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ON THE

RECENT FORAMINIFERA

OF

GREAT BRITAIN.

BY

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TO

MR. JOHN WILLIAMSON,

OF SCARBOROUGH.

My dear Father,

There is no one to whom I can so fitly dedicate this volume as to you. From my earliest childhood you strove to inspire me with the love of Nature; your industrious example encouraged me to her study, both in the field and in the closet; whilst your early self-denial enabled me to follow the pursuits in which you had taught me to delight. That you may long live to reap where you have sown, is the affectionate hope of

Your grateful son,

THE AUTHOR.

Manchester; *April 26th*, 1858.

INTRODUCTION.

When I first contemplated the preparation of a Monograph on the British Foraminifera, I proposed appending to it a general history of this class of objects; reviewing the various modifications of their structure, their zoological affinities, and their geological history. The Council of the Ray Society have thought it desirable that these subjects should be more elaborated than could be done in the introduction to a monograph, and they have consequently intrusted my friend Dr. Carpenter with the preparation of a separate volume, embracing the entire history of the Foraminifera. In such competent hands the work cannot fail to become a valuable addition to English scientific literature. When it appears, though following the present volume in order of publication, Dr. Carpenter's publication will be the true introduction to mine. Such an introduction is essential to a large number of students; for, though of late years many inquirers have paid special attention to these minute creatures, it is surprising how much ignorance still exists respecting their philosophy and general affinities; an ignorance that reflects itself in most of the works that have been devoted to their classification and description.

Being thus relieved from a laborious though pleasant duty, I need only examine such questions as specially relate to our British forms of these organisms. On one or two points I may appear to trench upon the domain of my fellow-labourer, but shall not do so further than is essential to elucidate the conclusions announced in the subsequent pages, and to a comprehension of the descriptions.

The earliest British writer in whose works I have discovered any notice of the Foraminifera, is Hooke, the father of microscopical science in this country. In his 'Micographia,' published in 1665, he figures a single specimen, apparently of a Rotalia, which he found in some sea-sand. This figure is copied in the 'Micrographia Illustrata' of the elder Adams (1747). No further progress was made until the time of Mr. Boys, the well-known conchologist, whose labours converted Sandwich Bay into classic ground. His discoveries amongst minute shells led to the publication of the 'Testacea Minuta Rariora,' for which work the drawings were made by Mr. George Walker, an intelligent bookseller at Faversham, whilst the well-known Edward Jacob wrote the descriptions.[1] The volume contained thirty-six figures of Foraminifera, divided into

[1] No date is attached to this work, but the copy in the library of Mr. J. G. Jeffreys, with the use of which I have long been favoured, and which was originally in the possession of Dr. Turton,

twenty-two supposed species; but the descriptions are very brief, rarely exceeding half a dozen words, and though the twelfth and thirteenth editions of Linnæus's 'Systema Natura' had appeared, containing both descriptions and binomial designations for the Linnean forms, Walker avoided assigning trivial names to his objects, "through fear of giving such as might any way interfere with those already given by Linnæus to shells of the same kind."[1] The fact that subsequent conchologists have usually ascribed to Walker several of the specific names now employed, requires a word in explanation. In 1787, George Adams the younger published his volume of 'Essays on the Microscope.' A second edition of this work, with considerable additions and improvements, appeared in 1798, edited by Frederic Kanmacher, who introduced into this edition Walker's figures of the Foraminifera, and appended to them generic and specific names in accordance with the binomial plan of Linnæus. These names were chiefly modifications of prominent terms selected from Walker's, or rather Jacob's, brief descriptions; for example, the *Nautilus subarcuatus geniculis exertis* of the latter became the *Nautilus subarcuatulus* of Adams. These facts would lead us to ascribe the names usually given to the more common British Foraminifera to Adams, rather than to the authors of the 'Testacea Minuta Rariora;' but my kind friend Dr. Gray has called my attention to a note on p. 344 of Dillwyn's 'Catalogue of Recent Shells,' where, under the head of *Nautilus lobatulus*, the author observes, "It first appeared with the present name in the 'Essays on the Microscope,' and Adams there says he had obtained a manuscript corrected copy of the minute shells, to which Walker had added all the trivial names." "This," as Dr. Gray observes to me in a recent communication, "sets the matter at rest, why they are quoted as Walker's."

Pulteney's 'Dorsetshire Catalogue' (1800) merely enumerates a few previously known forms met with on the Dorsetshire coast, whilst Turton's edition of the 'Systema Naturæ" (1800-6) was only enriched by the addition of what had already appeared in Kanmacher's edition of Adams's 'Essays.'

The appearance of Montagu's 'Testacea Britannica' in 1803, and the Supplement in 1808, marked a new era in the study of the British Foraminifera. Not only were several new forms added to the list, but improved figures and more elaborate descriptions were substituted for the imperfect ones hitherto published. In the first of these publications the difficulty of defining the limits of specific variation obviously dawned upon the mind of the author; and in describing his *Vermiculum intortum*,[2] he distinctly states, that "this is so variable in its formation that, without great attention, it might be formed into several species"—a warning that might have been received with advantage by many of Montagu's successors in the study of the Foraminifera. Shortly after the appearance of Montagu's first volume, the publication of the 'Testacea Microscopica' of Fichtel and Moll indicated that these accurate observers had obtained further light respecting the variableness of many of the Foraminifera; a fact especially demonstrated by their descrip-

contains the manuscript date of May 1st, 1784. That this was the date of publication is rendered increasingly probable by the fact that the copy in the library of the British Museum, which formerly belonged to Sir Joseph Banks, contains a manuscript letter from Jacobs to Sir Joseph, written to accompany the two copies of the work that Walker sent to the worthy baronet. The letter is dated May 2d, 1784. For this fact I am indebted to Dr. Gray, of the British Museum.

[1] 'Test. Minut. Rar. Introduction,' p. 5.

[2] *Miliolina seminulum* of the present work.

tion of *Nautilus calcar*;[1] but notwithstanding his previous experience, when publishing his 'Supplement' Montagu was unable to follow these authors in their accurate determinations. "If," he remarks, speaking of the numerous forms of *N. calcar* delineated by those writers, "these can be admitted as the same species, we may bid defiance to specific definition." Nevertheless, Fichtel and Moll were, in all probability, right.

The conclusion of the labours of Montagu was followed by a long period in which the study made little further progress, notwithstanding the numerous writers on British conchology who presented their works to the public. The 'Transactions of the Linnean Society' for 1807 contains a memoir by Dr. Maton and the Rev. Thomas Rackett, entitled, 'A Descriptive Catalogue of the British Testacea;' but so far as related to the Foraminifera, this was merely a reprint of what had been published by previous authors, with the addition of a few new localities. One significant passage presents itself in this memoir; speaking of *Serpula seminulum*, *subrotunda*, *oblonga*, and *bicornis*,[2] the authors observe, "We may be permitted to express our doubts whether the last four Serpulæ ought not to be considered rather as varieties than as distinct species. Their form is very irregular and variable, and it is scarcely possible to give any permanent characters by which they may be satisfactorily discriminated."[3] Turton's edition of the 'Systema Naturæ' (1800-6), and his 'Conchological Dictionary,' were mere compilations. The first edition of Brown's 'Illustrations of Conchology' (1827) contributed little that was new to the study of the Foraminifera; and the same remark applies to Dr. Fleming's 'History of British Animals' (1828). The former writer only adds two varieties to those already known, but the latter introduces some valuable alterations in the distribution of the various species of Walker and Montagu, enlarging the number of genera.

Previous to the appearance of Dr. Fleming's work, my friend Mr. J. G. Jeffreys had commenced the study of the British Foraminifera, and collected numerous varieties unnoticed by previous writers. He presented a memoir to the Linnean Society, in 1828, containing figures and descriptions of all the British and Irish forms in his fine collection, which memoir the society ordered to be published; but being temporarily withdrawn by the author for further revision, its publication never took place. About the same time, Dr. Turton appears to have become aware of the defective state of the subject, and striven to remedy it. Mr. J. Alder, of Newcastle, has placed in my hands Turton's manuscript of a monograph on the Polythalamia, dated 1832, which, like that of Mr. Jeffreys, was never published; but which, unlike the production of the latter conchologist, takes no cognisance of the numerous undescribed forms then existing in several British cabinets. Its scope is limited to the rearrangement, on a very mechanical plan, of the species already described.

In 1843 appeared the little volume by Professor Macgillivray, on the 'Molluscous Animals of Aberdeen,' containing descriptions of what the author thought to be several new species; but which prove, with one exception, to be merely varieties of such as had been already described. That exception is a Textillaria, the first *published* record by a British writer of that interesting genus. The species had been already recorded in Mr. Jeffreys's memoir in 1828. On one point Dr. Macgillivray's book advanced a step on the works of his predecessors, since he applied to British species the generic names of M. D'Orbigny, which no British writer had hitherto done.

[1] *Cristellaria Calcar.*

[2] *Miliolina seminulum, trigonula,* and *bicornis,* of this work.

[3] Loc. cit., p. 246.

From the above outline it will be seen that the study of the British Foraminifera made little real progress during more than thirty years subsequent to the publication of Montagu's classic works. Collecting the commoner varieties amongst the branching roots of the Laminariæ, as well as the fossil forms of the Calcaire Grossière, had been one of the amusements of my boyhood; and my attention was more recently drawn to the subject by Ehrenberg's wondrous discovery that chalk chiefly consisted of the aggregated shells of Foraminifera; and by some sands from a post-pliocene deposit at Boston, in Lincolnshire, supplied to me by the late Mr. Rackett, abounding in Lagenæ and other Foraminifera. The conviction resulting from the study of the latter specimens, that all existing works on this subject were replete with imperfections, led me to investigate anew the natural history of the Microzoa that had played so marvellous a part in the economy of the pre-Adamite world. In 1847, I ventured to publish my monograph on the British species of the genus Lagena, basing my classification on a principle of which Montagu, Maton and Rackett, and Fichtel and Moll had already obtained faint glimpses, viz., that amongst the Foraminifera the widest variations of form and aspect were compatible with specific identity. Hence I united numerous varieties hitherto regarded as specifically distinct. I fear that, at the time of their publication, my conclusions found few practical conchologists who were prepared to indorse them; but prolonged inquiry has satisfied me that, instead of advancing too far in this new path, I stopped short of the truth—a conclusion which has received irresistible confirmation from the investigations of my valued fellow-labourer, Dr. Carpenter, as well as from those of Messrs. Parker and Jones, published in their memoir on the 'Foraminifera of Norway.'

Since the publication of my monograph on the Lagenæ, several memoirs on the subject have appeared in various British works; but these have chiefly related to the histology and physiology of the Foraminifera, and not to their generic or specific distinctions. But these memoirs have tended to influence the systematic study of the objects in a very important manner, since they have tended to demonstrate that previous writers, both at home and abroad, were wholly in the dark on several fundamental points affecting the classification of the Foraminifera. Before dilating further on this subject, it is desirable to glance at the important labours of a few continental naturalists who have done much to advance the study of the Polythalamia.

The abundance of these objects in the Adriatic early attracted the attention of the Italian conchologists, and during the first half of the eighteenth century the writings of Beccarius, Planchus, Gualteri, and Ginnani had laid the foundations of their systematic study. But the most remarkable of these writers was unquestionably the Abbé Soldani, whose large works, with their profuse illustrations, are monuments of industry and enthusiasm. At the same time, nothing can be worse than his attempts at the discrimination of species. Plate after plate is crowded with figures merely representing varieties of one protean form,[1] every modification in the diversified arrangements of the segments entitling the specimen, in the Abbé's opinion, to the immortality conferred by pen and pencil.

Fichtel and Moll (1803) were observers of a different stamp. As already pointed out, they clearly discerned the wide variations of form which some species of these animals displayed, and it would have been well if subsequent observers had derived more profit from their labours. In 1804, Lamarck did good service by delineating with great accuracy the leading forms abounding in the older Tertiary strata around Paris; but he was soon followed by Denys de Montfort (1808),

[1] See his 'Test. et Zoot. parv. et Micros.,' tab. lxx to lxxxvi.

whose bad figures and worse philosophy again added to the confusion of the subject. Pursuing a course diametrically opposed to that indicated by Fichtel and Moll, he not only erected mere varieties into species, but even genera. Out of a single species[1] he constructed at least nine such genera, and other types received similar treatment.

In 1826 a writer entered the field who, though in some respects treading in the footsteps of his predecessors, has nevertheless left the impress of his earlier labours on this subject in abiding characters. The 'Tableau Méthodique' of M. D'Orbigny (1826) was the first successful attempt to reduce the chaotic materials accumulated by his predecessors to something like order; and we owe very much to the French naturalist for his establishment of generic groups, many of which have found, and will doubtless continue to find, general acceptance. At the same time, M. D'Orbigny has, more than any other naturalist, needlessly multiplied the number of species. Indeed nothing can well be more complete than the way in which he has ignored the difficulties attendant on this part of the question. The memoir referred to contains little more than an arrangement of the Cephalopoda, of which class the Foraminifera were then thought to be members, with definitions of the genera and lists of species and localities, but it constituted the basis of his more detailed future labours, in all which varieties have been made into species with reckless indifference to the innumerable inosculating forms. Had these intermediate varieties been fairly examined, the difficulty of locating them would have revealed to M. D'Orbigny the imperfections of his system. As it is, new species have been created for each prominent variety; but against this plan all the results of recent and more philosophic researches constitute one unvarying protest. M. Blainville, in his various publications, pursued a course in relation to species equally fallacious with that of M. D'Orbigny; and, misled by these guides, most of the modern conchologists, depending upon mere modifications of external contour as sufficing to distinguish species, have fallen into the same errors.

The revolution which the study has undergone within the last few years, and to which reference has already been made, has resulted from the careful study of the histological features and development of these objects. M. Dujardin (1835) led the way in exploding the previously received fallacy that the Foraminifera were Cephalopodous molluscs; demonstrating their low organization and their affinity with the animals generally comprehended under the designation of Rhizopoda. The conclusions at which I had arrived in the case of the Lagenæ have been further confirmed and elucidated by Dr. Carpenter in several able memoirs published in the 'Philosophical Transactions.' It may now be regarded as an established truth, that most of the external features on which both earlier and later writers relied for distinguishing their species, possess but little value. The direction of growth in these shells, and the sculpturing of their exteriors, are alike influenced both by age and local circumstances; hence a dissimilarity between the different stages in the development of the same individual such as finds few parallels amongst the mollusca with which conchologists have so long identified them.

What amount of variation is compatible with specific unity, is perhaps the most important inquiry now engaging the attention of philosophic zoologists; and the reply to this query must be the common postulate of many philosophical syllogisms. No satisfactory response to the question has yet been given, even by the higher organisms; still less by those diversified inferior creatures whose histories present so much that is anomalous and obscure. It is from amongst these latter,

[1] *Cristellaria calcar.*

in all probability, that the most important materials for solving the problem must finally be drawn; but these are precisely the objects whose history is most difficult to read, from the impossibility of tracing their infinitesimal germs through all their conditions of life and development. In the case of the Rhizopoda this difficulty is further increased by our entire ignorance of these germs; we have not yet learnt to recognise them when they meet our eyes. Hence, in the absence of direct knowledge, we can only concentrate such faint rays as gleam through the darkness, and thus try to obtain some glimpses into this obscure recess of nature's domain.

