossil 6.	...	1	4	F.	65. Pavonia.
		Species living 28.	...	...	2	F.	66. Agaricia.
		In the Red Sea 5.	...	...	2	F.	67. Polyastra.
			...	...	...	F.	68. Monticularia.
TRIBUS V.	Phytocorallia Dodecactinia.	Fam. XIII. MADREPORINA.	...	7	21	...	69. Heteropora.
		Genera 3. Fossil 3.	...	17	20	F.	70. Madrepora.
		Species living 41.	...	...	...	F.	71. Catenipora.
		In the Red Sea 24.	...	...	...	...	Pleurodictyum.
		Fam. XIV. MILLEPORINA.	...	...	...	F.	72. Calamopora.
		Genera 4. Fossil 2.	...	4	6	...	73. Seriatopora.
		Species living 23.	1	2	7	F.	74. Millepora.
		In the Red Sea 11.	...	3	10	...	75. Pocillopora.
TRIBUS VI.	Phytocorallia Octactinia.	Fam. XV. ISIDEA.	...	...	1	...	76. Corallium.
		Genera 4.	...	...	4	...	77. Melitæa.
		Species living 10.	...	1	3	...	78. Mopsea.
		In the Red Sea 1.	...	...	2	...	79. Isis.
			1?	...	3	...	80. Prymnoa.
		Fam. XVI. GORGONINA.	1?	...	10	...	81. Muricea.
		Genera 6. Fossil 1.	...	...	23	...	82. Eunicea.
		Species living 63.	1?	...	4	...	83. Plexaura.
		In the Red Sea 3.	...	...	12	F.?	84. Gorgonia.
			...	...	11	...	85. Pterogorgia.
TRIBUS VII.	Phytocorallia Oligactinia.	Fam. XVII. ALLOPORINA. Genus 1. Species living 1. In the Red Sea 0.	...	...	1	...	86. Allopora.
		PHYTOCORALLIA	5	61	235	27	
		ZOOCORALLIA	5	49	151	8	
		ANTHOZOA	10	110	386	35	
		Of the Red Sea	120				

In the preceding Table we see that of the forty-three genera of Zoocorallia, there are eight which are found fossil; the living species amount to 151, of which fifty-four exist in the Red Sea, and forty-nine of these have been observed by the author, five remaining unproved. Of the forty-three genera of Phytocorallia there are twenty-seven which are found fossil; the living species amount to 235, of which sixty-six exist in the Red Sea, and sixty-one of these have been observed by the author, five remaining unproved. The general result is, that out of eighty-six genera of Anthozoa, thirty-five occur in the fossil state; and that of 386 known living species of Anthozoa, 120 exist in the Red Sea, of which 110 species were observed by the author. The same Table also shows that of the seventeen families of known Coral animals, thirteen exist in the Red Sea, while four are wholly wanting, namely, those of Pennatulina, Hydrina, Tubularina and Alloporina. The total number of known living species comprised in each family is also given, as well as the relative number actually existing in the Red Sea.

The 120 species of Anthozoa existing in the Red Sea thus constitute nearly one third of the whole number of living species, and being comprised in forty-four genera, the latter rather exceed one half of the number of known living genera.

Of the known living Corals there are eight genera peculiar to the Red Sea, namely, *Megalactis*, *Thalassianthus?*, *Epicladia*, *Heterodactyla*, *Anthelia*, *Ammothea*, *Stephanocora* and *Strombodes*. It appears also that eighty-eight species are peculiar to it, not having been hitherto observed anywhere else.

Among the genera of the Red Sea that of *Strombodes* excites peculiar interest, having previously been found only in the fossil state. It affords a key to the structure of the remarkable Cyathophylla, differing from the view hitherto entertained, and rendering it quite clear that the internal central star of the encased forms is not a young one, but the oldest or mother star, which is often surrounded by broad radiated mantle-folds productive of buds.

It appears probable that the Red Sea and the part of the Mediterranean so nearly adjoining on the Libyan coast, possess only two forms out of the 120 species in common, namely, *Actinia Tapetum* and *A. Mesembryanthemum*.

Of the Bryozoa group, Dr. Ehrenberg gave in the same memoir, contained in the volume of the Transactions for 1832, only the more general results of his investigations, without entering into detail; but the subject is resumed in his later memoir, inserted in the volume for 1838, in which he has presented a tabular view of the Bryozoa, distributed into Orders,

Families and Genera, with their characteristics. According to this view the Bryozoa comprise four Orders, *Polythalamia*, *Gymnocoræ*, *Thallopodia* and *Scleropodia*; the Polythalamia being divided into *Monosomatia* (single-bodied), consisting of fifty-six genera, and *Polysomatia* (many-bodied or polyparian), composed of twenty-two genera, forming altogether seventy-eight genera of Polythalamia. The following Table exhibits the general arrangement.

BRYOZOA.

Animalia asphycta, tubo cibario simplici, sacciformi aut tubuliformi, vera corporis articulatione nulla aut sensim numerosiore, corporis forma gemmis aut novis articulis accedentibus sensim aucta, hinc indefinita, nunquam sponte dividua, omnia et singula verisimiliter periodice ovipara, ideoque hermaphrodita.

ORDO I.—POLYTHALAMIA.

Libere vagantia et loricata.

Monosomatia.

Familia I. MILIOLINA.
Genera 2. ? Miliola, ? Gromia.

Familia II. NODOSARINA.
Gen. 11. Glandulina, Mucronina, Nodosaria, Orthocerina, Dentalina, Lingulina, Frondicularia, Rimulina, Vaginulina, Planularia, Marginulina.

Familia III. TEXTULARINA.
Gen. 6. Bigenerina, ? Dimorphina, Textularia, Grammostomum (*Vulvularia*), Polymorphina, Virgulina.

Familia IV. UVELLINA.
Gen. 11. Guttulina (et *Globulina*), Uvigerina, Bulimina, Valvulina, Rosalina, Clavulina, Globigerina, Pyrulina, Sphæroidina.

Familia V. ROTALINA.
Gen. 22. Operculina, Soldania, Planorbulina, Rotalia, Trochulina, ? Spirulina, Calcarina, Pleurotrema, Planulina, Discorbis, Omphalophacus, ? Gyroidina, Truncatulina, Lenticulina, Nonionina, Cristellaria, Siderolina, Dendritina, Robulina, Anomalina, Saracenaria, Cassidulina.

Familia VI. PLICATILIA.
Gen. 6. Biloculina, Spiroloculina, Triloculina, Articulina, Quinqueloculina, Adelosina.

Polysomatia.

Familia VII. ASTERODISCINA.
Gen. 5. Asterodiscus, Lunulites, Orbitulites, Cupularia, Flustrella.

Familia VIII. SORITINA.
Gen. 2. Sorites, Amphisorus.

Familia IX. FRUMENTARINA.
Gen. 3. ? Dactylopora, ? Ovulites, ? Polytripe.

Familia X. HELICOSORINA.
Gen. 5. Peneroplis, Pavonina, Vertebralina, Orbiculina, ? Heterostegina.

Familia XI. Helicotrochina.
Gen. 3. Polystomella, ? Amphistegina, ? Geoponus.
Familia XII. Alveolinea.
Gen. 2. Melonia, Alveolina.
Familia XIII. Fabularina.
Gen. 2. Fabularia, Coscinospira.

Ordo II.—Gymnocoræ.

Libere vagantes, nudæ.

Familia I. Cristatellina.
Gen. 2. Cristatella, Zoobotryon.

Ordo III.—Thallopodia.

Stolonibus thallove membranaceo affixa, incrustantia nec adnata, sed loricata.

Familia I. Halcyonellea.
Gen. 8. Halcyonella, Vesicularia, Bowerbankia, Farrella (= *Lagenella*) *, Valkeria, Stephanidium, n. G., Dynamene, Halodactylus (= *Alcyonidium*).
Familia II. Cornularina.
Gen. 1. ? Cornularia.
Familia III. Escharina.
Gen. 5. Eschara, Melicertina (= *Melicerita*) †, Crisia, Acamarchis, Notamia.
Familia IV. Celleporina.
Gen. 5. Cellepora, Flustra, Membranipora, Briolophus, n. G., Apsendesia.
Familia V. Auloporina.
Gen. 1. Tubulipora.

Ordo IV.—Scleropodia.

Stolonibus destituta, excreto fulcro axique anorganicis firmiter affixa eisque fruticulosa.

Familia I. Myrioporina.
Gen. 9. Hornera, Idmonea, Retipora, Distichopora, Myriopora, Tilesia, Cricopora, Ceriopora, Spiropora.
Familia II. ? Antipathina.
Gen. 1. Antipathes.

"The two last orders, the Thallopodia and Scleropodia," the author observes, "are considerably richer in forms, and it would be very easy by an uncritical compilation to enlarge greatly the number of names; but such confusion has been produced in names by Lamouroux and later writers, the same body being often designated by many new names, that I shall not venture to extend my judgment further at present. What

* The name *Lagenella* was appropriated to an infusorial form in 1832.

† *Melicerta* is already employed among the Radiaria, *Melicertum* with the Acalepha, *Melicerita* is not correct in language.

Perhaps hereafter it may be advisable to substitute *Textilaria* for Textularia, *Polystomatium* for Polystomella, *Cyclodiscus* for Discorbis, &c.

has been advanced will suffice to show clearly the position of the Polythalamia, such as it appears to me, in the animal kingdom."

On Chalk and Chalk Marl.

The memoir on the chalk and chalk marl is distributed under the following heads :—

1. Historical Introduction, pp. 59—68.
2. New method of observing, pp. 68—70.
3. On calcareous-shelled organisms, invisible to the naked eye, as the principal constituents of writing chalk, pp. 70—74.
4. On Chalk Marl and its relations to Chalk, and to the Flints of the Chalk, pp. 74—87.
5. On the compact limestone of Upper Egypt and Arabia, as formed by the Polythalamian calcareous animalcules of the White Chalk of Europe, pp. 87—90.
6. On the principal organic calcareous forms which constitute all chalk, and the local differences, pp. 90—95.
7. Preliminary view of new researches respecting living Polythalamia, and their relation to the formation of the sand of Sea Downs, pp. 96—106.
8. Application of the preceding observations to the systematic distinctions of Polythalamia, with a tabular view of the Bryozoa, according to their orders, families and genera, with their characteristics, pp. 107—121.

(N.B. Of this tabular view I have given a transcript above.)

9. On the geographical distribution of living Polythalamia on the African and Asiatic coasts of the Mediterranean, and in the Red Sea, with a tabular view of the genera and species, pp. 121—127.
10. A concise Diagnosis of the new families, genera and species,
    1. Of the siliceous Infusoria of the chalk marl, containing thirty-one new species, of which seventeen species belong to five new genera, and fourteen species to five former-known genera, pp. 128—130.
    2. Of the calcareous-shelled Polythalamian animalcules of the chalk and sea sand, sixty-seven new species, beside two new species from the Jura (Oolite) limestone, pp. 130—135.
11. A summary view of the conclusions drawn from the preceding expositions, pp. 135—139.
12. Explanation of the Plates, pp. 140—147.
13. A tabular view of the organic bodies invisible to the naked eye, which form the chief constituents of chalk, chalk marl, the compact limestone of Egypt and Arabia, and the nummulitic limestone of the Pyramids of Geza or Gyzeh.

The reader being thus put in possession of the general scope of the work, I now proceed to exhibit in full the conclusions to which the author has been led (as indicated under the head of No. 11), to which I shall subjoin further extracts taken from different portions of the Memoir, for the purpose of general illustration.

Conclusions.

1. Many, and probably all, *White Chalk Rocks* are the produce of microscopic coral-animalcules, which are mostly quite invisible to the naked eye, possessing calcareous shells of $\frac{1}{24}$ to $\frac{1}{288}$ line in magnitude, and of which much more than one million are well preserved in each cubic inch, that is, much more than ten millions in one pound of chalk *.