Nothing is easier than to throw the Foraminifera obtained by dredging over some limited area into defined groups, each of which has apparently a specific value. But as we extend our researches to more distant localities, new and intermediate forms perplex our minds as to what are the same and what different species. Long before our dredging-net has swept round the British coasts, we find that what was already difficult trenches upon the impossible; and when we test our results, by applying them to collections made in remote parts of the globe, we become convinced that the limited amount of our present information makes that impossibility absolute. The more extensive our experience, the weaker become our convictions respecting the limits of variation in any species. Examples abound which we are unable to locate with confidence; and we are at length tempted to believe that amongst the Foraminifera specific distinctions have no existence. This is not, however, the conclusion at which I have arrived: I should rather infer that the hard shells of the Foraminifera do not constitute a sufficiently constant and important element in their organization to justify our trusting to them as guides in the discrimination of species. They appear to be a variable feature, like the hair amongst human beings, or the changing contours of a protean Amæba. That species exist amongst the Foraminifera as elsewhere, analogy would, of course, lead us to infer; but I believe there are several actual indications of the fact, more substantial than what can be supplied by mere analogy. But we have hitherto failed to detect the real specific peculiarities, or even to ascertain in what part of the living organism they are likely to be found. As yet they are but unseen potentialities, of which the eye has hitherto been unable to detect any concrete or objective manifestation; and I strongly suspect that the remark is equally applicable to the entire group of the Rhizopoda as to the Foraminifera.

I have observed that we can detect a few stray gleams illumining this obscure subject. The existence of some definite relationship between the outward forms of successive generations is indicated by the frequent prevalence of special varieties in particular localities. Thus the remarkable variety of Polymorphina, represented in fig. 149, prevails at Southport, in Lancashire, and also near the Eddystone Lighthouse and Plymouth Sound; the probability is that in each locality these examples are the common products of some ancestral individuals, amongst which acquired peculiarities of contour have been hereditarily transmitted. Be that as it may, the study of specimens, both from our own coasts and foreign stations, satisfies me that there exists amongst the Foraminifera a strong tendency to the perpetuation of certain unvarying types of form; and the similar occurrence of many existing varieties in a fossil state demonstrates that this tendency has operated through countless ages. But, side by side with this disposition to constancy of form, we have the opposite one to endless differentiation. Whence do these diverse tendencies originate, and what circumstances are essential to their free operation?

In another part of this volume (pp. 19 and 20) I have called attention to the specimens represented by figures 32*a*, 41*a*, and 49, as indicating the existence of spontaneous fission amongst the soft animals of the Foraminifera. In each of these examples there appears to have

been an abortive attempt at division of the uncalcified germ, which attempt the premature supervention of the calcifying process has arrested. Whenever such specimens occur *it invariably happens that the two halves of the twin organism belong to the same variety or type.* It is fair to conclude that if the spontaneous fission had not been arrested, but the germ had effected its division into two parts prior to calcification, both of these, when calcified, would have retained their identity of form just as they have done when linked together. Whether these germs were merely unimpregnated gemmiparous products, or whether they have resulted from the union of a germ-cell and a sperm-cell, cannot now be determined, though probably both these processes will ultimately be demonstrated to exist amongst the Rhizopoda. The former of these is merely a modification of true spontaneous fission; being but a small portion of the organism pinched off, in the place of its being divided into two nearly equal halves. The specimens just referred to indicate that *fission tends to repetition of identical types and not to differentiation;* hence I am disposed to believe that the origin of varieties of Foraminifera must not be sought amongst non-sexual fissiparous products any more than a florist would seek corresponding varieties amongst the slips and cuttings from older plants. Analogy renders it probable that some equivalents for true ova exist amongst these creatures; if so, we might expect to find the tendency to differentiation commencing amongst these ova, just as new varieties of flowers result from varied potentialities hidden within the different seeds of individual plants. This hypothesis is perfectly compatible with the fact that the same individual Foraminifer often undergoes important changes in its progress to maturity, the newer segments differing from the older ones; we must here carefully distinguish between true primary variations and those merely dependent on age and unequal development. The tendency to such ultimate differentiation in each individual resided potentially in each primary embryo; but this tendency must be distinguished from the variations between different individuals, *the sum of which variables, whether potential or actual, constitute the characteristics of the species distinguishing it from all other species.*

It follows from the preceding remarks that though in the descriptive portions of this volume I have employed the machinery of binomial classification, I have only done so provisionally as a useful mode of indicating special types of form. At the same time there are, as already remarked, more than merely analogical reasons for concluding that species have an existence here, notwithstanding the bewildering gradations of form which tempt to an opposite belief. The materials of which the shells are composed suggest such a conclusion. On this point the Foraminifera vary. In one group, to which the majority of the Miliolæ belong, the shell consists of an opaque calcareous substance having a porcelainous aspect, and presenting, when seen by transmitted light, a rich brown or amber colour. Such varieties are rarely if ever foraminated.

In a second group, the calcareous shell when young is transparent and glassy (hyaline). When advanced growth has thickened and rendered it semi-opaque, light transmitted through it retains its white hue, instead of becoming yellow or brown as in the last example.

A third group differs wholly from the preceding two. The shells composing it consist of agglutinated grains of sand, but little, if any lime entering into their composition; the sand is apparently bound together by some animal secretion which boiling solutions of caustic potass do not destroy though they render the substance more brittle.

Such differences in the chemical and histological composition of these shells probably indicate corellate physiological differences in the living sarcode, or secreting animal substance, that have at least a specific value. I have not met with one fact contravening this idea. No examples

have occurred to me in which the same *form* of shell has indifferently presented the arenaceous, porcelainous, and hyaline textures. Should further investigation sustain this conclusion it will afford a starting point whence to proceed in our further search for real specific distinctions.

It follows that if the preceding observations are accurate, little value can be attached to the Foraminifera either in determining the relations between zoological provinces or in identifying stratified deposits, since the most diverse forms may have had a common origin and present specific unity; at the same time it appears probable that *identity of form* more certainly indicates unity of species than *diversity* does the opposite. Hence when we find in Portsmouth Bay a shell[1] that is undistinguishable from one abounding in the older Tertiary strata of Belgium,[2] we may infer that the object in question has lived through the Tertiary period, surviving catastrophes and changes of external conditions that have proved fatal to most of its early companions in life. On the other hand it is unsafe to conclude that deposits existing at different localities belong to different epochs, because very distinct varieties of Nummulites abound in each, since these distinctions may be quite compatible with specific identity; in a word, the positive evidence may have value, whilst that which is but negative is valueless.

Localities and Modes of Collection.

A pocket lens of moderate power usually enables us to discover Foraminifera in *shelly* sand from any part of our coasts, but these are usually worn and imperfect specimens. The common sand of our beaches is rarely productive in any degree. The home of these objects is in the deeper parts of the ocean, commencing with the coralline zone of Forbes where there is always a few fathoms of water though a few occur in the shallower Laminarian zone, especially towards its outer border. In the latter instance they are to be found amongst the interlacing roots of the Laminariæ, and especially amongst the tufts of corallines with which those roots are so frequently surrounded. How far their habitat extends into deeper water we have as yet no means of determining, since it is difficult to say whether the shells brought up from such vast depths in the middle of the Atlantic[3] were living or dead at the time they were collected. The same remark applies to the majority of the specimens that have been forwarded to me by my dredging friends. I have found such numerous examples of corallines with the sessile Foraminifera abounding upon them as clearly prove that they both lived on the same ground. The Foraminifera do not appear to affect districts where the ocean bed consists of gravel or coarse clean sand, but prefer localities where there is much fine-grained oozy sediment. This especially applies to the more delicate, minuter varieties.

The method of obtaining specimens must vary according to the object in view; if the collector merely seeks dried shells for his cabinet, indifferent whether living or dead, the process of floating them is by far the most productive. A few pints of the sand must be collected from

[1] *Nummulina planulata.*

[2] 'On the Tertiary Strata of Belgium and French Flanders,' by Sir Charles Lyell, 'Quart. Jour. Geol. Soc. Lond.,' vol. viii, 1852.

[3] See 'Dr. Bailey's Memoir in the Smithsonian Contributions,' vol. ii, 1851.

beneath, at least, two or three fathoms depth of water, and thoroughly dried; it should then be passed through a coarse conchologist's sieve, or through a piece of coarse net so as to eliminate all the rough material. The finer portions passed through the sieve must be poured into a bowl containing cold water, and well stirred up, so that the whole may become saturated. On being allowed to stand a few moments the more delicate of the concamerated shells, rendered buoyant by the air contained within their chambers, readily float to the surface, whilst the sand and mud settle to the bottom.[1] A little manipulation enables the collector to blow off this scum, so rich in treasures, into an empty vessel, and the addition of fresh water further cleanses the objects from impurity; the *creaming* of the bowl being repeated so long as any sediment or impurity remains. The water may now be drawn off by means of a syphon, and the objects dried, when they are easily collected for examination. I have found it desirable to carry the process a stage further before drying the shells, in order to obtain the cleanest specimens: sweeping them off the moist sides of the bowl by means of the forefinger I transfer them to a small evaporating dish containing a solution of caustic potass,[2] in which I allow them to boil over a spirit-lamp for some moments, thus dissolving the organic matter and leaving the calcareous shells free from impurity. The moment the lamp is removed the shells settle to the bottom of the vessel, since the fluid has filled all the chambers of each shell, displacing the air. The solution must now be poured off, and the shelly residue be well washed in clean water; otherwise drying will leave an efflorescence of alkaline matter on the specimens, marring their beauty. After washing they may be dried, when they are ready for examination.

The advantage of the process here recommended lies in the facility with which very unproductive sands are made to yield their tribute of specimens. I have often obtained but a few hundreds of shells from several pints of sand. It is obvious that the examination of such large quantities of material under the microscope, would involve a labour which the results would not repay; but the above operation effects the purpose in a few minutes. At the same time it is only the smaller and more delicate objects that can be thus collected. The larger and heavier ones sink to the bottom of the water along with the refuse sediment: by placing the *wet* sand on a flat plate or dish, and gently shaking it, the shells rise to its surface, where they are readily discovered by means of a pocket-lens. The superfluous water should first be drawn off, with as little disturbance as possible, and the sand dried, otherwise the glistening moisture interferes with the search.

When specimens are wanted in a living state an entirely different process must be adopted. On parts of the coast where the sand is coarse and gravelly there is nothing for it but dredging up the smaller corallines and seaweeds, and picking out the specimens one by one; but where the sea-bottom is muddy and fine-grained the process applied by Mr. Warrington to the oyster-ooze of Faversham is the best. It is just the reverse of the floating process just recommended, since the chambers of the shells are occupied by animal sarcode; consequently they cannot be rendered buoyant. The mud is put into a vessel containing water and well stirred up. The fine inorganic particles are floated off, whilst the shells, from their greater density and larger size, sink to the bottom; a repetition of the washings leaving them perfectly clean.

[1] Care must be taken at this stage to break up the air-bubbles floating on the surface, since these buoy up numerous inorganic particles which require to be precipitated.

[2] The Liq. Potassæ, P.L., is a convenient form for this purpose.

Relation of the British types to those of other Zoological provinces.

Amongst objects so little amenable to the influence of climate as the Foraminifera appear to be we cannot expect to find numerous definite facts bearing upon the question of zoological provinces. So many of the forms have a world-wide range, that it becomes difficult to obtain from them trustworthy evidence of any value. We cannot compare the British Foraminifera with those of the Mediterranean and the West Indies on the one hand, and those of the Norwegian coast brought to light by Messrs. Jones and Parker on the other, without seeing that the former belong to a northern rather than a southern province. At least thirty-five out of forty-six figures given by those authors in their second plate[1] are those of English varieties. But the fact that the Cassidulinæ, Buliminæ, Uvigerinæ, and Lagenæ, so abundant on the northern shores of these islands, also occur with great frequency amongst the sub-tropical shells of many Tertiary strata, indicates how little reliance is to be placed on them as witnesses in any moot question relating to climate and physical conditions. Nevertheless, the absence of Orbiculina and Amphistegina, and the great rarity of Peneroplis and Vertebralina, contrasted with their abundance in more tropical seas, indicates a difference between the tropical and polar areas. So far as England is concerned, this difference equally prevailed in the Pleistocene and newer Pleiocene epochs. The highly interesting deposit underlying some of the fenny districts of Norfolk and Cambridgeshire corresponds closely in the entire absence of the genera just referred to, with those now accumulating in our seas; whilst the discovery of some of these tropical types in the Coralline Crag of Sutton and Sudbourne by Messrs. Searles Wood and Rupert Jones, shows that their disappearance was coeval with that glacial irruption which effected so many changes in the British Fauna.

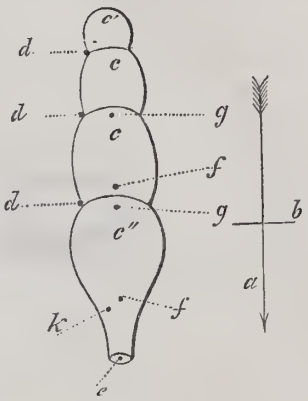
Descriptive terms.

The varying modes of growth prevailing amongst the Foraminifera, often render the recognition of homologous portions of these animals somewhat difficult; hence it is desirable to define the sense in which I have applied numerous terms, in the descriptive text, to the various types of form. By first adapting these terms to one of the simpler examples, and then tracing their application to others which gradually become more complex in organization, we shall be enabled to maintain consistency in their use. In the former case the task is easy, in the latter it becomes less so; but even in these, isolation of the soft animal by decalcification removes much of the difficulty. In all our British species decalcification by means of dilute hydrochloric acid separates the animal substance, or *sarcode*, as a continuous chain of segments connected together by constricted necks or stolons. Being soft and pliant, these can easily be stretched out in a straight linear series, when they become readily comparable with the simple type seen in a Nodosaria. Commencing with one of the latter (Lign. 1), consisting of four segments, the *length* corresponds with the axis or direction of growth, as indicated by the arrow, *a*,[2] and the *breadth* with a line, *b*,

[1] 'Annals and Mag. Nat. Hist.,' ser. 2, vol. xix, pl. xi.

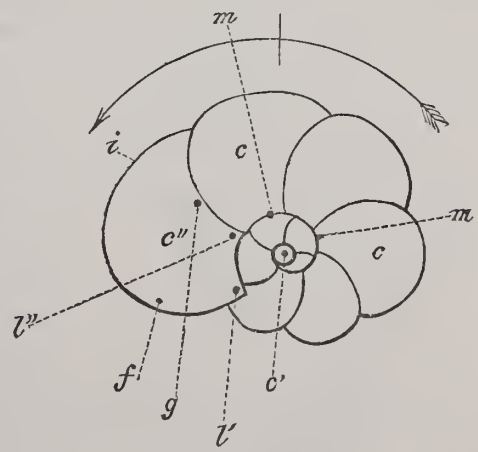
[2] Care has been taken that in all the illustrative diagrams the same letters indicate homologous parts.

at right angles to the former one. The shell is transversely divided into the four *segments*, *c'*, *c*, *c*, and *c''*, of which *c'* is the *primordial* one, being the immediate product of the gemmule or ovum from which the individual originated, and from which all the succeeding segments are gemmations; *c''* is the *ultimate* or last-formed segment. These segments are separated from each other by *septa*, or partitions, usually indicated externally by more or less deep constrictions, or *septal lines* (*d*); these being sometimes converted by age into raised ridges. The superficial area of each septum, corresponding in dimensions with the entire breadth of the constricted part of the shell, is the *septal plane* (*k*).[1] The part of the anterior surface of each ultimate segment which would be hidden by the growth of an additional segment, would by such growth become converted into a septum; hence, whether so hidden or not, the term *septal plane* is applied to it. The shape of each septal plane indicates the shape of a transverse section of the contiguous segments; and it is especially in reference to this point that the term is used in the text of this monograph. Each septum is perforated by one or more *septal apertures* (*e*), which establish a communication between the interiors of contiguous segments. These have usually been termed "oral" apertures by previous writers; but as this term indicates a higher organization and more complete specialisation of functions than appears to prevail amongst these Microzoa, I have preferred applying to them the designation of septal apertures. Each segment has an *anterior* (*f*) and a *posterior* (*g*) *margin*. The former term is applied to that part of the external surface of each segment which is nearest to the ultimate segment, and the latter to the side nearest the primordial one. The terms have thus a direct reference to the direction of growth, rather than to actual relations of position; a fact to be remembered in connection with their practical application to spiral shells.



Lign. 1.

Tab. 2, figs. 34, 37, and 41, represent what I have designated the *anterior aspect* of these straight types, in which we look down upon the septal plane of the ultimate segment. Figs. 33, 38, and 40, represent the *lateral aspects* of the same forms. But it sometimes happens that the shell is compressed, as in figs. 33—35, presenting two opposed flat surfaces and a thin peripheral margin; when the shell is viewed in the direction of the latter, as in figs. 35 and 59, I have employed the term *periphero-lateral* to indicate the aspect.

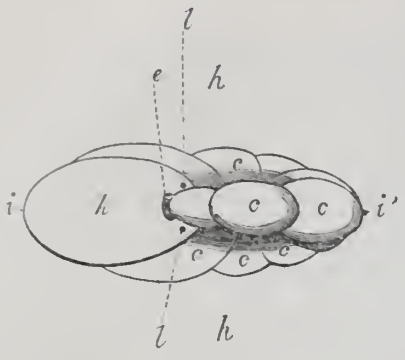


Lign. 2.

Passing from the straight Nodosaria, through the Dentalinæ in which the axis of growth is slightly curved, to the simple varieties of Cristellariæ in which it is still more inflected, we are conducted to the spiral equilateral types of shells termed Nautiloid (Lign. 2 and 3), in which the chain of segments is wound round the primordial segment in an unvarying horizontal

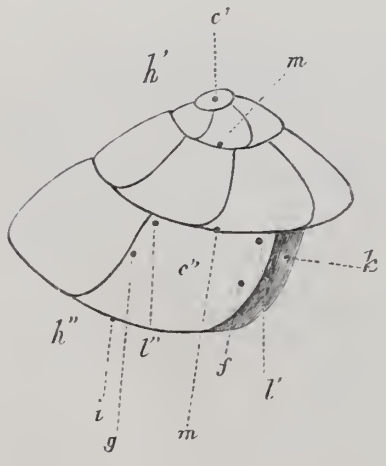
[1] The oral plane of Fichtel and Moll.

plane; those forming each complete circuit of the shell constituting a *convolution*. Here the bent arrow again indicates the axis of growth, which is now a spiral one; and the letters indicate homologous parts with those of Lign. 1; but the spiral nautiloid form involves the use of additional terms. Thus we have two similar *lateral surfaces* (*h*), one of which is represented in the entire superficies of Lign. 2, and both in the two sides of Lign. 3; which latter represents the same shell as Lign. 2, turned on its edge. The entire outline of Lign. 2, and the points *i*, *i'* of Lign. 3, represent the *peripheral margin*. As the outermost convolution usually embraces the preceding one, it follows that the septal plane becomes either heart-shaped (cordate) or arrow-shaped (sagittate), according as the peripheral margin is rounded, or thin and angular. The point *i*, in Lign. 3, indicates the *peripheral angle* of the septal plane, and *l l* the *umbilical angles* of the same, because directed towards the centre of each lateral surface occupied by the primordial segment, where there is very frequently a depression or *umbilicus*. When viewed laterally, each segment has a *peripheral margin* (Lign. 2 *i*), an *anterior margin* (2 *f*), a *posterior margin* (2 *g*), an *anterior umbilical angle* (2 *l'*), and a *posterior umbilical angle* (2 *l''*). The spiral line marking the external junction of contiguous convolutions I have designated the *spiral suture* (2 *m*).



Lign. 3.

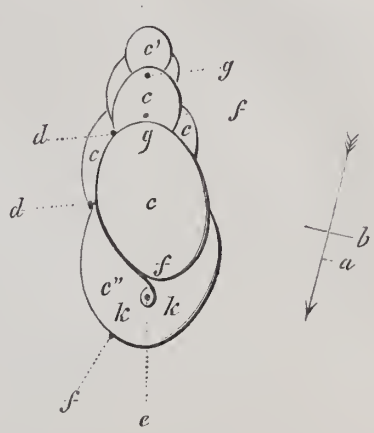
But we often find these spiral growths to be inequilateral; the chain of segments, instead of being coiled in the plane of the primordial segment, are developed on one side of it, constituting the *Trochoid* form of growth. The equilateral and inequilateral conditions may be illustrated by a coiled watch-spring; the former representing the spring in its normal position; the latter, when its inner extremity, occupying the position of the primordial segment, is drawn up, converting a flat spiral into a pyramidal one. The terms already employed continue applicable; but we now require to distinguish between the two lateral surfaces. The primordial segment (*c'*) usually occupies the apex of each trochoid form (*see* figs. 101, 103, and 104); and to the lateral surface on which this segment appears may be assigned the term *superior* (Lign. 4 *h'*); whilst the opposite one, or that in the direction of which the animal is extending its growth (*see* figs. 102 and 105), may be designated the *inferior lateral surface* (Lign. 4 *h''*). There are a few exceptional cases, as, for example, the British Truncatulinæ (figs. 121, 122, 123), and the foreign genus Faugasina, which simply represent an equilateral or nautiloid shell cut in half, the intersection being in the plane of the centre of the primordial segment. Hence, the surface in the centre of which the primordial segment appears, instead of being conical, is flat (fig. 121); whilst the opposite one, in which the animal is extending itself (fig. 122), is more or less conical; the former being that by which the animal attaches itself to other bodies. Notwithstanding the apparent incongruity of applying the term *superior* to a surface which in the living creature is so obviously *inferior*, I have not thought it desirable to disturb the general application of these



Lign. 4.

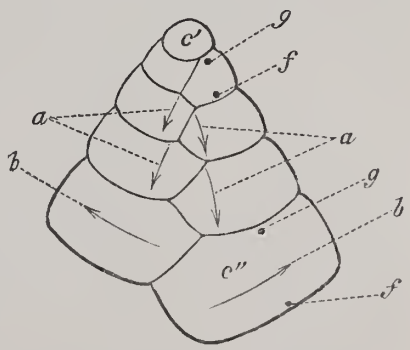
terms to meet so exceptional a case. As Mr. Darwin informs us that all the Balani and Lepades stand on their heads, a few of our Foraminifera may be allowed an analogous privilege.

But the equilateral spiral shells may also be viewed in the direction of their peripheral margins, as in Lign. 3, and in figs. 53 and 69. The term *peripheral* suggests itself as applicable to this aspect; but we have already employed that of *periphero-lateral* to designate the homologous view of the compressed straight forms: and as the spiral contour now assumed by the shell does not affect these primary relationships, I have applied the latter term to the same aspect whether the organism is straight or convoluted. In the inequilateral forms the aspect represented in Lign. 4, and in figs. 92 and 103, is the same as in those just described.



Lign. 5.

On passing from the above pyramidal types to the more elongated ones of Uvigerina and Bulimina, we require to bear in mind that, notwithstanding their peculiar contours, the latter are really trochoid shells. The spiral arrangement, especially obvious in figs. 134 and 135, is traceable in all, only there are fewer segments in each convolution than occurs amongst the Rosalinæ and Rotalinæ. The peculiar positions occupied by the septal apertures of these types render it somewhat difficult to maintain strict unity in the employment of terms: but the difficulty materially diminishes if we remember that the axis of each segment is coincident with its line of growth, as indicated by the relative positions of the septal orifices entering and emerging from the segment. In the genera referred to, this ideal segmental axis is nearly coincident with the common, long axis of the shell, but having a slight obliquity, as indicated by the arrow, Lign. 5 *a*; of course the spiral growth of the organism causes the direction of this obliquity to vary with each newly added segment; the movement being one analogous to the nutation of the earth's axis. Hence *f* becomes the anterior margin of each segment; *g* the posterior one; and the line *b*, intersecting the arrow, represents the transverse diameter of the last-formed segment; the extremity of the ideal nutating axis, around which the whole chain is wound, representing the umbilical region.

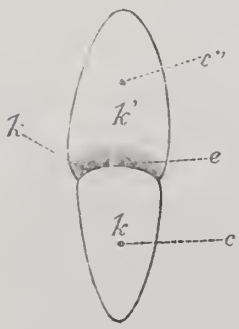


Lign. 6.

In Bulimina the segments usually tend to an arrangement in three oblique longitudinal rows. The transition from this type to *Textularia*, in which there are but two such rows, is furnished by the genus Verneuilina (of which no British examples have hitherto been discovered), and by the variety of Bulimina represented in figs. 129 and 130. The genus Verneuilina combines the symmetrical arrangement of Textularia, only having the segments in three series instead of two, with the spiral dispositions of a perfectly trochoid shell. The Bulimina belongs to a genus already shown to develop spirally, but in which the segments are in two vertically disposed series, as in Textularia. It follows that figs. 159, 160, and 162 respectively represent peripheral aspects, corresponding with Lign. 3 and 5. In Lign. 6 the arrows *a* indicate the length, and the transverse ones, *b*, the breadth of the respective segments; *f* being the anterior, and *g* the posterior margin of each. Lign. 7, representing the broad extremity of Lign. 6 seen in front, corresponds with figs.

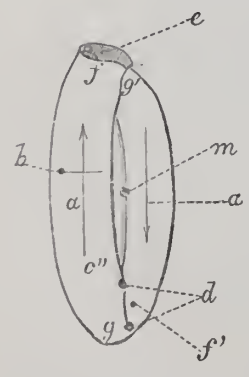
91, 94, and 102, of the trochoid types, being the *inferior* lateral surface; whilst the opposite extremity, supposing the position of the shell to be inverted, would correspond with figs. 90, 93, and 101, and become the *superior* lateral surface.

According to the definition already given, the term *septal plane* only denotes that part of each segment concealed by the next in order of development. Hence, amongst the Textulariæ, the application of the term should, strictly speaking, be limited to the deltoid portion seen in the upper part of figs. 159, 163, and 167, and in the centre of which the septal orifice is located. This portion is indicated by the undulating line running through the middle of Lign. 6, and by the shaded surface *k* in Lign. 7; but on the addition of a *third* segment, not only is this true septal plane of the *second* one enclosed, but also a part of the shell of the *first* segment, which the second had failed to invest. Thus each septum separating contiguous segments consists of two very distinct parts, viz., that separating it from the next developed segment, and that dividing it from the next but one. These two parts are shown in Lign. 7, where the addition of another segment would conceal the true septal plane, *k*, but leave uncovered the flat surface, *k'*, whilst it would hide the corresponding surface of the antepenultimate segment, *c*. In describing the Textulariæ and their allies, I have included *both* these continuous surfaces in the term *septal plane*, to avoid employing needless technicalities.



Lign. 7.

Amongst many of the Miliolæ it becomes impossible to recognise special aspects in conformity with the definitions already given. In numerous examples (figs. 180, 182, 183, 190) the plane of growth is a revolving one. Supposing a central axis to pass through the primordial segment, the new segments bear the same relations to it that the lines of longitude do to the axis of a terrestrial globe. They wind around the axis in a direction approximately parallel to it, but in planes that successively intersect one another. Hence the terms superior and inferior cannot be applied to the lateral aspects of these shells. But, in other examples, as in Spiroloculina (figs. 177, 178, 179), no such difficulties occur. The surface exhibited by fig. 177, in the centre of which is the spherical primordial segment, corresponds with that seen in fig. 74; and the plane of growth is the same for all the segments, instead of being a revolving one. But all the other terms employed are applicable to individual segments amongst the Miliolæ. Thus, in Lign. 8, the direction of the arrow *a* indicates the length, and *b* the breadth of each segment; *f* is its interior, and *g* its posterior border; as in this case each segment extends the entire length of the organism, the ultimate one, *c''*, being always the longest of the series, it follows that the septal aperture, *e*, alternately appears at opposite extremities of the shell. Hence the directions termed anterior and posterior become reversed in contiguous segments, as at *f*, *g*, and *f'*, *g'*. Owing to the large size of the septal aperture in shells of this type, as compared with the diameter of each segment, the septal plane is scarcely an appreciable one.



Lign. 8.

The feature which I have termed the *coronal* is a circle of radiating grooves surrounding the septal aperture. It only occurs in those forms in which that aperture is single; especially appearing in Entosolenia, Dentalina, Cristellaria, and Polymorphina.

Classification.

It will be seen that I have made no attempt to group the genera into classes or orders, as has been done by preceding writers. All such attempts hitherto made have been utterly worthless, because based on features upon which no reliance can be placed. Whether or not the time has arrived for propounding any less objectionable system of classification may well be thought doubtful, but unquestionably none more unphilosophical than that of M. D'Orbigny can be suggested, since in it mere varieties of the same shell continually require to be placed in different sections. As the present work refers only to a limited number of types, I have thought it best, for the present, merely to bring into juxtaposition those genera that bear the closest resemblance to one another, hoping that my fellow-labourer, Dr. Carpenter, dealing, as he will in his forthcoming volume, with the entire question, may succeed in propounding some more philosophical classification than has hitherto been published.

It now only remains that I should acknowledge my great obligations to numerous friends for the aid they have afforded me in preparing this monograph. To Mr. C. Clough, of Southport; Mr. Hyndman, of Belfast; Mr. J. Williamson, of Scarborough; Mr. J. Alder, of Newcastle; the late Dr. Fleming, of Edinburgh; Mrs. Brett, of Tenby; Mr. Spence Bate, of Plymouth; Professor Patterson, of Belfast; the Rev. Mr. Chalmers, of Whitehaven; and Mr. W. Kane, of Exmouth, I am indebted for supplies of dredged sand from their respective localities, with which at my request they so kindly furnished me. Mr. Brightwell, of Norwich, furnished me with interesting specimens of sand brought from the polar seas by Dr. Sutherland. My lamented friend, the late Professor Bailey, of New York, continually supplied me with rich materials from the Western hemisphere. Miss Macgillivray, through the intercession of Professor Dickie, obligingly intrusted me with the Foraminifera from her father's collection, for the purpose of accurately ascertaining the forms Dr. Macgillivray had in view when he established what he regarded as several new species. Mr. William Bean, of Scarborough, and Mr. Searles Wood and Mr. Parker, of London, afforded me every facility for examining their valuable collections; abundant specimens and papers have equally been placed at my disposal by the indefatigable officer of the London Geological Society, Mr. Rupert Jones; and Dr. Gray, of the British Museum, merits my warmest thanks for the unwearied courtesy with which he has given me the benefit of his rich stores of zoological information. But there are two gentlemen to whom my obligations are of a still deeper character, since, imperfect as this monograph is, without their invaluable co-operation it would have been immeasurably worse. I refer to Mr. George Barlee and Mr. J. G. Jeffreys. To the indefatigable perseverance of Mr. Barlee in the use of the dredging net we owe many of the most beautiful Foraminifera that have been found on our shores; and the liberality with which he has poured successive supplies into my hands has been in the ratio of his unwearied diligence. To the 'Memoir on the British Foraminifera,' laid before the Linnean Society in 1828 by Mr. Jeffreys, reference has already been made. On finding that I was engaged upon the preparation of this work, that gentleman not only placed in my hands the whole of his specimens, papers, and drawings relating to the subject, but with rare liberality, left them in my possession throughout the entire period during which this investigation has been in progress.

Would that the product of so much kindly co-operation had been more satisfactory to myself.