2. The *Chalk Marls* of the Mediterranean Basin are the produce of microscopic Infusoria possessing siliceous shells or cases, mostly quite invisible to the naked eye, intermingled with a small proportion of the calcareous animalcules of the chalk.

3. The peculiar state of aggregation in *White Chalk* does not arise from a precipitate of lime previously held in solution in the water of the sea, nor is it the result of the accumulation of the small animalcules, but it proceeds from a disintegration of the assembled microscopic organisms into much minuter inorganic calcareous particles; the reunion of which into regular, elliptical, granular laminæ, is caused by a peculiar crystalloid process, which may be compared to crystallization, but is of a coarser nature, and essentially different from it. The best writing chalk is that in which this process has been developed to the greatest extent.

4. The compact limestone rocks also which bound the Nile in the whole of Upper Egypt and extend far into the Sahara or Desert, being neither white nor of a staining quality, as well as the West Asiatic compact limestone rocks in the north of Arabia, are, in the mass, composed of the coral animalcules of the European chalk. This affords a new insight into the ancient history of the formation of Libya from Syene to the

* It is to be understood that I speak only of such Polythalamia as are well preserved, wholly disregarding their fragments. Of the well-preserved there are contained in one fourth part of a cubic line, or in one twelfth of a grain of chalk, frequently 150 to 200 in number, equal to 600–800 in each cubic line, or 1800–2400 in each grain, and from 1,036,000 to 1,382,400 in each cubic inch; and hence in one pound of chalk the number far exceeds ten millions.

The larger Polythalamia and Bryozoa of the chalk are best obtained from the sediment produced by brushing the chalk under water; the entirely microscopic forms remain long suspended in water.

Atlas, and of Arabia from Sinai to Lebanon, thus opening a large field to organic distribution.

5. Many of the chalk-like formations bordering on the Mediterranean in Sicily, Barbary and Greece, really belong to the period of the European chalk formation, as proved by their organic contents, although commonly held to be different from the chalk, and considered as tertiary *.

6. The chalk beds of the South of Europe, around the basin of the Mediterranean, are distinguished from those of the north and east of Europe by numerous well-preserved chalk animalcules, and less numerous inorganic laminæ; while in the north and east of Europe these relations are reversed †.

7. In the South of Europe the beds of marl which alternate with the chalk consist of siliceous shells of Infusoria, and flints are wanting; while in the North of Europe beds of flint alternate with the chalk, and marls with Infusoria are wanting. This exchange of character tends to explain the peculiar relation of flint to chalk, indicating that the pulverulent siliceous particles of Infusoria have been converted into compact nodules of flint.

8. It has been lately remarked that the chalk which contains flints is deficient in numerous siliceous Infusoria, when compared with the Bilin slaty Tripel or polishing slate (*Polirschiefer*) containing semi-opal; but this deficiency now disappears, and a rich substitute takes its place, the Infusoria in the North of Europe having been employed in the formation of flints; while in the south, remaining unchanged, they are preserved in the Infusoria marls.

9. The chalk animalcules resemble most those of the sea-sand and the Miliolites, which, up to the present day, have been ranged among the Mollusks with the Cephalopods; but neither of these are either Cephalopods or Mollusks, nor even Infusoria (as asserted by a late observer); but they are Bryozoa, animals of Moss-corals, which are most nearly related to Flustra and Eschara.

10. The sea downs of some, and probably of most coasts, are still in course of formation by living Bryozoa, which, though very small, resembling grains of sand, are yet, for the most part, larger than the chalk animalcules, and a large pro-

* In Sicily, however, there occur many breccias of chalk, which have suffered a subsequent change, and may be referred to the tertiary epoch.

† Thus in the white and yellow soft writing chalk of the North of Europe the inorganic crystalloid portions sometimes equal or rather exceed in mass the organic remains; but in the South of Europe, in Sicily, these organisms with their fragments are greatly predominant, consisting, as it appears, exclusively of well-preserved Polythalamia.

portion of the sand of the Libyan Desert has been proved to consist of such grains. It is only in Nubia above Syene that the desert sand becomes a pure detritus of granite*.

11. In the various countries of the earth in which occur white and earthy, as well as coloured and compact rocks, composed of microscopic calcareous animalcules, the genera and species of these animalcules present so striking an agreement with those of the white chalk of Rügen, that they may well be deemed characteristic of one and the same period of geological formation. It cannot be asserted for a certainty that the same forms have been observed any where else†.

12. In the beds subjacent to and more ancient than the chalk, namely, in those of the Oolite or Jura limestone formation, we have also clear evidence of the existence of other microscopic Polythalamia. These, however, are such as have not hitherto been found anywhere in the chalk.

13. The early assertion that *all* limestone was the produce of animals‡, though resting on no sufficient foundation, and therefore justly held in slight regard by modern geologists, yet now deserves every attention, since it clearly appears that a limestone formation widely extended on the surface of the earth is composed of microscopic animals, visibly converted in a gradual manner into inorganic chalk and compact limestone. If similar phænomena appear also in the Jura limestone formation, and should become still further confirmed, these considerations (combined with the long-known existence of coarser corals and shells in both formations) tend to show how necessary it is, when examining the composition of any considerable portion of the solid mass of the earth, to strengthen our natural senses by artificial means, in order to obtain a distinct knowledge of the extent to which organic life may have contributed to its production.

14. The extreme minuteness of the chalk animalcules is strikingly proved by this, that even in the finest levigated whiting multitudes of them are still present, and may be applied without suffering change to the most varied technical purposes. Thus in the chalk coating given to painted chambers, paper, or even glazed visiting-cards (when not coated with white lead

* On these very interesting and not easily developed relations, I hope, at a future day, to be able to make a more special communication.

† If I have applied the same name in some cases both to animalcules of the chalk and to forms existing in the present sea-sand, or in recent fossil beds, it has arisen partly from my being unacquainted with the original forms of the latter, and partly from my desire not to create unnecessary perplexity by the adoption of new names. It should be observed that they are distinguished by marks of interrogation. All those which I could really compare were different.

‡ By Linnæus in 1745 and 1748, and Buffon in 1749.

alone), may be seen a pretty mosaic of well-preserved, moss-coral animalcules, but which are invisible to the naked eye. And thus our natural vision receives from such a surface the impression of the purest white, little deeming that it contains the bodies of millions of self-existing beings, of varied and beautiful forms, more or less closely crowded together (as in Plate IV., where the subjects are magnified 300 times).

Explanation of the Plates and Tabular View.

The Memoir is accompanied by four Plates*, presented with the view of facilitating a comparison between the organic relations of minute fossil bodies invisible to the naked eye, and those of still living bodies visible to the naked eye.

Thus the first three Plates exhibit recent small bodies naturally visible, with which the naturally invisible forms of the fourth Plate may be readily associated.

The first three Plates serve also to elucidate the true nature of the Polythalamia (hitherto mistaken), showing their greater affinity to the Bryozoa (Flustra) than to all other animal forms, and in particular the great difference there is between them and Cephalopods and Infusoria. They represent partly the unfolded, soft, external parts of living subjects, and partly dead, naked bodies, artificially divested of their calcareous shell, and not hitherto figured.

Lastly, these first three Plates serve to convey a view, according to some of their principal divisions, of the structure of the whole group of forms occurring in Polythalamia, and in particular to illustrate their frequent assemblage in families, or Polyparies, as they are termed. Plate I. contains simple forms; Plates II. and III. composite or family forms, Polyparies; of which Plate II. contains family forms assembled in single rows, and Plate III. family forms arranged in many rows.

If, as already observed, we examine a wall or paper whitened with finely levigated chalk, or a glazed visiting-card not coated with white lead alone, but also with chalk, they would appear, when magnified 300 times, more or less rich in subjects, as represented in Plate IV.

Plate I. contains *simple recent Polythalamia* from the sea-sand of Rimini. Fig. 1. *Rotalia Beccarii*; the shell only was known, but the figures show also the form of the animal when deprived of its shell by an acid, the form of both being the same. Fig. 2. *Marginulina Raphanus* (*Nodosaria Raphanus*, *Nautilus Raphanus priorum*), also very common at Rimini and other Italian coasts, and which had hitherto been erroneously ranked with Orthocera.

Plate II. contains *Polyparies of recent Polythalamia assem-*

* These plates do not accompany Mr. Weaver's paper.

bled in single rows, from the Red Sea and the Mediterranean. The two subjects represented in this Plate were collected by me in the year 1823, and it is peculiarly interesting, through my newly-discovered method of observing*, to have been able to see in several divisions of the internal body the remains of the siliceous Infusoria, of which they had made a repast fifteen years before. Fig. 1. *Peneroplis planatus*, d'Orbigny, *Nautilus planatus* of Fichtel and Moll, from the Red Sea. The shells of this animalcule were hitherto only known, but the soft organic animal form which they inclose is here also represented. Fig. 2. *Coscinospira Hemprichii*, a form from the Red Sea, also found in the Libyan part of the Mediterranean, and which was formerly erroneously placed adjoining the *Spirula* of the Cephalopods, and more recently as connected, through *Lituolites nautiloides*, with *Spirolina*.

Plate III. contains *Polyparies of recent Polythalamia assembled in many rows*. This Plate contains the only living animalcule of the Polythalamia group, hitherto so far observed as to admit of its classification. The three forms given in this Plate, constructed of many rows of animalcules, may be distinctly associated with the Flustra and Eschara of the Bryozoa, to which, through the well-known *Lunulites* and *Orbitulites* (hitherto ranked with coral animals), they approximate in a convincing manner. Fig. 1. *Orbiculus numismalis*, from the sea-sand of the Antilles Isles. Fig. 2. *Sorites orbiculus* = *Nautilus orbiculus*, Forskål, *Nummulina* (*Assilina*) *nitida*, d'Orbigny, ? from the Red Sea. The same species lives also in the Mediterranean. In a part magnified 300 times we see the animalcule with eight feelers protruding from its cell. In some of the cells may be seen distinct shells of siliceous Infusoria; in others appear oviform globules. Fig. 3. *Amphisorus Hemprichii* closely resembles the *Sorites*; but it has cells on both sides bearing single animalcules, and hence

* The new method of observing is the following:—Place a drop of water upon a lamina of mica, and put into it of scraped chalk as much as will cover the fine point of a knife, spreading it out and leaving it to rest a few seconds; then withdraw the finest particles which are suspended in the water, together with most of the water, and let the remainder become perfectly dry. Cover this remainder so spread out with *Canadian balsam*, the turpentine of the *Pinus* (*Abies*) *balsamea*, and hold it over a lamp until it becomes slightly fluid without froth. A preparation thus made seldom fails, and when magnified 300 times in diameter we see that the mass of the chalk is chiefly composed of minute well-preserved organisms. In this preparation all the cells of the Polythalamia appear at first black with a white central spot, which is caused by the air contained in the cells, which, as is well known, appear under water as annular black bodies; but by degrees the balsam penetrates into all the single cells, the black rings of the air vesicles disappear, and we recognize all the small cells of the Polythalamian animals, often presenting a very pretty appearance.

the discs are twice as thick as in *Sorites*. If we compare *Sorites* with *Flustra*, we may place *Amphisorus* by the side of *Eschara*, but, being both free moving bodies, they are different from them.

Plate IV. contains the *invisible animalcules of the chalk and chalk marl*, displayed in twelve specimens of rock; 1 to 9 being portions from the chalk, and 10 to 12 from the chalk marl, magnified 300 times. In these specimens the calcareous Polythalamia amount to sixteen species, and the siliceous Infusoria to twelve species, with siliceous spicula of sponges. The twelve localities from which these specimens of the rock masses were derived are the following:—No. 1 to 5, *writing chalk*; namely, 1. from Puszkary, in Poland, opposite Grodno, from the shore of the Memel; 2. from Jütland, in Denmark; 3. from the island of Rügen in Pomerania; 4. from Gravesend, on the Thames; 5. from Meudon, near Paris; *firmer* writing chalk, No. 6, from Cattolica in Sicily; *compact, not writing* chalk, No. 7, from the Mokattum hills near Cairo; and No. 8, from the Catacombs of Thebes in Upper Egypt; *compact gray limestone*, No. 9, from the mountain mass of Hamam Faraūn in Sinai, Arabia; *chalk marl*, No. 10, from Oran in Africa; No. 11, from Caltasinetta in Sicily; No. 12, from Greece.

In the *general table* indicated above, under the head of No. 13 of the contents of the memoir, a list is given of the principal forms of the invisible organic bodies which constitute the rocks from which the twelve above-mentioned specimens were taken, as well as the chalk of Brighton, the chalk marl of Zante in the Ionian Islands, and the nummulite limestone of the Pyramids of Geza in Egypt. From this it results that the principal forms in these rocks consist of twenty-five species of calcareous-shelled Polythalamia, thirty-nine species of siliceous-shelled Infusoria, seven species of soft-shelled Infusoria of the flints, and five species of siliceous plants.

The twenty-five species of calcareous-shelled Polythalamia, belonging to eight genera, are the following:—

Flustrella *concentrica*; Globigerina *bulloides?*, G. *helicina?*; Planulina *sicula*, P. **turgida*; Robulina *cretacea*; Rosalina **fovcolata*, R. *globularis?*, R. **lævigata*, R. *pertusa*; Rotalia **globulosa*, R. *occllata*, R. *ornata*, R. *perforata*, R. *scabra*, R. *stigma*; Textularia *aciculata?*, T. **aspera*, T. *brevis*, T. **dilatata*, T. **globulosa*, T. *perforata*, T. *spinosa*, T. **striata*; Turbinulina *italica?* Quinqueloculina? from Benisuef, is doubtful. N.B. *Textularia globulosa*, when in fragments, is not easily distinguished from *Rotalia globulosa*; and in like manner the fragments of *Textularia perforata* may be confounded with *Rotalia perforata*.

The thirty-nine species of siliceous-shelled Infusoria belong to fourteen genera, and are as follow:—

Actinocyclus *ternarius*, A. **quaternarius*, A. **quinarius*, A. *senarius*, A. *septenarius*, A. *octonarius*, A. *denarius*; Coccoconema *Cretæ*; Cornutella *clathrata*; Coscinodiscus *Argus*, C. *centralis*, C. *lineatus*, C. **minor*, C. **Patina*; Denticella *Fragilaria*, D. *tridens*; Dictyocha *Fibula*, D. *Navicula*, D. *polyactis*, D. *speculum*, D. *stella*, D. *triangula*; Eunotia *zebra*; Fragilaria *rhabdosoma*, F. *striolata*?; Gallionella *aurichalca*?, G. *sulcata*; Haliomma *Medusa*, H. *crenatum*; Lithocampe *lineata*, L. *Radicula*, L. *solitaria*; Navicula *africana*, N. *Bacillum*, N. *curysoma*, N. *ventricosa*, N. *sicula*; Pyxidicula *prisca*; Synedra *ulna*.

The seven species of soft-shelled Infusoria of the flints belong to three genera, and are the following:—Chætophyta *Pyritæ*; Peridinium *pyrophorum*†; Xanthidium *bulbosum*, X. *furcatum*, X. *hirsutum*, X. *ramosum*, X. *tubiferum*.

The five species of siliceous plants belong to two genera, namely, Spongia (*Tethya*?) *aciculosa*, S. *cancellata*, S. **Cribrum*, S. *binodis*; Spongilla (*Tethya*?) *lacustris*‡.

Of these principal forms the before-mentioned rocks partake in the proportions as stated below: namely,

	Species of Calcareous Polythalamia.	Species of Infusoria.		Species of Siliceous Plants.
		Siliceous, in Chalk.	Soft-shelled in Flints.	
The *Chalk* of				
Puszkary contains	6			
Rügen	7	1		
Jütland	6			
Gravesend	6	3	5	
Brighton	7	1	4	
Meudon	9	.....	2	
Cattolica	9			
The *Chalk Marl* of		Siliceous Infusoria.		
Caltasinetta	7	27	.....	4
Oran	2	18	.....	1
Zante	5	8	.....	2
Greece	3	9	.....	1
The *Compact Chalk* of				
Egypt	8			
Arabia	6			
The *Nummulite Limestone* of The Pyramids of Geza	6	Containing 4 species of Nummulite, the largest of which is one inch in diameter.		

† *Peridinium delitiense* has hitherto been found only in flint pebbles near Delitzsch, yet accompanied with forms that are common in the flints of the chalk.

‡ In the preceding lists, the species which are marked with an asterisk * are those which most frequently occur, forming the masses of the rocks. The *Rotalia globulosa* occurs in all the localities.

On the Chalk Marl, and its relations to the Chalk and its Flints.

The whole coast of Oran in Africa appears to belong to the chalk formation, composing the plain east of the town, and extending thence to the Atlas. The marl brought from thence as tertiary by M. Rozet in great quantities I had an opportunity of examining in Paris, and I found not only Polirschiefer and an Infusoria conglomerate, but calcareous animalcules of the same species as occur in the chalk of Poland, Rügen, Denmark, and Paris, and which there mainly contribute to its mass. It thus appeared that the so-called tertiary formation of the coast of Barbary might, without much hazard, be brought into a nearer connexion with the chalk. In his description of this tract, M. Rozet states*, "The tertiary formation is extensively developed in Oran, forming the soil of the large plain on the east of the town, and on the south to the Atlas. It forms also the sea-coast to an extent of 3000 metres between Mers el Kebir and Cape Falcon, and the whole soil of the adjacent plain. The lower bed is a blue marl, like that which we found at Algiers and within the Atlas. It appears destitute of organic remains. The second or upper deposit consists of marly and calcareous beds in alternation, forming a thickness of 30 to 40 metres. In the plain these beds are apparently horizontal, as well as in the elevated plain of the Rammra hill; but in the hills south-west of the town of Kasba they are, on an extent of two hours march, inclined to the north, at an angle sometimes exceeding 30°. The beds of limestone are white and chalk-like, yellowish and coarse granular, usually forming the lower part, succeeded by others alternating with yellow marls, which are often slaty and charged with sand, and between them are found layers of ostreæ and other shells. Among them two beds are distinguished, each one metre in thickness, composed of very white finely-laminated marl, containing numerous well-preserved impressions of fishes, so that in a cubic mass of one foot we seldom fail to find three or four fishes. In these beds of marl thus enclosing the fishes, other organic remains do not appear; but in the calcareous and sandy beds which intervene, occur layers of large oysters mingled with gryphææ. The upper part of this deposit is composed of a calcareous breccia, which is exhibited at the surface in the soil of the whole plain on the south-west of Oran."

This exact description of the position and thickness of the white marl with impressions of fishes, has a reference to the

* Rozet, *Voyage dans la Régence d'Alger*, Paris, 1833. tome 1. chap. v. pp. 56, 63.

Infusoria conglomerate of Oran, to which I have already adverted. It is probably what formed the Tripel of the earlier periods of Italy. When M. Rozet speaks (at p. 28–30) of the great extent of the tertiary tract near Algiers as similar in its relations to those of Oran, I cannot agree with him. On the contrary, forming my judgment by the organic remains, I consider the desert tract near Algiers as really composed of a tertiary formation, which reposes on chalk. This opinion is founded on my observation, that the tract in Libya, extending from Alexandria to Siwa, is composed of tertiary beds, while from Cairo to Geza the chalk formation occurs, which terminates at the granite of Syene, but is far spread into the Desert. The valley of Siwa appears to form the northern boundary of the chalk in Eastern Libya.

In the South of Italy, at Caltasinetta and its neighbourhood, the relations had been correctly seized by our late friend Frederick Hoffmann, from whose diary I have been favoured with an extract by M. von Dechen. He represents the series of strata which occupy the greater part of Sicily as composed of limestones, sandstones, clays, and marls; the lower members being probably referable to the Jura formation, succeeded by such as clearly belong to the chalk, and many beds of which perfectly resemble the hard chalk of the north-west of Germany (Teutoburger Wald). Among the marls are white chalk-like thinly laminated masses, analogous to Tripel, designated by Hoffmann as *white chalk marl*, and which especially occur in the southern part of the island. The beds of the chalk formation usually dip 20° to 30°, while the strike is nearly constant, from 15° to 45° S. of E. and N. of W., parallel to the south coast. The tertiary beds which succeed the chalk are composed of loose sand, friable sandstone, testaceous breccias, clays and limestones. They cover the chalk unconformably, resting on the truncated edges of the latter. The chalk beds are upon the whole poor in organic remains, and these are seldom distinct; there occur Hippurites, Nummulites, Lenticulites, and in a few places indistinct Ammonites and Belemnites, while the tertiary beds are quite filled with innumerable Mollusks, of which nine-tenths are still living in the Mediterranean. This distinction is so striking that it scarcely required the difference of relative position in order to draw a correct line between the two formations. Even had so circumspect a geologist as Frederick Hoffmann not correctly seized and pronounced with decision on these local relations, the numerous microscopic siliceous Infusoria with calcareous Polythalamia which I have found in the chalk marl would have led to the same conclusion.

If we compare Hoffmann's description of this portion of

Sicily with that given by Rozet of the coast near Oran, we cannot avoid recognizing a similarity of relations; and the thinly laminated marly beds with impressions of fishes, between Caltasinetta and Castrogiovanni, which Hoffmann refers with certainty to the chalk formation, correspond to the similar beds which occur near Oran, but which were said to be tertiary. And the parallel is confirmed by the microscopic siliceous Infusoria and calcareous animalcules which I have discovered in both.

The genera and species of the siliceous Infusoria in Sicily are so similar to those of Oran and Zante, that of thirty-six species, four occur in all the three countries, three in Caltasinetta and Zante, seven in Caltasinetta and Oran, while in all of them the *Coscinodiscus Patina* is greatly predominant. Of all these siliceous animals, not a single species has been found in the chalk of the North of Europe, nor even in the flints. On the other hand, the calcareous-shelled animalcules, which in the South of Europe accompany the siliceous animals, comprise about one half of the same species that are found in the North, yet exceeding them in quantity.

From the examination of the organic constituents of the chalk marl we learn the hitherto unknown fact, that numerous swarms of microscopic Infusoria were in existence within the period of the secondary formation of the earth's surface, chiefly belonging to such as possess siliceous cases or shells, and which for the greater part are members of such sections of the Bacillaria family as had previously appeared to be confined to the tertiary or newest formations.

Of the thirty-nine or forty species of siliceous Infusoria occurring in the chalk formation, thirty-four or thirty-five have not hitherto been found in the recent state; but it is remarkable that the remaining five or six species so closely resemble existing species of the present day, that they present no peculiar character by which they could be distinguished from them, and hence the application of new names appeared inadmissible. They are, *Eunotia zebra*, *Fragilaria rhabdosoma*, *F. striolata ?*, *Gallionella aurichalca*, *Navicula ventricosa*, *Synedra ulna**.

In the chalk itself only four out of the thirty-nine or forty species of siliceous Infusoria have hitherto been met with,

* The indifference shown to climate by Infusoria, and the peculiarity of their organic development, seem to render it possible that they might be more readily preserved through many catastrophes of the earth than other forms. By the faculty which they possess of spontaneous division, a single individual can, under very favourable circumstances, be multiplied in the course of a few hours to the extent of millions.

namely, *Fragilaria rhabdosoma*, *Fragilaria striolata ?*, *Gallionella aurichalca*, and *Pyxidicula prisca*. They are very rare, and found only in the vicinity of the beds of flint.