But the preparation of this volume has been carried on under circumstances of considerable difficulty. Scientific investigation in the provinces is a very different affair from the same occupation in London. Those who are privileged in having the Library of the British Museum at hand, know nothing of the inconveniences endured by provincial naturalists; and occasional visits to the metropolis for purposes of reference are poor substitutes for having the required works constantly within reach. References thus casually made, and without the opportunity of frequent recurrence to the volumes quoted from, cannot fail to be attended by errors of transcription; and should such be discovered, the difficulties referred to must incline the student to note them with an indulgent eye. Equally unfavorable to sustained research is the life of a medical man engaged in the incessant duties of general practice. The investigations of which these pages are the results have constituted the relaxing occupation of uncertain intervals between hours devoted to professional life. The freedom from interruption, so essential to calm inquiry, is, under such circumstances, absolutely unattainable. But, notwithstanding these disadvantages, I hope the work may contribute something to the enjoyment of sea-side wanderings, by revealing a few of the unknown beauties that abound on our shores, as well as supply the philosophic naturalist with some new material shedding light on the difficult problem of specific unity.

Little to be envied is the man whose eye rests without interest upon forms so replete with elegance as are many of these microscopic atoms. Grace and beauty meet him on every hand; whilst the objects in which these attributes are displayed often suggest associations little to be anticipated in creatures so minute. Miniature and fairy-like representatives of the classic Nautilus present themselves in rich abundance. The Attic Amphora and the Roman Lachrymatory are foreshadowed amongst the graceful Lagenæ; whilst some of the Cristellariæ might have been the prototypes of those ancient lamps that illuminated the hall of the Carthagenian Queen, when

"Dependent lychni laquearibus aureis
Incensi, et noctem flammis funalia vincunt."

Imagination may long revel amongst these lovely creations, ever finding abundant scope for the play of fancy; and should any one still exist, in this nineteenth century, who is disposed to frown upon such objects as unworthy of serious study, let him submit to be reminded that, in nature, as well as in art,

"A thing of beauty is a joy for ever."

THE

RECENT FORAMINIFERA

OF

GREAT BRITAIN.

Genus—PROTEONINA, *nob.*

Shell free, irregular, fusiform, or compressed, and with a slight disposition in its young state to become convoluted; arenaceous. Septal orifice at the extremity of the shell, single, irregular in size and form.

This genus, which I have established for the reception of two undescribed objects, may possibly bear some close relation to the genus Gromia of Dujardin; but the latter has a membranous envelope, whereas Proteonina has an arenaceous one. I have no doubt that other modifications of this unsymmetrical rhizopodous type will be discovered.

PROTEONINA FUSIFORMIS, *nob.* Fig. 1.

Spec. Char. Oblong, fusiform, but very variable in its contour and hue. Texture coarsely arenaceous and granular. Septal aperture irregular, at one extremity of the shell, and sometimes scarcely visible. Long. $\frac{1}{40}$.

Loc. Skye; in sand dredged by Mr. G. Barlee.

This curious form does not appear to have been hitherto noticed. Its arenaceous structure is always remarkably obvious; and in the specimen figured, large coloured laminæ of micaceous and felspathic substances are imbedded in its parietes along with the coarse grains of translucent sand. This, however, is an exceptional condition.

It is barely possible that this object may prove to be a monstrous form of *Bulimina scabra,* which is very abundant at Skye. Sometimes the latter shell becomes very irregular in form, the large grains of sand imbedded in its parietes masking its division into segments; but as I have hitherto failed in tracing any internal septa in the Proteonina it must for the present stand as a distinct species.

PROTEONINA PSEUDOSPIRALIS, *nob.* Figs. 2, 3.

Spec. Char. Thin, compressed; at first exhibiting a tendency towards a spiral growth, but afterwards projected in a nearly straight line. Texture like that of *P. fusiformis*. Septal aperture oblong, at the extremity of the produced portion, but irregular and sometimes scarcely perceptible. Long. $\frac{1}{20}$.

Loc. Skye; Mr. G. Barlee.

I have detected no trace of segmentation in this species, its interior consisting of an undivided cavity. It obviously presents a rude and imperfectly developed example of a type of growth which assumes a completely symmetrical and concamerated condition in Cristellaria and its allies. The genus appears to constitute a connecting link between the irregular forms of the shelless Amæbæ and the more regular ones of the Foraminifera.

Genus—ORBULINA, *D'Orbigny.*

Shell free, regular, spherical, hollow; perforated by innumerable very minute foramina, visible only under a high magnifying power. Septal orifice single, small, situate at some point on the periphery of the shell; without any marginal projection; often invisible.

M. D'Orbigny suggests the possibility of the animal being able to close the septal aperture, since he only found it in about a sixth of the individuals which he examined—a condition which my observations have confirmed; but it appears more probable that its frequent closure is due to the inspissated animal matter of its internal cavity. The same author defines the shell as calcareous; but it is more arenaceous in its texture.

ORBULINA UNIVERSA, *D'Orb.*, 1839. Fig. 4.

Spærula petræa, Soldani, 1789. Testaceog., t. i, p. 116, tab. cxix, *i*, *k*, *l*, *m*.
— *hispida*. Ibid., 1798. Ibid., t. ii, p. 53, tab. xvii, fig. x; tab. xviii, fig. A.
Orbulina universa, D'Orb., 1839. Foram. de Cuba, p. 3, No. 1, pl. i, fig. 1.
— — Ibid., 1839. Foram. des Canaries, p. 122, pl. i, fig. 1.
— — Ibid., 1839. Foram. de Vienne, p. 21, tab. i, fig. 1.

Spec. Char. Spherical; parietes minutely granular, of a pale grayish-yellow hue. Texture finely arenaceous. Septal aperture small; normally round, but usually irregular, and sometimes entirely closed up by the inspissated gelatinous sarcode, so as to be invisible. Diam. $\frac{1}{30}$—$\frac{1}{80}$.

Loc. Shetland, Skye; Mr. G. Barlee. Eddystone, Brixham; Mr. Spence Bate.

This little species is a true cosmopolite. On our own coast I have never met with it in any abundance; but single specimens are not unfrequent, especially where the sea-bottom consists of very fine sand or mud. It frequents the same localities as *Globigerina bulloides*. Dr. Bailey found it in the soundings brought up from depths of the Atlantic varying from 1300 to 3000 fathoms, being especially abundant at 1800 fathoms;[1] and D'Orbigny has met with it in the Adriatic, Mediterranean, Canaries, Antilles, and India; and in a fossil state in tertiary strata at Sienna and Vienna.[2]

Genus—LAGENA, *Walker*.

Serpula (*Lagena*), Walker. *Vermiculum*, Montagu. *Serpula*, Maton and Rackett, Pennant. Turton, *Lagenula*, Fleming, Macgillivray, Thorpe. *Oolina*, D'Orbigny. *Lagena*, Williamson, Brown, Parker and Jones.

Shell free, regular, oval, oblong, or fusiform; hyaline; perforated by very minute pseudopodian foramina; prolonged anteriorly into a long, narrow neck, at the extremity of which is the septal aperture surrounded by a thickened rim; rounded or acuminate posteriorly; general aspect resembling a Florence flask, an ancient amphora, or a modern water-carafe.

Lagena differs from Orbulina in its hyaline texture, and in its long cylindrical neck; from Entosolenia in the much more frequent presence of the external neck and the absence of the internal prolonged tube.

Lagena vulgaris, *nob.* Figs. 5—14.

Orthocera perfecte globularia, Soldani, 1780. Saggio Orittografico, fig. 43, h.
Serpula (*Lagena*) *striata*, Walker, 1784. Test. Min., p. 2, tab. i, fig. 6.
— *lævis ovalis*. Ibid., p. 3, tab. i, fig. 9.
— *sulcata*, Adams, 1787; Micros. Essays, p. 634, tab. xiv, fig. 5. Soldani, 1789; Test. et Zool. parv., tab. 129; vas., 258 *c c*, tab. 167 *q q*.
Vermiculum læve, Mont., 1803. Test. Brit., p. 524.
— *perlucidum*. Ibid., p. 525, tab. xiv, fig. 3.
— *striatum*. Ibid., p. 523.
Serpula striata, Maton and Rackett, 1807, p. 248. Pennant, 1812, vol. iv, p. 365.
— *perlucida*. Ibid.
— *lævis*. Ibid., p. 247. Ibid., p. 364.

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[1] 'American Journ. of Science and Arts,' 2d ser., vol. xvii, March, 1854.

[2] 'Foram. de Vienne,' p. 21.

Serpula striata, Turton, 1819. Conch. Dict., p. 157.
— *perlucida*. Ibid., fig. 23, p. 157.
— *lævis*. Ibid., p. 157.
Lagenula striata, Fleming, 1828. Brit. Anim., p. 234.
— *perlucida*. Ibid., p. 235.
— *lævis*. Ibid., p. 235.
— — Macgillivray, 1843. Moll. Anim. Aberd., p. 38.
— — Thorpe, 1844. Brit. Mar. Conch., p. 234.
— *perlucida*. Ibid., p. 233.
— *striata*. Ibid., p. 233.
Oolina clavata, D'Orbigny, 1846. Foram. de Vienne, tab. i, fig. 23.
— *lævigata*. Ibid., 1847. Voyage, &c., vol. v, p. 18, tab. v, fig. 3.
— *caudata*. Ibid., fig. 6.
— *striaticollis*. Ibid., fig. 14.
— *striata*. Ibid., p. 21, tab. v, fig. 12.
Lagena lævis, Williamson, 1848. Annals Nat. Hist., 2d ser., vol. i, p. 12, pl. i, figs. 1, 2.
— *gracilis*. Ibid., p. 13, pl. i, figs. 3, 4.
— *striata*. Ibid., p. 13, pl. i, figs. 6—8.
— *substriata*. Ibid., p. 15, pl. ii, fig. 12.
— *lævis*, Parker and Jones, 1857. Annals Nat. Hist., vol. xix, pl. xi, figs. 22—24.

LAGENA VULGARIS, typica. Figs. 5, 5 *a*.

Spec. Char. Ovate or claviform; sometimes narrow and much elongated; having at its anterior part a long, slender, tubular neck, somewhat contracted near its apex, terminating in a thickened rim, surrounding a small, circular, terminal septal orifice; smooth, and in a young state shining. Texture hyaline and transparent. Hue becoming bluish-white and semi-opaque with increase of age. Under a high magnifier its surface appears crowded with very minute foramina. Long. $\frac{1}{30}$ — $\frac{1}{100}$.

Loc. Southport, large and fine; Mr. C. Clough. Whitehaven; Rev. Mr. Chalmers. Plymouth Sound and Eddystone; Mr. S. Bate. Swansea, Sandwich; Mr. J. G. Jeffreys. Arran, Skye, Shetland, Brixham; Mr. George Barlee. Scarborough; Mr. J. Williamson. Post-pliocene sands of Boston (Lincolnshire) and March (Cambridgeshire).

In assigning to this species the name *vulgaris* in preference to that of *lævis*, I have acted in conformity with the laws recommended by the committee of the British Association. It is necessary to attach some common name to this and all the following varieties; and since the smooth form is only one of several conditions, most of which are not smooth, to retain the name of *lævis* would involve employing such self-contradictory terms as *L. lævis*, var. *striata*, which is highly objectionable.

LAGENA VULGARIS, *var.* CLAVATA. Fig. 6.

Spec. Char. Elongated, cylindrical; greatest diameter behind the middle of the shell, usually at its posterior third; some having the form of var. *a*, *lævis*, with the addition of a slight mucro at the posterior extremity, others being lengthened and fusiform. Neck long, slender, tapering; surmounted by a small rim surrounding the septal orifice. Texture and hue like that of var. *a*. I have found every variety between the two forms represented in figs. 4 and 5. Long. $\frac{1}{40} - \frac{1}{36}$.

Loc. Oxwich, Sandwich, Oban; Mr. J. C. Jeffreys. Arran, Brixham; Mr. George Barlee. Whitehaven; Rev. Mr. Chalmers. Scarborough; Mr. J. Williamson. Plymouth Sound and Eddystone; Mr. Spence Bate. Southport, at twenty-five fathoms, remarkably fine; Mr. C. Clough. Post-pliocene sands of Boston and March. "Baden, fossil;" M. D'Orbigny. Cairnclough Bay, Antrim; Mr. Hyndman.

This is obviously the *Oolina clavata* of M. D'Orbigny. I have therefore abandoned my own sub-specific name of Amphora, and employed the specific one of the French naturalist to indicate this elegant variety, as being the one first assigned to it.

LAGENA VULGARIS, *var.* PERLUCIDA. Figs. 7, 8.

Spec. Char. Usually oblong or ovate; sometimes globular, and even dilated at the posterior extremity. Marked with longitudinal costæ, which are strongest posteriorly, disappearing as they ascend towards the tapering neck. Sometimes these striæ are so short and indistinct as to render the specimen very like the typical form; indeed, in some few individuals the striæ are only represented by a small circle of minute tubercles, forming a coronal at the base of the shell. Texture beautifully hyaline and pellucid. Hue sometimes of a pale milky tint, but frequently transparent as the purest glass. Long. $\frac{1}{160} - \frac{1}{60}$.

Loc. Shetland, Skye, Arran, Brixham; Mr. George Barlee. Swansea, Tenby, Manorbeer, Sandwich; Mr. J. G. Jeffreys. Plymouth Sound and Eddystone; Mr. S. Bate. Southport, very fine; Mr. C. Clough. Exmouth; Mr. Kane. Torquay; Mr. J. Ashworth. Whitehaven; Rev. Mr. Chalmers. Cairnclough Bay, Antrim; Mr. Hyndman. Boston, March, Levant.

I believe this to be the *Vermiculum perlucidum* of Montagu. His figure represents a highly depressed shell, with a small umbo at its base; but Montagu had never seen the specimen, and only copied a drawing sent to him by Mr. Boys. The number of costæ varies considerably as well as the form; I have seen some specimens with only seven or eight, whilst in others they are so numerous and prominent as to merge this form with that of var. *striata*, of which I believe it frequently to be but a young state. On the other hand, it gradually passes into var. *lævis*; I am now compelled to conclude that all these varieties belong to one species, so that we have but one British species of Lagena.

M. D'Orbigny's *Oolina caudata* is a finely costate form of the above variety, having a prolonged mucro at its posterior extremity, and being one of the transitional forms connecting it with *L. vulgaris*, var. *gracilis*.

LAGENA VULGARIS, *var.* SEMISTRIATA. Fig. 9.

Differs from var. *perlucida* in the costæ terminating abruptly at their upper extremity instead of gradually merging in the anterior part of the shell. I have found examples in which they were respectively arrested at the lower, middle, and upper third of the shell. One specimen was elongated inferiorly, as in var. *clavata* (fig. 6). Texture hyaline.

LAGENA VULGARIS, *var.* STRIATA. Fig. 10.

Ovato-claviform or spherical, with numerous parallel costæ, which generally extend nearly from one end of the shell to the other, excepting at a small central point at the posterior extremity, around which these abrupt terminations often form a small circular coronal. These costæ are sometimes thin and lamelliform; but more commonly obtuse and rounded. Shell terminated anteriorly by a long tubular neck, with a narrow rim at its extremity surrounding the septal orifice. Long. $\frac{1}{15} - \frac{1}{80}$.

Loc. Occurs almost everywhere. Cairnclough Bay, Antrim; Mr. Hyndman. Copeland Island, County Down; Professor Patterson. Swansea, Rossilly, Manorbeer, Tenby, Oxwich, Caswell Bay, Sandwich, Oban, Roundstone, Connemara; Mr. J. G. Jeffreys. Shetland, Arran, Skye, Brixham; Mr. George Barlee. Cullercoats, rare; Mr. Alder. Scarborough; Mr. Bean and Mr. J. Williamson. Exmouth; Mr. Kane. Southport; Mr. C. Clough. Plymouth Sound and Eddystone; Mr. S. Bate. Whitehaven; Rev. Mr. Chalmers. Boston, March. Hunde Island, Beechey Island, Arctic Regions; Dr. Sutherland. Fossil in a Miocene Tertiary deposit; Petersburg, U.S.; Dr. Bayley. Also in the English Crag; Mr. Searles Wood.