On the Composition of the Compact Limestone of Upper Egypt and Arabia by the invisible Animalcules of the White Chalk of Europe.

Both the nummulite limestone of the pyramids of Geza on the left bank of the Nile, and the same kind of rock on the right bank near Cairo, contain numerous microscopic animalcules of the chalk, which serve as a cement to the Nummulites. I had often examined microscopically specimens which I had brought from thence, but I did not succeed in separating and rendering visible the different elements with equal clearness, until I applied my newly-acquired practice, which was much facilitated by immersing these stones a longer time in water. The same result attended the examination of the other calcareous rock masses of Upper Egypt and Arabia, showing that the animalcules of the chalk occupy in a surprising manner a wide extent of country in Libya.

Nummulite limestone, wherever occurring, has been most usually referred to the tertiary period, although perhaps often belonging to the chalk. In Egypt it possesses no great extent. On the right bank of the Nile it is deposited only in the small hills near Cairo, and on the left bank, as it appears, in a tract extending from Siout to the declivity of the compact limestone, which latter constitutes the mass of the rocks that line the course of the Nile in Upper Egypt. It forms the foundation and principal material of the Pyramids. Northward it is directly bordered by the slimy delta of the Nile, the productive soil of Egypt. Between the Oasis of Jupiter Ammon and the Mediterranean, is a wide elevated plateau or tableland of rock, among whose numerous organic remains are known tertiary forms. The whole of Upper Egypt, as far as Syene, has a similar character. In 1828, though assured that its limestone rocks were more ancient than the tertiary period, yet, from want of distinct fossils, I was doubtful whether they might not be referred to the Jura formation. On the south, and not far from Syene, this limestone is incumbent on sandstone (Quadersandstein ?), and the two repose on granite and the primary rocks connected therewith. I gave these views in 1828 in the geologically coloured map which accompanied the first section of the first volume of my Travels in Egypt, Libya, Nubia, and Dongola.

It now results, from the microscopic examination which has taken place, that the whole of the limestones of Benisuef,

Siout and Thebes, on the western bank of the Nile, and of Cairo and Kineh (including the gray marl near Kineh), on the eastern bank, and which inclose the Nile at an elevation of frequently 100 to 300 feet above its level, extending along the river full sixty German miles in length, are, like the Nummulite limestone, composed of an inconceivable accumulation of microscopic calcareous-shelled animalcules, which are of precisely the same genera and species as those which constitute the chalk of Europe. The table-land formed by these calcareous rocks extends far westward into the Desert, and it is perhaps principally composed of them.

A new and unexpected light is thus thrown on these extensive regions. The phænomena apparent in Egypt may be connected with those of Western Africa. It has been already shown that the same animalcules constitute the territory of Oran, stretching far along the foot of the Atlas; and when we consider the equality of surface which prevails in the plain of the Great Desert, or Sahara, of the North of Africa, and compare it with what I have myself seen along the whole extent of its eastern border, as well as on a large portion of its northern, we may be well permitted to think of a similarity of composition.

But these distinct indications of a similar organic influence extend not merely to the west but also to the east of Cairo, expanded into Asia. The specimens collected by Dr. Hemprich and myself from Hamam Faraūn, and Tor in the Sinaian portion of Arabia, which I had formerly considered as ash-gray marl and yellowish-gray limestone of the tertiary epoch, were now proved, by the new method of examination, to consist of quite the same microscopic chalk animalcules as constitute the hilly masses of Upper Egypt. And from hence this formation appears to be continued eastward far into the interior of the Great Desert plain, trending toward Palestine; but on the Arabian coast of the Red Sea we did not find it further south than Tor, which locality alone, among all the points of the east, yielded flints similar to those which occur in the European chalk.

We have here to remark on the absence of siliceous animals in this limestone and marl formation, while the so-called Egyptian pebbles and jaspers occupy the same position in horizontal layers as the flints in the North of Europe, appearing as their substitute. But in these jaspers the organic siliceous elements are no longer to be distinctly found by reason of their intermixture with other substances, and their consequent opacity, giving rise to dendritic and other delineations. It seems as if the solution and conversion of the organic into

the inorganic in the Egyptian pebbles (*Cailloux d'Egypte*) is throughout more perfect than it is in many flints, although the constituent elements of both kinds of stone are very probably quite the same.

On the principal Organic Calcareous Forms which compose the mass of all Chalk.

From what has been already stated, it is evident that the production of the calcareous mass of the chalk is not to be attributed, as formerly conceived, to the larger organic bodies, but to the minuter, and in the greatest measure to such as are invisible, consisting of eight genera of Polythalamia with twenty-five species, and excluding all such as may be distinguished by the naked eye, that is, exceeding $\frac{1}{2}\frac{1}{0}$th of a line in magnitude; the latter, however, are comparatively rare. It is possible that several other, and perhaps many species of the same genera, may yet be discovered in the chalk, as well as other genera, since the investigations hitherto made could only be applied to a minimum of its substance; yet, as these were conducted by me on chalk from many regions, it does not appear probable that other sections of the animal kingdom will be found to have taken so great a share in the formation of chalk as the Polythalamia, the principal prevailing forms of which I have indicated.

From the preceding it is also apparent that the chalk rocks of all countries agree in their constituent organic forms not only according to the zoological class, but also in genera, and for the most part in species likewise; this character being not confined to the white tender writing chalk of Europe, but extending also to the compact limestone rocks of the North of Africa and the West of Asia. Particularly striking is the characteristic persistence of single forms through all these different and widely-separated countries. Thus in all of them are to be found *Rotalia globulosa*, with *Textularia globulosa*, *T. aciculata ?*, and *T. striata*, as well as *Planulina turgida*, thus giving a common character to all these rock formations; and this character becomes the more important, when we consider that these forms are the most numerous, and in fact are the chief constituents of the chalk*.

If now the question be asked whether the forms which occur in such masses in chalk belong to it exclusively, and are hence to be considered characteristic of that formation, I am almost disposed to reply in the affirmative. The analogous forms

* The Polythalamian forms which Mr. Lonsdale noticed in the English chalk in 1837 as visible to the naked eye, and amounting to 1000 in one pound of the chalk, and which, with Mr. Lyell, he has named *Lenticulina*

which occur in sea-sand, tertiary sand, and indeed in all modern formations, are viewed for the most part as different and larger species, although of the same genera; and it does not appear that any of these forms can be referred with perfect certainty to such as are now living in the sea.

To the theory of the formation of limestone, the observation is important, that these organic deeply-seated relations are not peculiar to the chalk formation. The tertiary calcareous beds consist, in like manner with the chalk, of multitudes of such Polythalamian animals, which compose in many quarters sandy sea-downs of great extent; and even in the sandy desert of Libya we can recognize distinct Polythalamia. On the other hand, having succeeded in discovering microscopic Polythalamia in the compact flints of the Jura limestone from Cracow, which are of decidedly different forms from those of the chalk, the calcareous animals being *Nodosaria urceolata*, n. sp., and *Soldania elegans*, n. sp., and the siliceous *Pyxidicula prisca*?, with *fragments of soft sponges*, it becomes apparent that such invisible organic bodies were also present in the formation of the Jura limestone.

[To be continued.]

LXIII. *Notice of an undescribed Native Subsulphate of Iron from Chili. By* John Prideaux, *Esq.**

THIS specimen, of which I have not found any description, was brought to Sir Charles Lemon's Mining School by Edward Hookham, one of the students, having been sent from Chili to Captain N. Vivian, by his son, without any geological reference.

Form, mammillary, or curved lamellar about one-sixth of an inch thick. *Structure*, fibrous parallel, transverse to the laminæ; *fracture* corresponding; fibres crystalline, but too minute to be easily definable. *Brittle* in mass, fibres rather flexible. H 2·5; specific gravity below 2·5.

and *Discorbis*†, appear, judging by the figures, to be referable to *Rotalia ornata* and *R. globulosa*, including perhaps fragments of *Textularia globulosa*.

I may here remark, that my continued researches on the Polythalamia of the chalk have convinced me, that very frequently in the earthy coating of flints, which is partly calcareous and partly siliceous, the original calcareous-shelled animal forms have exchanged their lime for silex, without undergoing any alteration in figure, so that while some are readily dissolved by an acid, others remain insoluble; but in the chalk itself all similar forms are immediately dissolved.

* Communicated by the Author.

† Dr. Buckland's Bridgewater Treatise, 2nd Edition, vol. i. p. 448. 1837. Lyell's Elements of Geology, 1838.

is instantly produced; if antimony be in the mixture, a curdy-white precipitate is obtained: if, on the contrary, neither arsenic nor antimony is in the matter under examination, the hydrogen instantly reduces the silver of the test-liquor to the metallic state.

It is really beautiful to see the admirable manner in which this test performs its duty, and I submit the same with confidence to the attention of your numerous readers and correspondents.

I am, Gentlemen, yours truly,

J. Marsh.

Royal Arsenal, Woolwich, May 10th, 1841.

LXXIII. *On the Composition of Chalk Rocks and Chalk Marl by invisible Organic Bodies: from the Observations of Dr. Ehrenberg.* By Thomas Weaver, *Esq., F.R.S., F.G.S., M.R.I.A, &c. &c.*

[Continued from p. 397.]

On the Geographical Distribution of Living Polythalamia on the African and Asiatic Coasts of the Mediterranean, and in the Red Sea.

THE materials collected by Dr. Hemprich and myself in the Mediterranean refer to four points on the Libyan coast, and one point on the Syrian coast. In regard to a second point on the latter coast (St. Jean d'Acre), I have acquired a knowledge of some forms from the collection of Dr. Parthey.

From the Red Sea nine forms were made known to us by d'Orbigny, collected from sand presented to him by Deshayes. But from the collections made by Dr. Hemprich and myself from thirteen points along the whole length of the Red Sea, it appears that very numerous forms exist. Of seven of those points, one occurs on the western (African) coast at Suez, and six on the eastern (Arabian) coast, namely, at Tor, Erraie and el Ard, Moileh, el Wusch and Gumfŭde; and of the remaining six, five are islands on the Arabian side, namely, Sanafer, Maksure, Barkan, Sanac and Ketumbul, and one an island on the African side of the Red Sea, namely, Massaua.

It is possible that by repeated and closer examination of the marine productions collected by us, many other Polythalamia may be found besides those already discovered. In the mean time, as a preliminary, I have drawn up a list of the species hitherto met with*. From this it results that the total num-

* Of d'Orbigny's nine species from the Red Sea, there are three which I cannot identify, namely, *Triloculina bicarinata, Quinqueloculina limbata,*

ber of species of Polythalamia observed in the Red Sea are *fifty*, and in the Mediterranean, on the Libyan and Syrian coasts, *twenty-seven*. The new species derived from the two seas amount to *fifty-four*, of which *twenty-seven* species are peculiar to the Red Sea, and *seventeen* are common to both seas. Particularly worthy of notice is the wide distribution and massy development of the *Peneroplis planatus* and *Sorites Orbiculus*, which are rare on the European coast. These forms are not only present almost everywhere in the East, but constitute the predominant masses. On the other hand, the *Rotalia Beccarii*, which composes the Italian hills, occurs only singly and very rarely in the Red Sea; and I nowhere found it on the Libyan and Syrian coasts. The *Sorites Orbiculus* I have also from St. Domingo.

In reviewing these subjects, even a superficial comparison of them with the contents of the chalk and chalk marl, is attended with the striking result, that none of these living forms are found among the animalcules of the chalk, not even among those which compose the compact limestone of the Egyptian and Arabian rocks, and which are still partly washed by the sea near Hamam Faraūn.

Remarks on Polythalamia.

After a preliminary view of the researches of earlier labourers in this branch of zoological inquiry, Dr. Ehrenberg observes:—A lively interest respecting the minute Polythalamian bodies which enter into the composition of sea-sand was excited anew by the work of Alcide d'Orbigny in 1826, in which are contained a great number of new species, while many of those which were previously known are examined with greater care, and an improved and easier view is taken of the whole subject. By his active exertions he had collected between 600 and 700 species from the sea-sand of France, Italy, England, the Isle of France, Sandwich Islands, the Malouine and Marian Isles, &c., of which, however, only 425 received names. The whole mass of these microscopic animalcules, which he again decidedly associates with the Mollusks and Cephalopods,

and *Q. punctata*; but the other six are probably those with which I have become acquainted, and to which I have therefore given the same names, namely, *Textularia communis, Calcarina Defrancii, C. Gaudichaudii, Quinqueloculina sulcata*, and *Vertebralina striata*. His *Assilina* (*Nummulina*) *nitida* I hold to be the *Sorites Orbiculus*.

Although I possess and have compared many of the Polythalamia which have been described by d'Orbigny derived from the same localities, yet I am in want of a great number of the originals named by him, and as this author has generally given new names unaccompanied by descriptions, I have not in most cases been able to determine to what form the name given by him belongs.

but in a distinct order under the name of *Foraminifères*, are distributed by him into five families, according to the spiral or other form in the grouping of the cells; these families comprising fifty-two genera. On this work Deshayes made various critical remarks in the *Dictionnaire Classique*. D'Orbigny expressly states that the animal of the Polythalamia (his Foraminifera) resembles the Sepia in the structure of its body, although much smaller, and then proceeds to give the essential characters of the living body of the Polythalamia, yet without naming specifically or generically any one animal from which they were taken*.

Both Blainville and Dujardin have made the correct observation that the minute shells of the Polythalamia are external cases, and not, as incorrectly viewed by Denys de Montfort and Alcide d'Orbigny, internal bones. Yet in referring the microscopic so-called Cephalopods to the Infusoria, Dujardin commits a mistake†. It was this contradiction between observers that induced Férussac, in his great work, *Histoire Naturelle des Mollusques*, to exclude the Foraminifers from the class of the Mollusks; and others entertained similar objections, yet without assigning to them a correct position.

In the year 1831 I laid before the Academy contributions to the knowledge of Coral animals, with an attempt to class them physiologically; which attempt was entirely founded on my own observations of the living animalcules, when, accompanied by Dr. Hemprich, I travelled on the Red Sea in the years 1823 and 1825. In that work I designated the Coral animals as composed of two strongly marked organically distinct groups, under the names of *Anthozoa* and *Bryozoa*. In the year 1831 also, I communicated in the *Symbolæ Physicæ* the first development made of the complicated structure of the *Halcyonella stagnorum*, one of the Bryozoa, and showed that it was quite similar to that of Flustra.

The researches of Dujardin in 1835 gave an entirely new direction to the ideas which had been formed of the Polythalamia, showing that not a trace of resemblance was to be found between them and Sepia; on the contrary, the greatest simplicity of structure became apparent, bespeaking a simple animal body covered by a shell, with the power of extending or contracting itself at will. But when Dujardin expressly compares the Polythalamia to the *Proteus* (*Amœba*) of the Infusoria, such an association cannot be admitted, unless it be first proved that a polygastric structure exists in those bodies. He has given to them the new name of *Rhizopodes*.

* *Annales des Sciences Naturelles*, 1826, t. vii. p. 245.

† *Annales des Sciences Naturelles. Seconde Série*, t. iv. p. 343, 1835.

I showed, in 1837, that the Polythalamia could not well possess an organization similar to that of the Infusoria, as not a single known true species of Infusoria has a calcareous shell; and I had, in 1823, discovered, as I conceived, a true living Polythalamia of earlier authors, resembling in organization the very complex Flustra. The correctness of this view was fully established in 1839, after having examined anew, according to my improved method, the small *Nautilus Orbiculus* of Forskål, which d'Orbigny designated in 1826 as *Nummulina* (*Assilina*) *nitida*, specimens of which I had collected from the sand of the Red Sea in 1823, and which I have named *Sorites Orbiculus*. The result proved that the disc-like shell was a Polypary, often composed of more than one hundred single animalcules, the cells of which quite resemble those of a Flustra, the animal putting forth and retracting from six to eight tentacula. And I even discovered in the interior of the single cells well-preserved siliceous Infusoria, the last food taken by the animal; and in some of them also small globular bodies, which, without much constraint, may be considered as eggs. Though I had at an early period observed that the disc was composed of many cells, yet I could not perceive an opening to them; but the discovery of Infusoria in their interior led me to consider by what means they could have been introduced. Reflection reminded me that I had often seen Coral animals which in the expanded state exhibited many large bodies with tentacula and a large mouth, yet when contracted left scarcely a trace of the openings through which they were protruded from the common Polypary. As such I remembered *Pennatula*, *Lobularia*, *Halcyonium* and similar forms, in which I had frequently observed, that in the skin of the animal existed calcareous particles, which on the contraction of the skin so completely closed the opening as to render it no longer perceptible. Renewed examination of the closed surface of the cells of the *Nautilus Orbiculus*, Forskål, now showed to me that in them also dendritic calcareous particles exist, the close approximation of which closes the cell, so that the cover of the cell is in fact the dried skin of the animalcule. I now made an experiment in proof, by dissolving the small shell in dilute muriatic acid, in order to obtain the animal body in a free state; and it succeeded perfectly. I obtained as many animalcular bodies as there were cells, connected together by band-like processes, and in the interior of many of them there were well-preserved siliceous Infusoria. I then treated in the same manner the *Flustra pilosa* and *F. membranacea* of the Baltic, and found in their interior also siliceous Infusoria. The same results followed a similar examination

of the shells of *Rotalia* from the sand of Rimini, of the shells of *Peneroplis planatus*, *Pavonina Antillarum*, and of *Orbiculina numismalis* from the sea-sand of St. Domingo, as well as of other shells with their animals from the sand of the Red Sea and the Mediterranean; so that now a view is obtained of the more general organization of the principal groups of the Polythalamia.

It results clearly from what has been said in respect of these species, which are so common and widely distributed, and which have hitherto been designated in systems as small Nautili, that the straight-jointed shells of Nodosaria (formerly viewed as Orthocera), as well as the spiral shells of Rotalia, Cristellaria, &c. (considered as Nautili or Ammonites), and the shells of Biloculina resembling vermiform tubes (*Serpula*), are none of them internal calcareous parts which were encased by an animal body, similar to the internal bone of Sepia, or the cylindrical spiral bone of Spirula; but, on the contrary, that they are external calcareous shells, bearing analogy to those of Mollusks, or more correctly to those of Flustra and Cellepora, which, after separation by an acid, disclose and render visibly free the internal simple body or the Polypary, exhibiting precisely the same form. If the shell of Polythalamia be frequently perforated with pores, this is no proof that no other openings exist, or that the animals receive nourishment through many tubes, for the same structure is not unfrequently found in Flustra accompanied with the peculiar opening from which the fore-part of the animal body may be protruded; and in these exist also fringe-like filaments, which are extensile and retractile, and by no means to be compared to the pseudopodia or variable feet of Amoeba, but probably bear analogy to the mantle fringes of many Mollusks, applicable to the purposes of creeping and attachment, and for which perhaps they were specially designed. Moreover, Flustra possess a distinct large animal organization; and the siliceous Infusoria, and probable eggs found in Polythalamia, clearly bespeak in them also similar relations, the discovery of which, however, had hitherto been prevented by the calcareous encasement and the minuteness of the objects.

It has resulted from the examination of the soft small animal bodies of living Polythalamia, that while many resemble Flustra or Eschara assembled in families or polyparies, each such family being often composed of hundreds of much minuter single animalcules, many others are single animals after the manner of Mollusks. Hence arise external characters and forms which have often a reference to very different relations, which it is first necessary to distinguish before we can succeed

in obtaining a clear view of the whole. The assiduous and careful labours of d'Orbigny retain their full value, serving as a basis to all future researches; and if in the present communications I shall have succeeded in turning the inquiry into a more physiological channel, my object will be attained.

To the term *Polythalamia*, (originally introduced by Dr. Breyn, of Danzig, in 1732,) a different extension or signification under other names has been given by different authors. To remove this unsteadiness and wanton change of names, which only lead to obscurity, it appears advisable to apply the term Polythalamia, in preference, as Soldani had done, to that group in which the animalcules actually live in many cells, and do not, like the Nautili, possess many empty cells. This distinction, that the animal of the Polythalamia has no empty cells, but that all its cells are simultaneously occupied, is of particular importance in their systematic arrangement among other animal bodies. Where there are many cells, they consist either of so many single animals, the whole constituting a polypary, or of organically filled integrant portions of one and the same individual forming groups. Both structures are foreign to the true Cephalopods. The shell-bearing Cephalopods may with Linnæus be divided into the *unilocular* and *multilocular*.

On the other hand, the want of a sipho which has been assigned as a character of Polythalamia, and from which they were named *Asiphonoidea* by De Haan, is incorrect, inasmuch as many really possess a part which may be fully compared to a sipho, if not in function, yet in form, namely, the tube which connects the separate cells of Nodosarina and of all individual many-celled forms. It is only in the *Miliolina* family among the simple Polythalamia, and it is only in the families of *Asterodiscina* and *Soritina* among those forming polyparies, that the want of a sipho is really necessary, because they live individually in single cells. But all the Nodosarina, Textularina, Uvellina, Rotalina, and Plicatilia among the simple Polythalamia, and the Frumentarina, Helicosorina, and Alveolinea among those which form polyparies, possess tubes of connexion between the cells, which very frequently resemble also in form the sipho of the Nautilus. D'Orbigny, it is true, states also that the cells of Foraminifers are connected by several openings; that, however, proceeds from an erroneous view, for such Polythalamia alone present several openings at the border of the cells, whose calcareous surface is interrupted in the form of a net-work, exhibiting often a relation analogous to that which is frequent in Madrepora and Astræa, in which the soft body is not divided or sharply cut off by com-

pact calcareous plates, but the soft parts appear interwoven with minute calcareous rods, in a lattice-like manner. These numerous small connecting openings, which are sometimes visible in some of the Rotalia and Rosalina, and also in the Textularia, I do not consider essential, but hold that the true channel of connexion has always a large diameter, and is simple for each single animal. The erroneous view of d'Orbigny and of all his followers becomes so complicated, that polyparies are held to be single animals, and consequently the various connecting openings to be those of a simple individual.

With respect to d'Orbigny's genus *Nummulina*, although it has derived advantage from his diligent investigations, I consider it as composed of very heterogeneous elements, which belong to quite different divisions of animals. Some species of the sub-genus *Assilina*, and perhaps all of them, may belong to the families *Soritina* and *Asterodiscina*, while the *Assilina nitida* of the Red Sea is assuredly Forskål's *Nautilus Orbiculus*, that is, *Sorites Orbiculus*.

I am of opinion that all those species which are provided with visible traces of mouths or openings, as in Lamarck's genus *Lenticulina* with d'Orbigny's character of Nummulina, are to be received among the Polythalamia; but that all such species as have the form of a lens or disc, and are provided with internal spiral cells, but without a trace of such mouths, the cells being moreover separated from the external surface by thick calcareous layers, are to be considered as internal bones. These mouthless Nummulina are rather to be ranged with the Velellida of the Acalepha along with *Porpita*, where similar internally cellular coin-shaped bones exist. The considerable size of many Nummulina is also striking and foreign to Polythalamia, but agrees very well with the family of the Velellida, as also in the want of traces of the attachment of muscles, and in the want of a sipho or channel of connexion between the cells. Until better informed, therefore, I decidedly exclude the mouthless Nummulina from the Polythalamia, and retain only Lamarck's Lenticulina in the sense attached to d'Orbigny's Nummulina in a young state.