Nothing can be more variable than the conditions under which this form presents itself. The tubular neck is chiefly seen in young specimens dredged from deep water; and in these the texture of the shell is transparent and hyaline, or of a pale bluish-white hue. On the other hand, the specimens usually seen in the cabinets of collectors, and obtained from water-worn shore sand, are strong, globular, of an opaque dirty white, the rounded costæ alone remaining transparent, as if rubbed bright, and with very imperfect traces of a neck, which has either been worn away by abrasion, or absorbed through the increase of age. Between this common form and that represented in fig. 10, which I conceive to be the perfect type, every modification exists. In some forms the costæ terminate abruptly near the base of the neck, the superior portion being smooth. This condition obviously connects the var. *striata* with var. *semistriata*. In others the costæ are continued longitudinally to the anterior extremity of the neck; and in a few elegant specimens I have found them winding spirally round that appendage. Two examples have come under my notice, as well as that of Mr. Barlee, in which the neck was encircled with a series of parallel transverse rings. A common variety occurring in Plymouth Sound has the posterior extremity furnished with a well-marked central mucro.

LAGENA VULGARIS, *var.* INTERRUPTA. Fig. 11.

The variety only differs from the last in the unequal lengths and discontinuous character of the costæ, which sometimes do not extend over more than one half of the shell.

LAGENA VULGARIS, *var.* GRACILIS. Figs. 12, 13.

This variety presents similar modifications of form to var. *clavata*, though generally it is more slender and tapering. Fig. 12 represents a rare condition, in which the posterior extremity is rounded, and the costæ very few in number. Fig. 13 represents the more common state; the posterior extremity being drawn out and acuminate, and the delicate costæ more numerous. I have seen one example in which the costæ were as abundant as in the var. *substriata* (fig. 14); clearly demonstrating that the possession of a rounded or an acuminated base is compatible with specific unity, and that all the forms may either be short, spherical, and obtuse, or oblong and acuminated. Texture hyaline. Length $\frac{1}{45}$.

Loc. Skye, Arran; Mr. George Barlee. Southport, rare; Mr. Clough. Boston.

The specimens from Skye, which were remarkably fine, were perforated with very minute, but distinct foramina.

LAGENA VULGARIS, *var.* SUBSTRIATA. Fig. 14.

Shell elegantly oval and cylindrical; sometimes considerably more elongated than represented in the figure, approaching the contours of figs. 12 and 13; furnished with a long tubular neck. Surface marked with numerous delicate parallel longitudinal striæ. Texture hyaline. Long. $\frac{1}{45}$.

Loc. Swansea, rare; Brixham; Mr. George Barlee. Exmouth; Mr. W. Kane. Cullercoats, rare; Mr. J. Alder. Whitehaven; Rev. Mr. Chalmers. Southport; Mr. Clough.

The finest specimens which I have seen of this beautiful variety were in sands sent me from Southport and Whitehaven by Mr. Clough and the Rev. Mr. Chalmers. Though I was formerly of opinion that this shell was specifically distinct from the *L. striata* of previous authors, I am now satisfied that this must be added to the other protean forms of this extraordinary species.

M. D'Orbigny's *Oolina striata* is merely an example of this variety.

Genus—ENTOSOLENIA, *Ehrenberg.*

Serpula (*Lagena*), Walker. *Vermiculum,* Montagu. *Serpula,* Maton and Rackett, Pennant, Fleming, Turton. *Lagenula,* Thorpe, Macgillivray. *Oolina,* D'Orbigny. *Entosolenia,* Ehrenberg, Williamson.

Shell free; spherical; oval; or compressed; with a slight prominence (rarely prolonged into a neck) at its anterior extremity, surrounding the septal orifice which opens into a long, straight or flexed tube, projecting into the cavity of the shell. Internal tube patulous at its free extremity, resembling an inverted neck of a Lagena. Posterior extremity rounded, or with a mucro. Shell hyaline or sub-hyaline. Very finely foraminated.

Differs from Orbiculina and Lagena in possessing the introverted tube.

Entosolenia globosa. Figs. 15, 16.

Serpula (*Lagena*) *globosa,* Walker, 1784, p. 3, tab. i, fig. 8.
Vermiculum globosum, Mont., 1803. Test. Brit., p. 523.
Serpula globosa, Maton and Rackett, 1807, p. 247. Turton, 1812, vol. iv, p. 364.
— — Turton, 1819. Conch. Dict., p. 157.
— — Fleming, 1828. Brit. Anim., p. 235.
? *Lagenula globosa,* Thorpe, 1844. Mar. Conch., p. 234.
Entosolenia globosa, Williamson, 1848. Annals Nat. Hist., 2d ser., vol. i, p. 16, tab. ii, figs. 13, 14.
— *lineata.* Ibid., p. 18, tab. ii, fig. 18.
— *globosa,* Parker and Jones, 1857. Ibid., vol xix, tab. xi, figs. 25—29.

Entosolenia globosa, typica.

Shell spherico-ovate; smooth; projecting slightly at the anterior extremity; the centre of the projection occupied by a small septal orifice opening into the internal tube, which is slender, patulous at the extremity, and sometimes reaching nearly to the bottom of the shell. Texture somewhat hyaline.

When examined under a very high power the parietes of this shell are seen to be perforated with minute pseudopodian foramina. Length $\frac{1}{10}$.

Loc. Exmouth; Mr. Kane. Brixham; Mr. George Barlee. Southport; Mr. C. Clough. Swansea, Portsmouth; Mr. J. G. Jeffreys. Scarborough; Mr. Bean. Mindanao, Philippine Islands; and fossil in a Miocene Tertiary stratum at Petersburg, U.S; Dr. Bailey. Boston. March. The Levant.

The cabinet of Mr. Bean contains one example of this species in which two shells appear united together at their posterior extremities, each having a septal aperture at the opposite end, apparently the result of partial fission of the germ prior to calcification. The *Lagenula globosa* of Thorpe's 'British Manual of Conchology,' is perhaps not the *Serpula globosa* of other authors, being described as having a long, slender neck, and its surface marked with opaque longitudinal lines. This description is more applicable to one of the Lagenæ.

Fig. 16 *a* represents a longitudinal section of one of these shells, displaying the internal tube.

ENTOSOLENIA GLOBOSA, *var.* LINEATA. Fig. 17.

Shell ovate; broadest near the posterior end; more or less truncate anteriorly, where it is sometimes furnished with a very short projection, having a septal aperture at its extremity. The posterior extremity is frequently furnished with a small mucro. Internal tube straight; slightly patulous at its lower end, which nearly reaches to the base of the shell. Texture hyaline; of a pale dull bluish-white hue. The microscope shows the surface to be covered with exceedingly numerous, fine, parallel lines, disposed longitudinally. Length, $\frac{1}{100}$—$\frac{1}{100}$.

Loc. Sandwich; Mr. Jeffreys. Exmouth; Mr. Kane. Southport; Mr. C. Clough. Plymouth Sound and Eddystone; Mr. Bate. Brixham, Shetland, Arran, Skye; Mr. George Barlee. Torquay; Mr. J. Ashworth. Boston, March.

ENTOSOLENIA COSTATA, *nob.* Fig. 18.

Globose. Slightly dilated posteriorly; septal orifice in the centre of the opposite extremity. Marked with numerous strong longitudinal costæ. Length, $\frac{1}{100}$.

Skye, very rare; Mr. George Barlee.

I have only seen two or three examples of this form. It may be merely a variety of *E. globosa;* but as I have not met with any inosculating examples, I have provisionally admitted it as a species, though a doubtful one.

ENTOSOLENIA MARGINATA. Figs. 19—28.

Serpula (*Lagena*) *marginata*, Walker, 1784, p. iii, tab. i, fig. 7.
Vermiculum marginatum, Mont., 1803. Test. Brit., p. 524,
Serpula marginata, Maton and Rackett, 1807, p. 247. Pennant, vol. iv, p. 364.
Oolina compressa, D'Orbigny, 1839. Voyage dans l'Amérique Méridionale, t. v, pt. v, p. 18, figs. 1, 2.
Lagenula marginata, Thorpe, 1844. British Marine Conch., p. 234.
Entosolenia marginata, Williamson, 1848. Annals, 2d ser., vol. i, p. 17, figs. 15—17.

ENTOSOLENIA MARGINATA, typica. Figs. 19—21.

Orbicular; compressed; with a prominent obtuse marginal ridge, which occasionally projects at the posterior end as a small truncate umbo. Opposite extremity furnished with a short compressed neck, at the end of which is an oblong but sometimes orbicular orifice. Each side of the shell has a strong, projecting, nearly circular ridge within the margin, interrupted only at the neck, in which it merges. Septal orifice communicating with an internal tube, which, except where it passes through the neck, does not project straight into the cavity of the shell, but follows the curvature of, and is in contact with, one of the lateral walls of the organism; in some cases the tube is incomplete on one side, being then closed in by the contiguous external shell; in other and rarer instances it is twisted in a variety of directions; its lower extremity patulous. Hue, a dirty white; opaque.

The young state of this shell (fig. 21) differs so materially from the matured form that the two may readily be mistaken for different species. The former is more orbicular; has the neck and marginal ridge less defined, and wants the lateral concentric ridges. Its texture is more hyaline, being perfectly transparent. Length, $\frac{1}{80}$ — $\frac{1}{200}$.

Loc. Swansea, Rossilly, Manorbeer, Portsmouth, Sandwich, Falmouth; Mr. Jeffreys. Oban, Kyleakin, Shetland, Skye, Arran; Mr. George Barlee. Scarborough, Lamlash Bay, Ayrshire; Mr. Bean. Exmouth; Mr. Kane. Hunde Island, Davis's Straits, at 100 fathoms; Dr. Sutherland.[1] Boston, March, the Levant.

This is the most common of our English species, and is apparently a true cosmopolite. A variety of the matured shell occasionally occurs, in which the central disc within the concentric ridge is marked by a few short, obscure, longitudinal costæ. Fig. 21*a* represents a young variety from Shetland, in which the basal margin was furnished with a number of acicular spines.

The *L. marginata* of Dr. Fleming is not our present species, but a concamerated shell—the *Rimula marginata* of some other authors, and doubtless identical with *Biloculina ringens*. I suspect that Walker's figure ('Test. Min. Rar.,' tab. i, fig. 7) is intended to represent the same shell. The two have repeatedly been confounded by British conchologists.

That the following varieties, dissimilar as they are, all belong to this species, is a point about which I am thoroughly satisfied. I have selected the most remarkable forms for representation; but I have seen all the intervening modifications which link these types together and demonstrate the specific unity of the whole group.

ENTOSOLENIA MARGINATA, *var.* LUCIDA. Figs. 22, 23.

Shell elongated, somewhat pyriform, compressed, smooth and shining; surrounded by a narrow marginal carina, which is sometimes scarcely visible, especially at the posterior extremity,

[1] For sand brought home by Dr. Sutherland I am indebted to Professor Dickie, of Belfast, and Mr. Brightwell, of Norwich.

but where it occasionally projects in a small mucro (fig. 23). This carina, and the central portion of each of the lateral parietes, are usually hyaline, whilst these translucent portions are separated by a horseshoe-like border of a milky white hue, corresponding with the more elevated lateral ridge of the typical form of this species. Shell perforated with innumerable very minute foramina, which in some examples become more conspicuous than in others Long, $\frac{1}{100}$.

Loc. Swansea, Rossilly, Manorbeer, Portsmouth, Sandwich; Mr. J. E. Jeffreys. Kyleakin, Shetland, Arran, Skye, Brixham; Mr. George Barlee. Southport, very fine; Mr. C. Clough. Plymouth Sound and Eddystone; Mr. S. Bate. Scarborough; Mr. J. Williamson. Whitehaven; Rev. Mr. Chalmers. Hunde Island and Beechey Island; Dr. Sutherland. Cairnclough Bay, Antrim; Mr. Hyndman.

I was long disposed to regard this as a distinct species,but I found so many orbicular specimens of the true marginata in which the marginal carina was less developed than usual, and where the lateral concentric ridges had degenerated into a mere superficial thickening producing increased opacity of the shell, that I no longer doubt their specific identity. In like manner fig. 23 is little more than an elongated form of fig. 22, the opaque marginal border being almost invisible.

ENTOSOLENIA MARGINATA, *var.* ORNATA. Fig. 24

Resembles the ordinary forms of this species, only the thin marginal carina contains numerous small detached cavities, like minute water-bottles with straight necks, each of which opens by a minute aperture at the outer edge of the carina. Fig. 24 represents a small portion of this carina, with part of the wall of the shell attached. Long, $\frac{1}{130}$.

Whitehaven; Rev. Mr. Chalmers. Shetland; Mr. George Barlee. Arctic Seas; Dr. Sutherland.

ENTOSOLENIA MARGINATA, *var.* LAGENOIDES. Figs. 25, 26.

An exceedingly variable modification, chiefly characterised by its oblongo-ovate form and lengthened neck. The latter appendage is sometimes short, as in fig. 26; at others long, as in fig. 25. In the latter case, the cavity of the shell is ovate; the long compressed neck being solid throughout, with the exception of the narrrow longitudinal canal prolonged through it from the internal tube, which latter determines this form to be a true Entosolenia. Long, $\frac{1}{80} - \frac{1}{100}$.

Loc. Shetland, Brixham; Mr. George Barlee. Whitehaven; Rev. Mr. Chalmers. Plymouth Sound; Mr. Spence Bate.

ENTOSOLENIA MARGINATA, *var.* QUADRATA. Figs. 27, 28.

An obvious modification of the var. *lucida*, distinguished by its tendency to assume the form

of a parallelogram, with somewhat rounded extremities. In fig. 28 the neck is a little elongated, approximating to the form of fig. 25. Long, $\frac{1}{70}$.

Loc. Shetland, Brixham; Mr. George Barlee; Whitehaven; Rev. Mr. Chalmers. Boston.

ENTOSOLENIA SQUAMOSA. Figs. 29—32.

Vermiculum squamosum, Mont., 1803. Test. Brit., p. 526, tab. xiv, fig. 2.
Serpula squamosa, Maton and Racket, 1807, p. 247. Pennant, 1812, vol. iv, p. 364.
— — Turton, 1819. Conch. Dict., p. 158.
Lagenula squamosa, Fleming, 1828. Brit. Annals, p. 235.
— *reticulata*, Macgillivray, 1843. Molluscous Animals of Aberdeen, p. 28.
— *squamosa*, Thorpe, 1844. Brit. Mar. Conch., p. 234.
— *reticulata*. Ibid., 235.
Oolina melo, D'Orbigny, 1847. Voyage dans l' Amérique Méridionale, t. v, pt. v, p. 20, tab. v, fig. 9.
Entosolenia squamosa, Williamson, 1848. Annals Nat. Hist., 2d ser., vol. i, pl. ii, fig. 19.

ENTOSOLENIA SQUAMOSA, typica. Fig. 29.

Shell ovato-globose, with a slight projection anteriorly, in the centre of which is the round septal orifice; posterior extremity rarely furnished with a mucro; surface beautifully ornamented with numerous small white, areolar spaces, separated by a network of elevated transparent ridges. The areolæ irregular in form and distribution, being sometimes nearly round or oval, but more usually tending to become hexagonal; the lower ones being sometimes the longest. Occasionally the areolæ are transparent, and the reticulations of a milky hue, corresponding with the *L. reticulata* of Macgillivray. Long, $\frac{1}{100}$ — $\frac{1}{160}$.