The distinctive character of the Polythalamia, when compared with their nearest relatives the *Flustra*, *Eschara*, *Cristatella*, &c., consists in the shell, and in their freedom of motion. But with this may be combined the power of attaching itself to other bodies, just as in the *Cristatella* (or *Hydra* also) which often remains long attached, and then creeps again. Those bodies which are apparently Polythalamian, but are really adherent and immoveable, belong to the *Cellepora*, *Flustra*, *Tubulipora*, and similar forms. The simplest Poly-

thalamian form is the *Miliola* in Dujardin's sense, if there be really such self-existent animals, and they be not the young of others, or of many-celled forms most nearly related to Biloculina. And perhaps *Gromia oviformis* might be so viewed, should it not prove to be a *Difflugia* (an Infusoria). In this series I myself place provisionally, as doubtful, those numerous small globules of the sand of Rimini which have no distinct opening, or sometimes present a very minute one. The next simplest form is that of a simple straight row of cells, as in the *Nodosaria*, a jointed continued development of a simple body. *Textularina*, *Uvellina* and *Rotalina* (Lenticulina), may, as to external form, be viewed as Nodosarina developed in another manner, namely, in botryoidal or spiral forms.

I have here to make a remark that appears important. In the entire vast mass of known Polythalamia, a case or vestment prevails which is either cuticular or composed of a calcareous substance, while in Infusoria either a cuticular or siliceous substance prevails, so that hitherto no calcareous-shelled Infusoria nor siliceous-shelled Polythalamia had presented themselves. Yet among the fossil microscopic organisms of the chalk marl of Sicily, we find intermingled with the Infusoria shells bodies whose forms may be ranked with Polythalamia, namely, with Nodosarina, but the shells of which are siliceous, insoluble in acids, and which to the eye have a more transparent vitreous aspect than the calcareous shells when penetrated by balsam. I have hence been induced to place these siliceous-shelled forms, until a further knowledge may be acquired of their organization, among the polygastric Infusoria near the shelled Amoeba, in a separate family, under the name of *Arcellina composita*, or *Polycystina**. Such siliceous-shelled *Polycystina*, resembling calcareous-shelled Polythalamia, are the genera *Lithocampe*, *Cornutella* and *Haliomma*, with several species.

I wish here to draw attention to a small character hitherto unregarded, which is distinctive of true Polythalamia, and often even of their fragments. It consists in this, that in the tube or channel of connexion between the cells, the mouth of the tube which belongs to the earlier smaller cell is overgrown and surrounded by the succeeding larger cell. If the mouth of the last cell be prolonged in a beak-like form, we find in all the earlier smaller cells a distinct tube, quite similar to the hard remains of the sipho in the Nautilus; but so placed that the tube always projects forward from the smaller into the larger cell, and never backward from the larger into the smaller

* This view has been already indicated in the work "On the Infusoria as perfect organisms," 1838, p. 136.

cell. In the Nautilus, this projection of the tube of connexion is reversed, always proceeding from the larger to the smaller chamber, so that in the last, the greatest chamber, the body of the animal thus acquires a smooth foundation, upon which it can move more freely. In true Nautili also the base of the cells is concave or undulated in the forward direction, while in the Polythalamia it appears without exception to be either quite straight or convex in that direction. This character was also observed by Fichtel and Moll.

The tabular view which I have given of the Bryozoa, founded as it is on the new observations which I have made, is drawn up with special regard to a definite expression of fossil phænomena, the ancient names of d'Orbigny being mostly retained. This very diligent precursor in these studies first laid down a foundation rich in forms and systematically ordered, which may serve for all future investigations, and has given names to families which are well adapted to his purpose; but these I have been obliged to alter, yet not arbitrarily, inasmuch as from the difference of our views it became necessary to separate from each other the forms which constitute his families, according as they are either simple Polythalamia, or Polythalamia composing polyparies.

Since the foregoing pages were drawn out, a newer work by Dr. Ehrenberg has made its appearance, embracing communications made to the Berlin Academy, on the continued researches of the author between September 1839 and August 1840, and bearing the title, "On the numerous Living Species of Animals found in the Chalk Formation*." Of this very interesting publication I had designed presenting an abstract, but having learned that a complete English edition of the work is about to appear† accompanied by the engravings, I now confine myself to a few notices immediately connected with the preceding part of this paper.

In this memoir Dr. Ehrenberg repeats his objections to the views entertained by MM. Alcide d'Orbigny and Dujardin. It has been seen, that to the Polythalamia, whose minute and often microscopic calcareous shells compose in inconceivable numbers, and in now nearly 1000 known different forms, the principal mass of chalk rocks and of many sands of the sea, M. d'Orbigny had several years since ascribed an external animal bearing the form of a Sepia, the small shell itself, which

* *Ueber noch zahlreich jetzt-lebende Thierarten der Kreidebildung*, pp. 94, with four plates, Berlin, 1840.

† In the Scientific Memoirs of Mr. R. Taylor. Its publication cannot fail to prove very acceptable to British Naturalists in general.

often resembles an Ammonite or Nautilus, being considered as the internal bone. On the other hand, at a later period, M. Dujardin denied that these animals possessed any organic structure, stating that they consisted simply of an animated slime capable of extension, encased by an indurated external shell, and associating them with the pseudopodian Amoeba of the Infusoria. Dr. Ehrenberg now further demonstrates, by figures and descriptions, their true organic structure, thus fully establishing his former positions, both as to simple Polythalamia and Polythalamia forming Polyparies. He proves that they are not internal bones, but external shells encasing a soft body, the shell being perforated, as it were, in all parts by numerous pores, from which the animal projects long filaments, capable at will of extension, retraction and bifid division, and productive of locomotion. The author further observes: M. Dujardin has, in August 1840, presented to the Paris Academy a *Mémoire sur une Classification des Infusoires en rapport avec leur organisation*, in which a new arrangement of the Infusoria is exhibited, and in this the Polythalamia are again introduced as *Rhizopodes* in association with *Amoeba* and *Actinophrys* of the Infusoria, forming a separate family. If, however, anatomical and physiological details are to be taken into account when we proceed to the systematic arrangement of different organic bodies, and we are not governed merely by the relations of external forms, M. Dujardin's arrangement cannot be deemed a happy one. He has in no case shown a polygastric structure in the Rhizopodes, and that it is not polygastric is proved anew by my investigations now communicated.

It has been shown in a former part of this paper that Dr. Ehrenberg had recognized six species of Infusoria in the chalk formation, so closely resembling living species as not to be distinguished from them, and hence he was led to give to them the same names; namely, *Eunotia Zebra*, *Fragilaria rhabdosoma*, *Fragilaria striolata?*, *Gallionella aurichalca*, *Navicula ventricosa*, and *Synedra ulna*. He had also referred, with a mark of interrogation, the following four species of calcareous-shelled Polythalamia to the white chalk, in which they are very extensively distributed, namely, *Globigerina bulloides*, *Globigerina helicina*, *Rosalina globularis*, and *Textilaria aciculata*, all of which were stated by M. d'Orbigny to have occurred in the living state only in the Adriatic Sea and the Ocean. If any doubt had existed as to the identity of all these fossil and living species, it has been completely removed by the later researches of Dr. Ehrenberg, by which the actual number of known species found in the chalk formation and in

the living state has been extended to fifty-seven, namely, of calcareous-shelled Polythalamia nine species, and of siliceous-shelled Infusoria forty-eight species. The following is a list of these species and of the localities in which they occur, both in the living and fossil state. In the fossil localities, W. C. signifies white chalk, C. M. chalk marl, and C. C. compact chalk.

Calcareous-shelled Polythalamia.

	Living.	Fossil.
1. Globigerina bulloides	In the Adriatic Sea and the Ocean	W. C. Denmark.
2. —— helicina	——	W. C. Cattolica.
3. Rosalina globularis	——	W. C. Gravesend.
4. Planulina (Synon. Rotalia) ocellata	North Sea, near Cuxhaven	W. C. Cattolica.
5. Rotalia globulosa	——	W. C. in Russia, Poland, Prussia, Denmark, England, France and Sicily; and C. M. in Greece, Zante, Sicily and Oran.
6. —— stigma	——	W. C. Cattolica. C. M. Caltasinetta.
7. —— (Synon. Planulina?) turgida	——	W. C. England, France, Prussia, Denmark. C. M. Oran. C. C. Egypt and Arabia.
8. Textilaria aciculata	——, and Adriatic and the Ocean	W. C. Prussia, Denmark, England and Sicily. C. M. Greece. C. C. Egypt and Arabia.
9. —— globulosa	North Sea.	W. C. of all European countries, from Wolsk to Ireland. C. M. Sicily, Oran, and Greece. C. C. Egypt and Arabia.

Siliceous-shelled Infusoria.

10. Actinocyclus quinarius	North Sea, Tjörn Isle in the Cattegat	C. M. Caltasinetta.
11. —— biternarius	North Sea, Tjörn	C. M. Oran and Caltasinetta.
12. —— senarius	North Sea, Cuxhaven, Christiania, Tjörn	C. M. Oran, Caltasinetta, and Greece.
13. —— septenarius	North Sea in the Cattegat	C. M. Oran, Caltasinetta, and Zante.
14. —— octonarius	——	C. M. Oran and Caltasinetta.
15. —— nonarius	N. Sea, Cattegat near Tjörn.	C. M. Oran.
16. —— denarius	——	C. M. Oran.
17. —— undenarius	——, and Bay of Christiania.	C. M. Oran and Zante.
18. —— bisenarius	Cattegat near Tjörn	C. M. Oran.
19. —— quindenarius	——	C. M. Oran.
20. Amphitetras antediluviana	——	C. M. Oran and Greece

	Living.	Fossil.
21. Biddulphia pulchella.	Baltic, N. Sea, Mediterranean, and Ocean near Cuba	C. M. Greece.
22. Cocconema lanceolatum	Brackish and fresh waters.	C. M. Greece.
23. Coscinodiscus Argus.	North Sea, Cuxhaven . .	C. M. Caltasinetta and Oran.
24. —— eccentricus . . .	——————, Tjörn in Cattegat, and Mexican Gulf, Vera Cruz.	C. M. Oran.
25. —— lineatus	North Sea, Cuxhaven . .	C. M. Caltasinetta.
26. —— minor	—————— . .	C.M. Caltasinetta, Oran, and Zante.
27. —— Oculus Iridis . .	—————— . .	C. M. Greece.
28. —— Patina	—————— . .	C. M. Zante.
29. —— radiatus	——————, and Baltic, Wismar. . . .	C. M. Oran, Caltasinetta, and Zante.
30. Dictyocha sulcata . .	North Sea near Tjörn . .	C. M. Caltasinetta, Oran, Zante, and Greece.
31. —— Fibula	N. Sea, Christiania and Tjörn, & Baltic, Wismar	C. M. Oran and Caltasinetta.
32. —— Pentasterias . .	N. Sea, Christiania haven.	C. M. Zante.
33. —— Speculum . . .	N. Sea, Cuxhaven, Christiania and Tjörn, Baltic, near Kiel	C. M. Caltasinetta, Oran, Zante, and Greece.
34. Eunotia granulata . .	Brackish and fresh waters.	C. M. Greece.
35. —— Zebra	Berlin fresh waters. . . .	C. M. Greece.
36. Fragilaria rhabdosoma	Berlin, Halle, Copenhagen, Sweden	W. C. Gravesend.
37. —— striolata	. . . . .	W. C. Gravesend.
38. Gallionella aurichalca	Berlin fresh waters, Leipzig, Thuringia, Franconia, Würzburg, Stuttgart, and on rocks near the Faroe Isles	W. C. Rügen.
39. —— sulcata	North Sea, Cuxhaven . .	C. M. Caltasinetta, Oran, Zante, and Greece.
40. Grammatophora africana	N. Sea, Heligoland, Tjörn	C. M. Oran.
41. —— angulosa	North Sea, Tjörn	C. M. Oran.
42. —— oceanica	Callao in Peru, Vera Cruz in Mexico, Tjörn in Cattegat, Wismar in Baltic, and the Mediterranean.	C. M. Oran.
43. —— undulata	Among marine Confervæ near Vera Cruz.	C. M. Greece.
44. Haliomma radians . .	North Sea, Cuxhaven . .	C. M. Greece.
45. Navicula Didymus. .	N. Sea, Cuxhaven, Baltic, Wismar.	C. M. Caltasinetta.
46. —— Entomon	N. Sea, Christiania haven.	C. M. Greece.
47. —— norwegica . . .	——————	C. M. Greece.
48. —— quadrifasciata .	——————, and Tjörn Isle.	C. M. Greece.
49. —— ventricosa	Paris, Berlin, Saxony, Bohemia, Buchtarma in Altai, and Irtysch.	C. M. Oran.
50. —— viridula	Berlin fresh waters, Weissenfels in Saxony, and Wismar in Mecklenburg.	C. M. Greece.

	Living.	Fossil.
51. Peridinium pyrophorum	Baltic, near Kiel	Flints of the W. C. near Gravesend, and Flints of the plain of North Germany near Delitzsch.
52. Striatella arcuata . . .	Gulf of Flensburg, Breakers near Gothenburg.	C. M. Oran.
53. Synedra ulna	Baltic near Wismar, Berlin fresh waters, North of Germany, Denmark, Scotland, Holland, the Ural, and perhaps Isle of France, and Mascarene Isles	C. M. Oran.
54. Tessella Catena . . .	Breakers near Gothenburg and Berlin waters.	C. M. Caltasinetta.
55. Triceratium Favus . .	North Sea, Cuxhaven . .	C. M. Greece.
56. Xanthidium furcatum	Berlin	Flints of W. C. Gravesend, and Flints of Delitzsch.
57. —— hirsutum	Peat waters near Berlin.	Flints of W. C. Gravesend, and Flints of Delitzsch.

Of these fifty-seven species, thirty belong to the geologically acknowledged chalk and its Sicilian marls. The remainder from Oran, Greece (probably Egina), and Zante, though perhaps from beds not equally well defined by relative position as chalk marls, yet occurring, as they do, with numerous decided calcareous and siliceous animals of the chalk,—the geological relations of these species may also be considered as firmly established.

These new discoveries naturally lead to the conclusion that we have now no very definite boundary between secondary and tertiary tracts, and that the first dawn or eocene period of the present living organic creation, must be sought for deeper than the chalk formation; a view that appears to be confirmed by the occurrence of a living *Trochus* below the chalk, of the *Paludina vivipara* and *Cyclas cornea* in the Weald Clay, and of the *Terebratula caput serpentis* in the Upper Oolite. But as this and other interesting conclusions and views entertained by the author will be shortly laid open to the reader, with a full detail of the progressive researches made, I shall not now enter further upon the important matter contained in the volume.

Appendix.

Closely connected with the preceding subjects is the valuable Memoir of M. Alcide d'Orbigny, which has recently appeared, entitled, "On the Foraminifers of the White Chalk of the Paris Basin*." The subjoined extracts may serve to convey a view of the general scope of the work, which, placed in parallel with that of Dr. Ehrenberg, cannot but excite a double interest in the mind of the reader.

Previously to entering upon the direct object of the Memoir, M. d'Orbigny indulges in a few general reflections.

Let us, says the author, cast a rapid glance upon what has existed and upon what still exists in nature, in reference to the Foraminifers. We have found them distributed through the oolite series, extending from the lias to the uppermost beds; but in the cretaceous system they appear still more numerously and more varied in their forms. The Neocomian beds, those of the gault and the green sand, contain many; but in proportion as we ascend from the lower to the higher strata, they increase infinitely. In these latter the rock may be said to be often composed of them, and, as an example, we may mention the largest of the Pyramids of Egypt. In the white chalk the number is nearly as great as in those seas in which they now most abound. In a word, we have found Foraminifers in the cretaceous basins of the Seine, the Loire, the Gironde, and of the whole South of France, and in Belgium.

If we pass to the tertiary tracts, a whole world is opened to us. The multiplied Foraminifers which appear in the basins of Paris, Bourdeaux, Touraine, Italy, Austria, Germany, England, and Belgium, often form there the greater part of the mass. A bed of considerable thickness in the environs of Gentilly, near Paris, is entirely composed of them, the Foraminifers being in contact with each other, scarcely united by a slight cement. In a cubical inch of the rock we have found *fifty-eight thousand*, which is equal to *three thousand millions* in a metre, and shows what myriads may exist in the Paris basin. These small bodies, which we thus see forming entire beds in the lowest portions of the tertiary series, are not less common in the higher stages; for in Austria, and

* *Mémoire sur les Foraminifères de la Craie Blanche du Basin de Paris*, in the 4th vol. part 1 of the Transactions of the Geological Society of France, 1840.

in the environs of Sienna in Italy, they often constitute one-sixth of the fossil mass; they are also extensively distributed in the Crag of England* and of Belgium. So much in reference to what has existed; let us now throw a glance upon that which exists.

We are in the present day acquainted with Foraminifers from every region of the sea, and we know that they exist in extent from the equator to the frozen portions of continents. If we judge of the important part they play by their numbers in certain quarters, it will be impossible to doubt that their remains form the greater part of the banks of sand which impede navigation, obstruct gulfs and straits, fill up ports, and form with corals those isles which are daily rising in warm regions from the bosom of the ocean.

Thus these minute shells, which, anterior to our epoch, have assisted in leveling basins of immense extent, and in forming mountains, are now still constantly changing the depth of coasts and modifying the bottom. This view of their agency in nature is doubtless sufficient to prove the importance which attaches to their study.

We will add, that the comparative study of the fossil Foraminifers of all beds has proved to us a fact important to geology, namely, that each bed has its characteristic species, which serve to distinguish it, let the circumstances be what they may; and as these minute shells are infinitely more com mon than those of Mollusks, the knowledge to be derived from them is so much the more certain, and becomes extremely interesting.

Another fact no less curious has been demonstrated to us by the study of living species from every region of the globe†. Many genera are peculiar to the hottest zones of continents, while others, on the contrary, are found only in temperate or cold regions. Hence the geographical distribution of living genera and species offers to us a means of comparison of the highest importance with a view to the determination of the temperature of the waters in which fossil species lived,

* Mr. Lyell has communicated to us the species which he discovered in the Crag.

† We are acquainted at present with nearly *fifteen hundred* living and fossil species of Foraminifers; and how many important facts may be derived from the study of these small bodies may be seen in three works which we are now publishing: 1. the Fauna of the Antilles, printed in *l'Histoire politique, physique, et naturelle de l'Ile de Cuba*, by M. de la Sagra; 2. that of the Canaries, published in *l'Histoire Naturelle* of those islands, by MM. Webb and Berthelot; 3. the Fauna of the southern extremity of America, forming a part of our *Voyage dans l'Amérique Méridionale.*

and may lead to very satisfactory results in geology, if we may judge by the fruits of our observations in this respect.

We could have desired to establish some general facts of much greater extent, founded on new observations recently made by us on the class of the Foraminifers; but the present occasion not admitting such an extension, let us pass to the Foraminifers of the white chalk of the Paris basin.

The geological position of the white chalk of Paris is so well known that we have not thought it necessary to speak of it; yet, if we seek to determine its position relatively to the other cretaceous beds by means of the Foraminifers it contains, compared with living species, the *facies* of the genera and species proves to us, that the chalk of Maestricht, of Fauquemont (Belgium), of Tours, of Chavagne, and of Vendome, is above it; while, on the contrary, all the other beds are below it; thus in the chalk of Maestricht and the upper beds of the basins of the Loire, we recognize only genera still existing, or at least occurring in tertiary tracts, while the white chalk of the Paris basin already exhibits to us different genera, such as *Flabellina*, *Verneuilina*, and *Gaudryina*, and a great number of species quite distinct.

It would therefore be easy to establish, by means of the Foraminifers alone, the relative antiquity of the cretaceous beds; but we must previously make two geographical sections quite independent of each other, founded on the zoological forms; the first comprising the entire basin of the Seine, of the Loire, of Belgium, and of England, in which we find a striking analogy between the species found in all the beds, from the lowest to the highest, with a regular passage from one to the other; the second, comprising the West and South of France, in which the species of Foraminifers have not only no analogy with those of the other section, but in which, moreover, almost all the genera are different. If we seek an example of this fact, we shall find it on comparing the green sand of the environs of Mans with that of the mouth of the Charente. The first, which in fact contains species approximating to those of the white chalk of Paris, contains already several species analogous to those which have lived up to that bed; while the second, with perfectly distinct species, presents to us genera different from all that we know in the cretaceous beds of the North of France and of Belgium.

The Foraminifers are sufficient to establish the following descending order of superposition in the cretaceous beds :—

Group of the North of France and of Belgium.	*Group of the West and South of France.*
Upper chalk of Maestricht and Fauquemont (Belgium).	
Coral chalk of Valognes and Nehou.	
Coral chalk of the basin of the Loire, at Vendome (Loir and Cher), at Chavagne (Maine and Loire), at Tours (Indre and Loire).	
White chalk of Ciply (Belgium).	
White chalk of Paris, of the departments of Yonne and Aube, and of England.	
	Nummulite chalk of Royan (Charente Inférieure), of Saint Martory (Haute Garonne), of Saint Gaudens, &c.
	Coral chalk of Saintes (Charente Inférieure).
Chalk marl of the Loire, with *Gryphæa columba*.	Ammonite chalk of Martrous, near Rochefort (with *Gryphæa columba*).
	Caprine chalk of the Isle of Aix, of the Corbières (Aude).
Green sand of Mans (Sarthe).	Green sand of Fouras, of the Isle of Aix, and Corbières.
Gault of the environs of Troyes (Aube).	
Neocomian tract of Aube.	

To establish zoologically what we have advanced, let us pass in review the succession of the genera, and endeavour to convey an idea of the modifications which have taken place in the Foraminifers of the cretaceous system, in the ascending order of the beds.

At the epoch of the Neocomian formation we have hitherto found only the genus *Textularia*.

The green sand presents, as we have said, two series of genera nearly distinct. That of the mouth of the Charente contains the genera *Dentalina*, *Cristellaria*, *Lituola*, *Alveolina*, *Chrysalidina*, and *Cuneolina*; that of Mans, the genera *Dentalina*, *Citharina*, *Frondicularia*, *Flabellina*, *Cristellaria*, *Bulimina*, and *Guttulina*. Hence we see, that, with the exception of two genera common to both localities, all the rest are different in each of them.

If we follow our examination of the succession of genera in the cretaceous groups of the South and the North, we shall find—

1. That in the South the same genera of the green sand are reproduced in the Caprine chalk. By degrees they prevail at length in the upper beds, and are reduced to the *Cristellaria* alone in the environs of Saintes; but near the mouth of the Gironde (at Royan) they are accompanied by the genera *Nummulina* and *Guttulina*, as well as on the whole line of the foot of the Pyrenees, at Saint Martory, at Saint Gaudens, extending into the department of Aude; thus pre-

senting a zone well characterized by the abundance of Nummulina, of which we have not found the analogue in the cretaceous beds of the North of France.