Loc. Torbay, Swansea; Mr. Jeffreys. Brixham, Shetland, Skye, Arran, Fowey; Mr. George Barlee. Lamlash Bay, Scarborough; Mr. W. Bean and Mr. J. Williamson. Exmouth; Mr. Kane. Whitehaven; Rev. Mr. Chalmers. Southport; Mr. C. Clough. Plymouth Sound and Eddystone; Mr. S. Bate. Hunde Island, Davis's Straits; Dr. Sutherland. Cairnclough Bay, Antrim; Mr. Hyndman. Boston, March.

In the figure of this exceedingly variable species given in the supplement to Montagu's 'Testacea Britannica,' the areolæ are made to represent scales overlapping each other. This appearance, though not real, is easily obtained by throwing the microscope a little out of focus, and I have no doubt would be the aspect the object would present when viewed through the imperfect instruments used in the time of Mr. Walker. Dr. Fleming considered these areolæ to be "parietal cells." They are, however, mere concavities left in the exterior of the shell by the more rapid growth of the intervening reticulations. Dr. Macgillivray speaks of his shell as being

"considerably compressed." This must have been an accidental circumstance, all the species, both of Lagena and Entosolenia, being liable to a considerable degree of deformity.

Fig. 32 *a* is an abnormal double specimen corresponding with that of *E. globosa*, already described at p. 9. The probable physiological significance of these specimens will be pointed out in the description of a similar specimen of *Dentalina subarcuata*.

ENTOSOLENIA SQUAMOSA, *var.* SCALARIFORMIS. Fig. 30.

Areolæ large and few in number, forming hexagonal figures, the parallel sides of which constitute the anterior and posterior borders of each areola.

ENTOSOLENIA SQUAMOSA, *var.* CATENULATA. Fig. 31.

Closely resembles the last, only with more numerous very minute reticulations, which are sometimes even much smaller than represented in my figure.

ENTOSOLENIA SQUAMOSA, *var.* HEXAGONA. Fig. 32.

Areolæ numerous, hexagonal, with the parallel sides of each hexagon placed at its lateral margin. This form of areola is almost always associated with a more pyriform shell, with very strongly marked reticulations, indicating deeply excavated areolæ, and often with a short projecting neck at the anterior extremity, at the end of which is the septal aperture. The variety occurs abundantly at Shetland.

Messrs. Parker and Rupert Jones regard all the preceding forms of Entosolenia as varieties of one species, to which they assign the name of *E. globosa*. I have not yet met with examples linking the compressed *E. marginata* with the globular forms; but that *E. globosa* and *squamosa* may prove to be identical appears exceedingly probable.

Genus—LINGULINA, *D'Orbigny*.

Shell free, regular, straight, equilateral, oblong, compressed; consisting of several compressed segments, each slightly embracing the anterior extremity of its predecessor by its posterior one. Hyaline; very finely foraminated. Septal orifice central; oblong; at the convex anterior extremity of the ultimate segment.

Distinguished from Nodosaria by being compressed, instead of cylindrical; and by its fissural septal orifice.

LINGULINA CARINATA. Figs. 33, 34, 35.

Orthoceratia zoophytica subcordiformia, Soldani, 1789, t. ii, tab. xcix, fig. *m* 4, p. 94.
— *pyriformis,* Soldani. Saggio Orit., t. iv, tab. xii, fig. P, p. 37.
— *zoophitica.* Ibid., t. ii, tab. c, fig. P (young).
Lingulina carinata, D'Orbigny, 1825. Tab. de Ceph., p. 257.[1]
— — Ibid., 1839. Foram. des Canaries, p. 20, tab. 1, figs. 13, 14.

Shell straight, compressed; consisting of about seven slightly convex segments; the posterior margin of each embracing the anterior extremity of the preceding one. Septal plane oval, oblong. Septal orifice, an oblong slit, at the anterior extremity of the ultimate segment (fig. 34). Peripheral margin thin, entire. Texture hyaline. Length, $\frac{1}{80}-\frac{1}{100}$.

Loc. Shetland, Skye; Mr. George Barlee. Plymouth Sound; Mr. S. Bate.

I have only seen six specimens of this very rare shell. Of these I found four in Shetland sand and one in sand from Skye, both sent me by Mr. Barlee. The sixth was in sand dredged up for me in Plymouth Sound by Mr. S. Bate, of Plymouth. But all these six examples were such near representatives of each other, varying only in the length and number of the segments, as to leave no doubt on my mind that this is a good species. I see no difference between my specimens and the figure given in M. D'Orbigny's Foraminifera of the Canaries, except that in the latter, the primary segments are more closely approximated than is usual in our British forms, though one which I have met with corresponds even in this respect.

Genus—NODOSARIA, *Lamarck.*

Nautilus, Linnæus, Montagu, Turton, Maton and Rackett, Pennant. *Nodosaria,* Lamarck, D'Orbigny, Brown, Thorpe, Parker and Jones. *Orthocera,* Lamarck, Fleming, Brown. *Reophagus,* Montfort. *Mucronina,* D'Orbigny.

Shell free, regular, elongated, straight, cylindrical; consisting of several more or less ventricose segments, arranged in a linear series; the anterior part of each segment being embraced by the posterior margin of its successor. Septal lines constricted; at right angles to the long axis of the shell. Septal orifice central; terminating a projection of varying length at the anterior extremity of the ultimate segment.

Nodosaria differs from Lingulina in being cylindrical instead of compressed; and from

[1] My references to this memoir are taken from it as paged in the 'Annales,' which does not appear to be the case in some of M. D'Orbigny's writings, but from some reprint of the memoir which I have not seen.

Dentalina in being straight, having rectangular septal lines, and a central septal orifice instead of the shell being usually arcuate, the septal lines oblique, and the septal orifice unilateral.

NODOSARIA RADICULA, *Mont.* Figs. 36—38.

Soldani, 1789. Test. et Zoot., tab. xcv, vas. 225, B to L.
? *Nautilus Radicula,* Linnæus, 1767. Syst. Nat. Ed., 12, vol. ii, p. 1164.
? — — Martini, 1769, Conch., i, fig. 1, G.G.G.
? — — Turton's Lin., 1800-6, iv. p. 309.
— — Mont., 1803. Test. Brit., p. 197, tab. xi, fig. 4; tab. xiv, fig. 6.
— — Maton and Rackett, 1807, p. 119. Pennant, 1812, vol. iv, p. 249.
— — Turton, 1819. Conch. Dict., p. 122.
— — Wood, 1825. Index Test., p. 64, gen. 19, sp. 27.
? *Nodosaria Radicula,* D'Orbigny, 1826. Tableau, p. 252.
— *longicauda.* Ibid, p. 253.
— *sulcata.* Ibid.
Orthocera Radicula, Fleming, 1828. Brit. Anim., p. 236.
Nodosaria striaticollis, D'Orbigny, 1839. Foram. des Canaries, p. 124, tab. i, figs. 2, 3, 4.
— *Radicula,* Thorpe, 1844. Brit. Mar. Conch., p. 227.
— *octolocularia,* Brown, 1844. Illustrations Rec. Conch., 2d ed., pl. 1, fig. 25, p. 2.
— *Badenensis,* D'Orbigny, 1846. For. de Vienne, p. 38, tab. i, figs. 34, 35.

Shell straight, consisting of from three to five segments, but most commonly with three or four. The first, or primordial one, sometimes a little larger than the second, though not invariably so; the remainder increasing slightly in size to the last, which, when perfect, is furnished with a long neck, like that of the Lagenæ. Segments ventricose, especially the posterior ones; the primordial one sometimes furnished with a small mucro; surface sometimes smooth, but usually ornamented externally with numerous parallel longitudinal costæ, which are very strongly marked in matured shells, but much more indistinct in young individuals. Texture hyaline, especially when young. Septal aperture at the extremity of the prolonged neck of the ultimate segment. Length, $\frac{1}{35}$.

Loc. Arran, Shetland; Mr. Barlee. Sandwich, Loch Fine; Mr. J. G. Jeffreys. Southport; Mr. C. Clough. Plymouth Sound; Mr. S. Bate. Whitehaven; Rev. Mr. Chalmers. Davis's Straits; Dr. Sutherland. Fossil in the Tertiary Strata at Baden; M. D'Orbigny. Boston.

In its transition from a young to a more matured state, the costæ in this shell become stronger and more marked; as we have seen to be the case in *Lagena vulgaris,* vars. *striata* and *perlucida.* Consequently I have little doubt that this is the *Nautilus Radicula* of Montagu, though he describes his shell as smooth and of an "opaque brown," which none of my specimens are.

Linnæus, whom Montagu quotes for his synonym, also distinctly describes the shell, which

he designates *Radicula*, as being smooth. These circumstances led me to hesitate in employing the above specific name, though Montagu's figure in Tab. VI, but the absence of any other British shell at all answering to his description, leave no doubt on my mind that his specimens were smooth varieties of the shell before us, such as occasionally occur. Hence I have allowed the species to stand as the *Nod. Radicula* of Montagu, though I doubt its identity with the Linnean one of the same name.

The identification of the various shells described by Montagu and his followers under the names of *N. Radicula, rectus, costatus, jugosus, subarcuatus,* and *obliquus,* presents no easy task, and an examination of the works of Gualtieri, Martini, and Planchus, so often referred to by Montagu and others, affords no material assistance to the English conchologist pursuing this inquiry. The fact is, Planchus, whom the other writers chiefly follow, obtained his specimens from the Adriatic and Mediterranean, where a group of large and strong Nodosarian shells abound, presenting a very different aspect from their English representatives, which are much smaller, more delicate, translucent, and fragile; but when *drawings* of the two groups are placed side by side, the difficulty of defining these differences by means of the pencil becomes obvious. Hence the general uncertainty attending the identification of Foraminifera by means of figures. Montagu had only seen the defective plates, not the specimens of the German and Italian naturalists; consequently, all his references to them in connection with the above species become of little value. Knowing, on the other hand, that Montagu obtained his own examples from British localities where similar specimens still abound, we have less difficulty in determining the objects which his figures represent; but the result in connection with the nomenclature is some degree of confusion. It is undesirable to change trivial names that have become so familiar to British conchologists as those of Montagu beyond what is imperatively requisite; at the same time, there is frequently ground for grave doubts whether they indicate the shells to which the same names were originally given in the Systema Naturæ; this confusion multiplies difficulties like those just referred to in the case of *Nodosaria Radicula.*

I can detect no difference between our English specimens and the *N. sulcata* and *Badenensis* of M. D'Orbigny. The mere variation in the number of costæ, and the presence or absence of a mucro, are insufficient reasons for the establishment of new species, as we have seen from the Lagenæ and Entosoleniæ. And since a Nodosaria is little more than a linear chain of Lagenæ, what is true of the isolated segments of the latter is equally so of the aggregated segments of the former. M. D'Orbigny's *N. striaticollis* is merely a variety in which oblique spiral costæ exist on the prolonged neck. We have already found similar modifications in the Laganæ. That writer describes his specimens from the Canaries as only differing from his *N. longicauda,* fossil at Sienna, in the presence of these oblique costæ. Hence I presume the latter species also may be regarded as identical with our *N. Radicula.*

In one of Mr. Barlee's specimens some of the costæ are much more elevated than the rest, giving an angular contour to the shell. Specimens occasionally occur in which the segments display irregularities in their growth, some of the middle ones, and even the primordial one, being larger and more ventricose than the ultimate one.

NODOSARIA PYRULA, *D'Orb.* Fig. 39.

Soldani, 1789, 4. Tab. x, figs. B, C.
Nodosaria Pyrula. D'Orbigny, 1825. Tableau Method.
— *semirugosa.* Ibid., Foram. de Vienne, p. 34, tab. i, figs. 20—23.
? — *rudis.* Ibid., tab. i, fig. 17.

Shell consisting of about four ventricose pyriform segments, connected together by long slender necks, resembling a chain of smooth Lagenæ arranged in linear series. Terminal neck with a small septal orifice at its extremity. Segments usually smooth; widest at their posterior third, below which they are occasionally somewhat fluted, as in *Lagena vulgaris,* var. *perlucida* (fig. 7); sometimes increasing in size from the primordial to the ultimate one; in other instances this arrangement is reversed. Texture hyaline.

It is difficult to say of how many segments this shell normally consists, since, owing to its extreme fragility, it is usually broken; more than two connected segments being rarely met with. It obviously exhibits some variations analogous to those seen in the Lagenæ. When perfectly smooth it appears to be the *N. Pyrula* of D'Orbigny. When slightly costate, it appears to be the *N. semirugosa* of the same author. The segments vary in their relative lengths and diameters. In one example, in Mr. Chalmers sand from Whitehaven, each segment presented, in an exaggerated degree, the fusiform type of *Lagena vulgaris,* var. *clavata* (fig. 6), closely resembling the *N. Mariæ* of D'Orbigny. In one monstrosity the anterior segment had *two* divergent necks. The existence of such variations render it more than probable that the shell described by M. D'Orbigny, under the name of *N. rudis,* belongs to this species.

Loc. Skye, Shetland, Zetland; Mr. Geo. Barlee. Whitehaven; Rev. Mr. Chalmers. Southport; Mr. C. Clough. Plymouth Sound; Mr. S. Bate. Swansea; Mr. J. G. Jeffreys. Exmouth; Mr. W. Clark. Lamlash Bay; Mr. Bean.

Genus—DENTALINA, *D'Orbigny.*

Nautilus, Linnæus, Walker, Gmelin, Turton, Montagu, Maton and Rackett, Pennant. *Orthocera,* Lamarck, Fleming, Brown, Thorpe. *Vaginulina,* D'Orbigny, Risso, Macgillivray. *Nodosaria,* D'Orbigny, Lamarck, Brown. *Dentalina,* D'Orbigny, Macgillivray, Parker and Jones. *Spirolina,* Brown. *Citharina,* D'Orbigny.

Shell cylindrical, or but slightly compressed; often a little curved; composed of several segments arranged in a linear series. Segments ventricose or flat. Septal lines oblique; constricted; or on a level with the segments. Septal aperture at the salient anterior extremity of the oblique ultimate segment; rarely central, but on the concave side of the arcuate shell.

Dentalina differs from Nodosaria in the frequent curvature of its shell, in the obliquity of its septal lines, and in the unilateral position of its septal orifice; but the separation of these genera is of doubtful propriety. I see no sufficient reason for separating Vaginulina from Dentalina. M. D'Orbigny candidly states that some of his genera of Stichostegues, or Foraminifera with segments arranged in one linear series, have little zoological value; and it does not appear that the number of species is so great as to render the needless introduction of arbitrary divisions desirable, especially as we now find it necessary materially to reduce the number of species. Varieties of *D. Legumen* so clearly establish a transition from the typical form of Dentalina to that of Vaginulina, that it becomes impossible to distinguish these two genera by any constant characters.

DENTALINA SUBARCUATA, *Mont.* Figs. 40—44.