2. That in the North the succession is far from taking place in the same manner; and that the Foraminifers, in much greater numbers, present a larger suite in superposition, with facts not less curious. The genus *Citharina*, which constitutes the greatest portion of the species in the oolite formation, ceases with the green sand of Mans, being found no further in the cretaceous beds. In the chalk marl of the banks of the Loire we meet for the first time with the genus *Lituola* with the *Dentalina*; but all at once, in the white chalk, we observe a great number of species, among which, with all the genera and even some analogous species of the green sand of Mans, there appear for the first time on the globe the genera *Nodosaria*, *Marginulina*, *Valvulina*, *Rotalina*, *Rosalina*, *Truncatulina*, *Uvigerina*, *Verneuilina*, *Gaudryina*, *Globigerina*, *Pyrulina*, *Sagrina*, *Flabellina*, and *Frondicularia*. These genera contain a considerable number of species; but with the white chalk the genus *Flabellina* ceases, which had continued hitherto from the green sand, and the genera *Verneuilina* and *Gaudryina*, which first appear in the white chalk, also terminate with it; while in its interior the Frondicularia abound, as well as species whose cells form a pile on a single line.

The white chalk of Ciply, although contemporaneous with that of the Paris basin, since it also contains Flabellina, does not present the same species, and may perhaps be a little higher in the series, but we have not as yet sufficient data to enable us to affirm this fact.

In the beds which we consider higher in the series than the white chalk of Paris, namely, in the coral chalk of Tours, of Chavagne, and of Vendome, we meet for the first time with the genera *Polystomella*, *Polymorphina* and *Globulina*, yet accompanied with the same genera as those of the white chalk, with the exception of those whose discontinuance we have noticed; again, in the upper chalk of Maestricht and Fauquemont we have, with the three genera just mentioned, also the genera *Nonionina*, *Faujasina*, and *Heterostegina*. All are found living at present, or at least occurring in tertiary tracts; but we arrive at the last beds of the cretaceous group without having seen a single species of the *Miliola* of Lamarck (our order of Agathistègues), which, as we ascertained in 1825, only commences with the tertiary beds, and may be considered as the most certain sign of a change of formation.

This rapid survey shows that in ascending from the lower

to the higher beds of the cretaceous group, the genera and species of Foraminifers progressively increase, and that the forms, at first very simple, analogous to those of oolitic tracts, afterwards more complicated and specially appropriate to the lower beds of the cretaceous system, have at last been replaced in the upper parts by forms still more varied, the whole recurring in tertiary tracts, and even in the living state; facts which it has appeared to us important to establish in the history of Palæontology.

M. A. d'Orbigny then proceeds to describe the species of Foraminifers found by him in the white chalk of the Paris basin. The following is a list of them, together with their localities:—

	Localities.
1. Nodosaria limbata	Meudon: very rare.
2. Dentalina aculeata	Common at Sens: more rare at Meudon and in England.
3. ——— communis	Meudon: rare. Its analogue is found fossil in the Subapennine tracts of Italy and Austria, and living in the Adriatic.
4. ——— gracilis	At Sens and in England.
5. ——— nodosa	Common at Sens, more rare at Meudon and St. Germain.
6. ——— Lorneiana	Only in the environs of Sens.
7. ——— sulcata	Very common at Sens, Meudon, and St. Germain, and in the chalk of England. Found also in the green sand of the environs of Mans (Sarthe).
8. ——— multicostata	Sens, St. Germain: rare. Also at Maestricht rarely.
9. Marginulina trilobata	Common at Sens, very rare at Meudon, St. Germain, and in England: found only in the young state.
10. ——— compressa	Meudon: very rare. Occurs also in the green sand in the environs of Mans.
11. ——— elongata	Common near Sens, very rare at Meudon and St. Germain. Occurs also in the chalk of Ciply.
12. ——— gradata	Only near Sens.
13. ——— raricosta	Meudon: very rare.
14. Frondicularia radiata	Meudon and St. Germain: very rare.
15. ——— elegans	Meudon and Sens: very rare.
16. ——— Verneuiliana	Common at Sens, on the banks of the Yonne; rare at St. Germain and Meudon.
17. ——— Archiaciana	Meudon and Sens: rare.
18. ——— ornata	Found only once at Meudon.
19. ——— tricarinata	Environs of Sens: seems to be rare.
20. ——— angulosa	Meudon: very rare.
21. Flabellina rugosa	Sens and Meudon: common.
22. ——— Baudouiniana	Only at Sens.
23. ——— pulchra	Meudon: very rare.
24. Cristellaria rotulata	Very common in the white chalk of Meudon, St. Germain, Sens, and in England. Occurs also in the green sand near Mans.
25. ——— navicula	Sens and Meudon: rare.
26. ——— triangularis	Sens: very rare.
27. ——— recta	Meudon and St. Germain: rather rare.

	Localities.
28. Cristellaria Gaudryana	Only at St Germain: rare.
29. Lituola nautiloidea	Very common at Sens in the complete state, at St. Germain only young, and adult very rarely at Meudon. Occurs also in the chalk of England.
30. Rotalina Voltziana	Very common at Meudon, St. Germain, and in England.
31. ——— Micheliniana	Common at St. Germain, Meudon, and in England; rare at Sens.
32. ——— umbilicata	Common at Meudon and St. Germain; rare at Sens and in England; common also in the tertiary tracts of Austria. Its analogue is found living at Rimini in the Adriatic, there being no difference between the fossil and living species.
33. ——— crassa	St. Germain, Meudon, and England: rather rare.
34. ——— Cordieriana	St. Germain, England, and upper chalk of Maestricht.
35. Globigerina cretacea	St. Germain and England.
36. ——— elevata	Common near Sens; rare in England.
37. Truncatulina Beaumontiana	Meudon and England: rare.
38. Rosalina Lorneiana	Common at St. Germain and Meudon; rare at Sens and in England.
39. ——— Clementiana	Rare at St. Germain, more common in England.
40. Valvulina gibbosa	St. Germain: rare.
41. Verneuilina tricarinata	St. Germain and Sens: rather rare.
42. Bulimina obtusa	Very common at Meudon; rare at St. Germain and in England.
43. ——— obliqua	Very common at Meudon, St. Germain, Sens, and in England.
44. ——— variabilis	Very common at Sens; rare at Meudon, St. Germain, and in England.
45. ——— brevis	Very common at Meudon, St. Germain, and Sens.
46. ——— Murchisoniana	St. Germain and England: rare.
47. Uvigerina tricarinata	Sens: very rare.
48. Pyrulina acuminata	Very rare at Sens and St. Germain; very common at Meudon.
49. Gaudryina rugosa	Meudon, St. Germain, and Sens: rather common.
50. ——— pupoides	Rather common at Meudon, Sens, St. Germain, and in England.
51. Textularia trochus	Only at Meudon.
52. ——— turris	Sens, Meudon, St. Germain, and England, without being common.
53. ——— Baudouiniana	St. Germain and Meudon: rare.
54. Sagrina rugosa	St. Germain and Meudon.

From the preceding list it appears, that of the fifty-four species found in the white chalk of the Paris basin, *thirty-eight* occur at Meudon, *thirty-three* at Saint Germain, and *twenty-eight* at Sens: of these numbers, *nine* are peculiar to Meudon, *two* to Saint Germain, and *six* to Sens, while all the others are simultaneously common to two or three localities, thus proving the perfect identity of the beds. It will be seen also, that of these fifty-four species, *twenty-two* are common to the white chalk of England also.

Of the fifty-four species, *seven* occur also in lower or higher beds: thus in the green sand of Mans are found three species, *Dentalina sulcata*, *Marginulina compressa*, and *Cristellaria rotulata*; in the coral chalk of Tours, which is higher in position than the white chalk, two species, *Bulimina obtusa* and *Textularia turris*; and in the chalk of Maestricht, being the highest in position, two species, *Dentalina multicostata* and *Rotalina Cordieriana*. We also find two species, the analogues of which occur both fossil in the tertiary tracts of Austria and Italy, and in the living state in the Adriatic, namely, *Dentalina communis* and *Rotalina umbilicata*. With these exceptions there still remain *forty-seven* species peculiar to the white chalk, showing clearly that it forms a bed distinct from all the rest of the cretaceous system, belonging to a small local fauna well-defined.

On comparing the above genera given by M. d'Orbigny with those named by Dr. Ehrenberg in his tabular view of the Bryozoa, inserted in the early part of this paper, it will be seen that Nodosaria, Dentalina, Marginulina, Frondicularia are included in the family of the Nodosarina of the latter author; Cristellaria, Rotalina, Truncatulina, included in his family of the Rotalina; Globigerina, Rosalina, Valvulina, Bulimina, Uvigerina, Pyrulina, in his family of the Uvellina; and Textularia in his family of the Textularina. The *Lituola nautiloidea* of Lamarck and d'Orbigny is the *Coscinospira nautiloides* of Ehrenberg, included in the Fabularina family of the latter.

If we now, observes M. d'Orbigny, compare the fauna of the Foraminifers of the white chalk with those of different seas, with a view of determining the analogy of composition, and of obtaining data respecting the temperature of that basin at the time when these species lived, we shall find this analogy more striking in the Adriatic Sea than anywhere else. There only, the same as in the chalk, are found in abundance Nodosaria, Dentalina, Marginulina, Frondicularia; there only occur a considerable number of species of Bulimina. This sea alone in the present day contains living Frondicularia; of Frondicularia so varied in the white chalk; and, to complete the approximation, it exhibits to us the only two living species, the analogues of which are found in the fossil state in the white chalk, namely, *Dentalina communis* and *Rotalina umbilicata*. This analogy of zoological forms would lead us to believe, 1st, that the basin in which is deposited the white chalk of Paris was subject to a warm temperature; 2nd, that it was circumscribed, protected from waves and from every violent current proceeding from a distance, since the bodies

are deposited there without having experienced the slightest wearing previous to their becoming fossil; 3rd and lastly, that it extended to the whole of the white chalk of England.

Concluding Remarks.

The preceding extracts from the labours of Dr. Ehrenberg and M. A. d'Orbigny show that microscopic Polythalamia are found in all calcareous formations from the lias upward; but in England they have been lately discovered in still deeper strata. Mr. Tennant was, I understand, the first to announce their discovery in 1839 in the mountain limestone of England. In 1840 they were also met with in the Kendal limestone, from which Mr. Lonsdale has prepared thin slices mounted on glass, which appear transparent under a strong light, exhibiting the crowded state of the microscopic Polythalamia in great perfection. Mr. Bowerbank also has been led to turn his attention to this subject by examining the siliceous bodies of the chalk, green sand, and oolites*.

I had written thus far, when an interesting article by the Rev. Dr. Buckland, in reference to the researches of Dr. Ehrenberg up to 1839, met my eye, entitled, "On the agency of Animalcules in the formation of Limestone†," which notices in particular the researches of MM. Tennant and Darker on this subject in the Derbyshire limestone and the Stonesfield slate, as well as the labours of Mr. Bowerbank, referred to above, and conveying judicious reflections. Dr. Buckland justly remarks, that in the application of the microscope from the living to the fossil Infusoria and Foraminifers we are commencing a new and important era in Palæontology. A very interesting branch of the inquiry will be to ascertain whether these microscopic bodies retain throughout a distinctive character in the several formations into whose composition they enter. In the unbounded field of nature presented to the consideration of the Microscopical Society of London lately established, no subject appears more worthy of their attention than an examination of the microscopic organic constituents of all the older limestone formations of the British Isles, as well as of other countries; and it is much to be desired that this attention may not be wanting, although the concurrence of many labourers may be required to reap a harvest of great promise, yet of indefinite extent.

* Proceedings of the Geological Society, March 11, 1840.

† Edinburgh New Philosophical Journal, January to April, 1841.