? Gualtieri, 1742. Tab. xix, figs. H, H.
? *Nautilus obliquus,* Lin., 1758. Syst. Nat., 12th ed., p. 1163.
? Martini, 1769. Conch., p. 1, vig. 1, fig. H, *h.*
Soldani, 1789. Test. 2, tab. 94, fig. T; tab. cv, vas. 239, L, M, O; tab. xcvii, vas. 227.
? *Nautilus obliquus,* Turton, 1800-6. Linnæus Syst. Nat., p. 308.
— *subarcuatus,* Mont., 1803. Test. Brit., p. 198, tab. vi, fig. 5.
? — *rectus.* Ibid., p. 197; Suppl., 1808, p. 82, tab. xix, fig. 4—7.
— *jugosus.* Ibid., p. 198, tab. xiv, fig. 1.
? — *costatus.* Ibid., p. 199, tab. xiv, fig. 5; Suppl., p. 83, tab. xix, fig. 2.
— *subarcuatus,* Maton and Rackett, 1807. Lin. Trans. vol. viii, p. 119; Pennant, 1812, vol. iv, p. 250.
— *rectus.* Ibid., p. 249.
— *jugosus.* Ibid., p. 250.
? — *costatus.* Ibid.
— *subarcuatus,* Turton, 1819. Conch. Dict., p. 122.
? — *rectus.* Ibid., p. 121.
— *jugosus.* Ibid., p. 123.
? — *costatus.* Ibid., p. 122.
? — — Wood, 1825. Index Test., p. 64.
— *subarcuatus.* Ibid., p. 65.
? — *rectus.* Ibid., p. 65.
? *Nodosaria costata,* D'Orbigny, 1826. Tableau Méthod., p. 253.
— *rapa.* Ibid., p. 253.
Dentalina communis. Ibid., p. 254.
Orthocera subarcuata, Fleming, 1828. Brit. Anim., p. 236.
? — *recta.* Ibid., p. 236.
— *jugosa.* Ibid., p. 235.
? — *costata.* Ibid., p. 236.
Dentalina communis, D'Orbigny, 1839. For. d. c. Craie Blanche, fig. 4.
Orthocera jugosa, Thorpe, 1844. Brit. Conch., p. 225.

? *Orthocera costata*, Thorpe, p. 224.
? — *costata*, Brown, 1844. Illust. Conch., ed. 2, pl. i, fig. 17, p. 2.
— *septemcostata*. Ibid., p. 2.
— *jugosa*. Ibid., pl. i, fig. 13, p. 2.
? — *recta*. Ibid., pl. i, figs. 16, 19, 20, p. 2.
Nodosaria decemlocularia. Ibid., p. 2.
— *subarcuata*. Ibid., pl. i, fig. 18, p. 2.
Dentalina Badenensis, D'Orbigny, 1846. For. de Vienne, p. 44, tab. i, figs. 48, 49.
— *inornata*. Ibid., p. 44, tab. i, figs. 50, 51.
— *elegans*. Ibid., p. 45, tab. i, figs. 52—56.
— *pauperata*. Ibid., p. 46, tab. i, figs. 57, 58.
— *consobrina*. Ibid., p. 47, tab. ii, figs. 1—3.
— *Boueana*. Ibid., p. 47, tab. ii, figs. 4—6.
— *semiplicata*. Ibid., p. 53, tab. ii, figs. 24, 25.
— *scripta*. Ibid., p. 51, tab. ii, figs. 21—23.
— *semicostata*. Ibid., p. 53, tab. ii, figs. 26—28.
— *antennula*. Ibid., p. 53, tab. ii, figs. 29, 30.
— *urnula*. Ibid., p. 54, tab. ii, figs. 31, 32.
— *elegantissima*. Ibid., p. 55, tab. ii, figs. 33—35.
— *furcata*. Ibid., p. 56, tab. ii, figs. 38, 39.
Nodosaria (*Dentalina*) *communis*, Parker and Jones, 1857. Ann. and Mag. Nat. Hist., vol. xix, p. 10, tab. xi, fig. 1.

DENTALINA SUBARCUATA, *typica*. Figs. 40—41.

Shell elongated; slender; slightly curved; consisting of numerous small ventricose, smooth, oblique, segments. Primordial segment sometimes larger than the second; rounded at its free extremity, or prolonged into a pointed mucro. Ultimate segment sometimes obtuse at its anterior extremity, oblique, with a small septal orifice at its apex, which is on the concave side of the curved shell; and is surrounded by a well-defined coronal of radiating grooves. In others, especially small young shells, the place of this coronal is occupied by a long narrow tubular neck, at the extremity of which is the septal aperture. Septal lines constricted; oblique. Texture hyaline, especially in young shells; very finely foraminated. Length, $\frac{1}{20}$.

This shell varies extremely in the extent of its curvature, in the ventricosity of its segments, and in the obliquity of its septal lines; the latter sometimes traversing the shell at nearly right angles to its long axis. The greatest number of segments I have met with in one individual has been thirteen, but in the specimens of most frequent occurrence they have been from six to nine. Examples occasionally occur in which the segments are larger and fewer in number, the entire shell having a more robust habit and more opaque texture; I was long disposed to regard these as distinct from *N. subarcuata*, but am now convinced that they are merely varieties of that species. Two examples have occurred in which the primordial segment was a double one.

When the shell has a tubular neck terminating its ultimate segment, it appears to be the *Nautilus rectus* of Montagu.

I am satisfied that the numerous species of M. D'Orbigny, quoted above, are nothing more than varieties of this shell, the differences being too slight to justify their separation. Thus he describes his *D. Badenensis* as distinguished from *D. communis* by "ses loges infinement plus longue et plus oblique," whilst his *D. inornata* differs from *Badenensis* by its segments being "beaucoup moins oblique, moins longues, et bien plus convexes" ('Foram. de Vienne,' p. 44), presenting the identical characters, the want of which is supposed to distinguish his preceding example from *D. communis*. The other supposed species are distinguished by points equally trivial; and, as we have already seen, insufficient to constitute specific distinctions. The specimen of this shell, first described and figured by Montagu, has been one in which the anterior segments were more ventricose, and consequently more obvious than the posterior ones; but I have no doubt that it belonged to the present species. M. D'Orbigny's figure of the cretaceous examples of *D. communis* agrees closely with some of these recent forms.

Fig. 41*a* represents a specimen tending to prove that the Foraminifera multiply by fission of the sarcode prior to the calcification of their shell, and the formation of additional segments. The fission has commenced at the inferior part of the primordial segment, and proceeded upwards, but the secretion of the shell has taken place prior to the completion of the process, the two halves being united by the part which remained undivided. The process in this instance has been the reverse of what was described in a specimen of *Entosolenia squamosa*, where the division had commenced at the anterior extremity and proceeded backwards. These two examples indicate that whatever other modes of multiplication may prevail amongst these rhizopods, the germs are liable to fission prior to calcification.

Loc. Weymouth, Tenby, Sandwich, Loch Fine; Mr. J. G. Jeffreys. Plymouth Sound; Mr. S. Bate. Whitehaven; Rev. Mr. Chalmers. Fowey, Skye. Shetland, Arran; Mr. Geo. Barlee. Exmouth; Mr. Kane. Southport; Mr. Clough. Fossil in the Cretaceous strata; M. D'Orbigny. Boston.

Dentalina subarcuata, *var.* jugosa. Figs. 42—44.

Spec. Char. This variety differs from the common form in being costate; again repeating the modifications seen in Lagenæ. Sometimes the costæ are very slight, and chiefly seen in the lower part of each segment. In this state it is the *N. jugosus*, of Montagu, and the *D. semiplicata, semicostata,* and *antennula*, of D'Orbigny. In other examples these striæ are developed into strongly marked and prominent ribs, when it probably becomes the *N. costatus* of Montagu. The latter writer describes the shell as *straight*, which is often the case with small fragments such as he has figured; but when perfect examples are obtained, they are usually as much curved as the common forms of *D. subarcuata*. The costæ are usually continuous, running the entire length of the shell, but they are occasionally discontinuous, as in M. D'Orbigny's *D. bifurcata*. In some instances the costæ are quite straight, as in fig. 43. In others their curves follow the undulations of the shell (fig. 44). Even Montagu came to the conclusion that the variety which he designated

costatus was "subject to very great variation." Texture hyaline in young states, but more opaque in those in which the costæ are strongly developed. Long, $\frac{1}{20}$.

Montagu's *Nautilus spinulosus* appears to represent a form found in the London clay, but which I have not seen in a recent state. I suspect his specimen has been a fossil, washed out of some of the Tertiary beds of the south-east coast of England. It is probably a mere variety of the species under consideration, in which the costæ are interrupted near the septal lines, and developed into acute spines pointed backwards.

DENTALINA LEGUMEN, *Linn.* Figs. 45—49.

? Planchus, 1739. Conch., tab. i, fig. 7.
? Gualtieri, 1742. Test., tab. xix, fig. P.
Nautilus Legumen, Linn., 1758. Syst. Nat., 12th ed., p. 1162.
? Martini, 1769. Conch., i, p. 1, Vign., fig. E *e*.
— *rectus geniculis depressis*, Walker, 1784. Test. Min. Rar., tab. iii, fig. 74.
— *Legumen*, Gmelin, 1789, p. 3373, No. xxii.
— — Turton, 1800-6. Linn. iv, p. 309.
— — Maton and Rackett, 1807. Lin. Trans, vol. viii, p. 118. Turton, 1812, vol. iv, p. 249.
— — Montagu, 1808. Test. Brit., Supplement, p. 82, tab. xix, fig. 6.
— *linearis*. Ibid., p. 87, tab. xxx, fig. 9.
Orthocera Legumen, Lamarck, 1812, vii, p. 595, No. vii, Encycl., tab. cccclxv, fig. 3.
Nautilus Legumen, Turton, 1819. Conch. Dict., p. 121.
— *linearis*. Ibid., p. 123.
— — Wood, 1825. Index Test., p. 65.
— *Legumen*. Ibid.
Vaginulina Legumen, D'Orbigny, 1826. Tableau Méthodique, p. 257.
— — Risso, 1826-27. Eur. Merid., iv, 16.
Orthocera Legumen, Fleming, 1828. Brit. Anim., p. 237.
— *linearis*. Ibid., p. 236.
Vaginulina Legumen, Macgillivray, 1843. Molluscous Anim. Aberd., p. 322.
Dentalina rectiuscula. Ibid.
— *linearis*. Ibid., p. 40.
— *Davidsoni*. Ibid., p. 321.
Orthocera Legumen, Thorpe, 1844. Brit. Mar. Conch., p. 244.
— *linearis*. Ibid., p. 225.
Spiralina Legumen, Brown, 1844. Illust. Conch., ed. 2, Pl. i, figs. 22, 23, p. 1.
Orthocera linearis. Ibid., figs. 14, 15, p. 2.
Vagenulina Badenensis, D'Orbigny, 1846. Foram. de Vienne, p. 64, tab. iii, figs. 6—8.

Dentalina Legumen, typica. Fig. 45.

Spec. Char. Shell smooth, sometimes straight, often slightly arcuate, and sometimes considerably so; slightly compressed laterally; consisting of a linear series of flat, smooth, oblique segments, rarely exceeding twelve in number. Primordial segment abruptly truncate; sometimes cuneiform; occasionally prolonged into a large, solid, transparent mucro, or, in a few examples, two. Peripheral outline entire, and not lobulated; though sometimes having the ultimate segment ventricose and separated from the rest by a deeply constricted septal line. Septal lines smooth, oblique; tending backwards as they approach the convex margin of the shell. Septal aperture at the extremity of the ultimate segment, which extremity is not central, but at the concave margin; surrounded by a well-defined coronal. Texture semi-hyaline, translucent in the centre of each segment; more opaque and milky near the septal lines, which are narrow and translucent. General hue a dirty white. Length, $\frac{1}{10}$.

I quite agree with the late Professor Macgillivray[1] that M. D'Orbigny's genus Vaginulina differs so little from Dentalina that they ought to be united; at least, the *V. Legumen* of that author has no claim to be separated from the latter genus. In his original definition of Vaginulina, M. D'Orbigny states that it is straight, whilst Dentalina is described as curved; but his *V. Badenensis* is described as curved, and is even distinguished by that feature from the other species of the genus. The fact is, our *D. Legumen* presents every variation, from a perfectly straight form to one in which the curvature is considerable. The elongated mucro of *V. Badenensis* does not make the shell specifically distinct from *D. Legumen*, since it is as frequently present in the latter as absent, and in the former it occurs in various degrees of development.

Sometimes this species approaches so closely to robust forms of *D. subarcuata* as to be distinguishable with extreme difficulty; usually the latter is readily recognised by its smaller size, slender tapering form, ventricose segments, deep septal constrictions, and hyaline texture.

Fig. 49 represents a monstrous specimen, in the cabinet of Mr. Barlee, in which gemmation has taken place from the primary segment in two directions, again illustrating the fission of the uncalcified germ already referred to. The specimen described and figured by Montagu as having the anterior end "surrounded by an oblique ridge or margin," is merely an imperfect example in which the greater part of the ultimate segment has been broken away from the penultimate one. In this error Montagu has been followed by nearly all the subsequent British writers, including Dr. Macgillivray. *D. rectiuscula* of Dr. Macgillivray is merely a curved variety of *D. legumen*.

Loc. Same as the next variety.

[1] 'Moll. Anim. Aberdeen,' p. 322.

Dentalina Legumen, *var.* linearis. Figs. 46—48.

Spec. Char. This shell is merely the *D. Legumen,* with the addition of superficial costæ, which are sometimes straight and continuous from one end to the other, at others they are oblique and discontinuous; generally they are confined to the posterior segments of the shell, the anterior ones being smooth, as in *D. Legumen* (fig. 46). In this state we have the *Nautilus linearis* of Montagu. Occasionally they extend over all the segments save the anterior one (fig. 47), constituting the *D. Davidsonii* of Professor Macgillivray. When the costæ are strong and well defined, running the entire length of the shell (fig. 48), it sometimes approaches so closely to the strongly ribbed forms of *D. communis,* var. *jugosa*, as to be distinguished with difficulty; indeed, they have often been confounded. They are only to be identified through the general characters which distinguish the two species. At the same time I confess that I am not free from doubts respecting the propriety of separating *D. Legumen* and its varieties from *D. subarcuata.*

Loc. Barnstaple, Sandwich, Oxwich, Bantry Bay, Tenby, Frith of Forth; Mr. Jeffrey. Skye, Arran, Fowey; Mr. George Barlee. Exmouth; Mr. W. Clarke. Scarborough; Mr. Bean. Belfast Bay; Mr. George C. Hyndman.

Genus—FRONDICULARIA, *Defrance.*

Frondicularia, Defrance, D'Orbigny.

Shell straight; much compressed on its lateral faces; equilateral; oblong or rhomboidal; composed of few segments, all of which are visible in their entire extent, since their margins are in juxtaposition rather than embracing. Primary segment ventricose; subsequent ones more or less sagittate, or triangular. Septal orifice single, at the centre of the narrow anterior extremity of the ultimate segment.

In its structure this genus somewhat approaches Lingulina, but differs in the highly sagittate form of its segments, and in the accuminate anterior extremity of each being fitted into the angular excavation of the posterior border of the segment in front of it, without any overlapping on their lateral faces. Its septal orifice is never an oblong fissure, as in Lingulina.

Frondicularia spathulata, *nob.* Fig. 50.

Shell consisting of three segments; the primary one pyriform and convex; smooth. Second and third segments almost enclosing the primary one on each margin, but not the lateral faces; segments compressed; sagittate; ultimate segment with a septal orifice at its pointed extremity. Septal lines forming raised ridges. Texture hyaline; hue whitish.

I have only seen one specimen of this very rare British species, consequently the above description must be regarded as merely a provisional one, until we are better acquainted with the range of variation in the species. It was found in sand from Sandwich by Mr. J. G. Jeffreys.

FRONDICULARIA ARCHIACIANA Fig. 51.

? *Frondicularia angulosa*, D'Orbigny. For. de Craie Blanche, fig. 39.
— *Archiaciana*. Ibid., figs. 32, 33.

Shell compressed; thin; composed of four segments; the primordial one oval, ventricose, with two elevated longitudinal costæ on each surface. Subsequent segments sagittate, depressed, clasping each other laterally at their superior half; smooth. Septal lines forming strong, raised, superficial ridges.

Like the last, I have seen but one specimen of this shell, also found at Sandwich by Mr. Jeffreys. It only differs from *F. Archiaciana* of M. D'Orbigny in having but two costæ on the primordial segment instead of three. It approaches *F. angulosa* in the latter respect, only in that shell the raised septal ridge of the second segment completely surrounds the primordial one, instead of terminating abruptly at its upper part. I do not think these are sufficient differences to constitute specific distinctions, and consider it probable that these two British Frondiculariæ may be extreme varieties of one species; but until more specimens are discovered they may be admitted to be distinct.

Genus—CRISTELLARIA, *Lamarck*.

Nautilus, Linnæus, Soldani, Adams, Walker, Planchus, Montagu, Maton and Rackett, Pennant, Fichtel and Moll, Turton, Fleming, Brown. *Pharamum*, *Antenor*, *Rhinocurus*, *Clisophontes*, *Lampas*, *Patrocles*, *Robulus*, *Sphincterulus*, *Herion*, *Linthuris*, *Oreas*, *Periples*, *Scortimus*, *Cancris*, *Astacolus*, *Phonemus*; Montfort. *Lenticulina*, Blainville. *Polystomella*, Blainville, Macgillivray, Thorpe. *Cristellaria*, Lamarck, D'Orbigny, Defrance, Parker and Jones. *Robulina*, D'Orbigny. *Orthocera*, Lamarck, Thorpe. *Marginulina*, D'Orbigny. *Spirolina*, Fleming, Brown. *Lenticulites*, Lamarck.

Shell consisting of numerous segments; more or less compressed; usually commencing its growth as a spiral nautiloid shell, with one or more convolutions; but at a later period often projecting its new, oblique, segments in a straight linear series. Spiral growth of the early segments sometimes only represented by a slight disposition towards curvature, and forming even less than half a convolution. When the convolutions in the spiral forms are more than one, the outermost entirely encloses the preceding ones. In the more straight portions the segments only embrace each other, as in Dentalina. Septal aperture single; at the peripheral angle of the septal

plane in the convoluted portions, which angle occupies the *convex* margin of the shell in the straighter forms.

Probably no genus has been the subject of more divisions than the one before us. De Montfort endeavoured to carry out the principle on which such divisions have been founded; but, as subsequent writers have admitted, without success. Cristellaria may be defined as differing from Dentalina in the septal aperture being placed at the angle of the septal plane contiguous to the *convex* side of the curved shell instead of its concave one, and in its great tendency to assume a convolute form when young.

I am unable to separate Marginulina from Cristellaria, as M. D'Orbigny has endeavoured to do. The degree of convolution assumed by the early segments appears an insufficient basis for such a division. Thus his *Cristellaria Berthelotiana* has no greater curvature than his *Marginulina Webbiana;* and in like manner his *Cristellaria cymboides* (Foram. de Vienne) has even a smaller one than his *Marginulina pedium* (idem), or than occurs in numerous other species of the same genus. The variations of the two English species of Cristellaria satisfy me that the characters which distinguish Cristellaria from Marginulina are insufficient to be specific, much less generic ones.

Cristellaria Calcar, *Lin.* Figs. 52—55.

Planchus, 1739. Conch., 2d Ed., p. 85, tab. i, fig. 12, *s.* T V; fig. 13, *z z*; p. 12, tab. i, fig. 3.

Gualt, 1742. Ind. Test., tab. xix, fig. c.

Nautilus Calcar., 1758. Linné, 10th Ed., 12th Ed., p. 1162.

Ledermuller, 1764. Micros., tab. viii, fig. c.

Martini, 1769. Conch. Cab., i, tab. xix, fig. 169; tab. xx, figs. 180, 181.

Schröter, 1783. Einleit., i, pp. 9, 11.

Nautilus spiralis geniculis lævibus, Walker, 1784. Test. Min. Rar., p. 19, tab. iii, fig. 67.

— *Calcar.*, Gmel., 1789, p. 3370.

Lenticula, Soldani, 1789—98, i, p. 54, tab. xxxiii, fig. B &c.; tab. lviii, fig. *h h, m m;* tab. lix, fig. *q q, r r.*

Schreiber, 1793. Conc. Kenntn., i, pp. 2, 11.

Nautilus lævigatulus, Adams, 1798. Mic. Essays, 2d ed., p. 641, tab. xiv, fig. 32.

— *depressulus.* Ibid., p. 641, tab. xiv, fig. 33.

— — Turton, 1800-6. Linn. iv, p. 306.

— *lævigatulus.* Ibid., p. 306.

— *Calcar,* Fichtel and Moll, 1803, p. 69, tab. xi, figs. *a, b, c;* tab. xii, figs. *i, k;* tab. xiii, fig. *c, d, h, i.*

— — var. β. Ibid., p. 72, tab. xi, figs. *d, e, f.*

— — var. ε. Ibid., p. 74, tab. xii, figs. *a, b, c.*

— — var. ζ. Ibid., p. 75, tab. xii, figs. *d, e, f.*

— — var. η. Ibid., p. 76, tab. xii, figs. *g, h.*

— — var. λ. Ibid., p. 78, tab. xiii, figs. *e, f, g;* p. 47, tab. iv, figs. *g, h, i.*

Nautilus Calcar., Montagu, 1803-8. Test. Brit., p. 189, tab. xv, fig. 4; Suppt., p. 76.
— *depressulus.* Ibid., p. 190; Suppl., p. 78, tab. xviii, fig. 9.
— *lævigatulus.* Ibid., p. 188; Suppl., p. 75, tab. xviii, figs. 7, 8.
Lenticulites rotulata, Lamarck, 1804. Annal. Mus. V., p. 188, tab. lxii, fig. 11.
Nautilus rotatus, Maton and Rackett, 1807. Linnean Trans., vol. viii, p. 114; Pennant, 1812, vol. iv, p. 246.
— *lævigatulus.* Ibid., p. 115.
— *depressulus.* Ibid., p. 115.
Pharame perlé, Montfort, 1808, gen. 9, p. 34.
Antenor diaphanus. Ibid., p. 70.
Rhinocurus araneosus. Ibid., p. 234.
Clisiphontes Calcar. Ibid., gen. 57, p. 227.
Lampas Trithemus. Ibid., gen. 61, p. 243.
Patrocles querelans. Ibid., gen. 55, p. 219.
Robulus cultratus. Ibid., gen. 54, p. 215.
Sphincterules costatus. Ibid., gen. 56, p. 223.
Herion rostratus. Ibid., gen. 58, p. 231.
Nautilus depressulus, Dillwyn, 1817. Descript. Cat., p. 341.
— *lævigatulus.* Ibid., p. 341.
— *rotatus*, Turton, 1819. Conch. Dict., p. 118.
— *depressulus.* Ibid., p. 118.
— *lævigatulus.* Ibid., p. 118.
Lenticulina margaritacea, Blainville, 1825. Malac, p. 390.
— *diaphanea.* Ibid., p. 390.
— *araneosa.* Ibid., p. 390.
— *Calcar.* Ibid., p. 390.
— *trithemus.* Ibid., p. 390.
— *querelans.* Ibid., p. 389.
— *cultrata.* Ibid., p. 390.
— *costata.* Ibid., p. 390.
— *rostrata.* Ibid., p. 390.
Nautilus Calcar., Wood, 1825. Ind. Test., p. 63.
— *rotatus.* Ibid., p. 63.
— *lævigatulus.* Ibid., p. 63.
— *depressulus* Ibid., p. 63.
Robulina Calcar., D'Orbigny, 1826. Tableau Methodique, p. 289.
— *cultrata.* Ibid., p. 287. Modèles, No. 82, 4me, livraison.
— *costata.* Ibid., p. 289.
— *aculeata.* Ibid., p. 289.
Nautilus Calcar., Fleming, 1828. Brit. Anim., p. 228.
— *lævigatulus.* Ibid., p. 228.
— *depressulus.* Ibid., p. 228.
Robulina canariensis, D'Orbigny, 1839. Foram. des Canaries, p. 127, tab. iii, figs. 3, 4.

Cristellaria rotulata, D'Orbigny, 1839. Mem. Soc. Géol. France, tome iv, p. 26, tab. xxii, figs. 15—18.

Polystomella depressula, M'Gillivray, 1843. Mollusc. Anim. Aberd., p. 318.

— — Thorpe, 1844. Brit. Mar. Conch., p. 240.

— *lævigatula*. Ibid., p. 240.

Nautilus calcar, Brown, 1844. Illust. of Conch., 2d Ed., p. 1, tab. i, figs. 8—2.

— *lævigatulus*. Ibid., figs. 9—10.

— *depressulus*. Ibid., fig. 3.

Robulina cultrata, D'Orbigny, 1846. Foram. Foss. Bass.Vienn., p. 96, tab.iv, fig.10—13.

Cristellaria Calcar, typica. Figs. 52, 53.

Spec. Char. Matured shell consisting of numerous convolutions; the outermost, which encloses all the rest, being alone visible, consisting of about eight or nine segments; each segment triangular, its umbilical angle terminating a little in front of the transparent umbilicus, giving a peculiar obliquity to the septal lines, which are dark, translucent, frequently straight, sometimes slightly arcuate, often dilating at their peripheral extremity into a small triangular translucent area. At the anterior margin of the ultimate segment this area forms a projecting conical papilla, in the centre of which is the septal aperture (fig. 52). Umbilicus filled up with translucent carbonate of lime, smooth, sometimes very prominent. Peripheral margin entire in British specimens, more or less carinated; but sometimes slightly rounded, especially in old shells. Septal plane sagittate, a little concave in front, with the septal orifice at its peripheral angle, and surrounded by a defined coronal. Hue, in old shells, gray or pale brown, with a whitish margin fringing each side of the dark septal lines and umbilical centre.

Young shell highly transparent, hyaline, with fewer segments than when matured; the transparent septal lines bordered with clear milky white lines. Peripheral carina frequently thin and sharp. Primordial segment round and globose, often large and prominent. Septal lines often much curved; those on the anterior and posterior borders of a segment uniting at its umbilical border, presenting the aspect of a rounded loop. Diam. $\frac{1}{15}$ — $\frac{1}{30}$.

Fichtel and Moll commence their description of this variable species with the following words: "Forma hujus speciei ita comparata est, ejusque varietates tam multiplices, ut fere impossibile videatur characterem specificum erui posse, quo hæc species a reliquiis congeneribus distingueretur, et tamen nulla varietas excluderetur" (*loc. cit.*), eliciting the remark from Montagu, that if the varieties figured by him are to be admitted as the same species, "we may bid defiance to specific definition." Nevertheless Fichtel and Moll are most probably right. In its fully matured state, this shell is the *N. lævigatulus* of Montagu. Owing to the inner angles of the segments not terminating at the umbilical centre, but a little in front of it, the contiguous portions of the last septum approach the carinal margin of the shell, the tendency to do so becoming more marked with increase of age, and not unfrequently producing the exaggerated condition which Montagu represents in his figure of *N. lævigatulus*. In young shells we frequently see the conditions described by authors, especially Montagu, in his 'Supplement,' under the name of *Nautilus*

depressulus, which appears to belong to this species, since he distinctly refers to the semipellucid spot occupying the umbilical centre; otherwise some of his remarks apply to the *Nonionina umbilicatula*.

Maton and Rackett deny that the English shell is the *N. Calcar* of Linnæus. But the very brief Linnean description appears to be as applicable to our British forms as to any other. Consequently, though not absolutely certain that Linnæus had our shell in view, it is desirable to avoid altering a name which has been employed by all subsequent authors who have unquestionably applied it to this species.

Loc. Skye, Arran, Shetland, Fowey; Mr. George Barlee. Weymouth, Swansea, Sandwich, Bantry Bay, Loch Fine, Crowlin; Mr. J. G. Jeffreys. Margate; Mr. Rupert Jones. Scarborough, Lamlash Bay; Mr. Bean. Plymouth Sound; Mr. Spence Bate.

CRISTELLARIA CALCAR, *var.* ROTIFER. Fig. 54.

Spec. Char. Septa and connecting spirals developed into thick, prominent, superficial ridges. Peripheral margin carinated.

Loc. Scarborough; Mr. Bean.

This specimen accords with the description of *Nautilus Calcar* given by Linnæus. Somewhat similar examples from Weymouth, Manorbeer, and Sandwich, are in Mr. Jeffreys' cabinet, but in them the raised ridges are confined to the radiating septa, besides being much less prominent and well defined. Several of the examples described by Fichtel and Moll exhibited prominent septa.

CRISTELLARIA CALCAR, *var.* OBLONGA. Fig. 55.

Spec. Char. Several specimens exist in Mr. Jeffreys' cabinet in which the shell has grown for a time in the ordinary nautiloid form, but has subsequently shot out in a straight or curved line as in *Cristellaria subarcuatula*. The specimen figured exhibits this tendency less than some others in which the produced part contains as many as ten segments in addition to the spiral ones. The septal lines are usually prominent. In the above specimen this is chiefly the case at the inner margin, where each segment overhangs its predecessor as a thick plication. Irregular longitudinal ribs are sometimes present. Hue, opaque brown. Length, $\frac{1}{8} - \frac{1}{12}$.

A shell,[1] somewhat resembling this variety, is common in the London clay. Some of a series of specimens, for which I am indebted to Mr. Rupert Jones, approach it so closely as scarcely to justify their specific separation.

[1] *Marginulina Wetheralii*, auct.

Loc. Weymouth, Manorbeer, Sandwich; Mr. J. G. Jeffreys.

I strongly suspect that several others amongst M. D'Orbigny's species of Cristellaria belong to *C. Calcar*, especially *C. similis*, *inornata*, and *simplex* ('Foram. de Vienne'). If I am correct in accepting the decisions of Fichtel and Moll as to the wide range of variation in *C. Calcar*, the distinctions upon which M. D'Orbigny has separated the above species are such as entitle them to no higher rank than subordinate varieties of the same shell.

CRISTELLARIA SUBARCUATULA, *Walker*. Figs. 56—67.

Nautilus spiralis apertura lineari geniculis elevatis, Walker, 1784. Test. Min. Rar., fig. 66, p. 19.
— *oblongus carinatus apertura lineari ovali*. Ibid., fig. 72, p. 20.
— *subarcuatus geniculis exertis*. Ibid., fig. 73, p. 20.
Nautili lituitati, Soldani, 1789. Test., i, tab. lviii, *aa, bb, cc, dd*.
Adams, 1798, p. 640, tab. xvi, fig. 31.
Ibid., p. 642, tab. xiv, fig. 37.
Ibid., p. 642, tab. xiv, fig. 38.
Nautilus subarcuatulus, Mont., 1808. Test. Brit. Suppl., tab. xix, fig. 1, p. 80.
— *carinatulus*, Mont., 1803. Ibid., p. 195.
— *bicarinatus*, Mont., 1808. Ibid., p. 86.
— *crepidula*, Fichtel and Moll, 1803. Test. Micros., p. 107, tab. xix, figs. *g, h, i*.
— *subarcuatulus*, Maton and Rackett, 1807. Linnean Trans., vol. viii, p. 119; Pennant, 1812, vol. iv, p. 250.
— *carinatulus*. Ibid., p. 118; Pennant, p. 249.
Astacolus crepidulatus, Montfort, 1808, p. 263.
Nautilus subarcuatulus, Turton, 1819. Conch. Dict., p. 121.
— *carinatulus*. Ibid., p. 120.
— *bicarinatus*. Ibid., p. 123.
— — Wood, 1825. Ind. Test., p. 65.
— *carinatulus*. Ibid., p. 64.
Spirolina subarcuatula, Fleming, 1828. Brit. Anim., p. 227.
— *carinatula*. Ibid., p. 228.
Marginulina Webbiana, D'Orbigny, 1839. For. des Canaries, p. 124, pl. i, figs. 7—11.
Cristellaria Berthelotiana. Ibid., p. 127, pl. i, figs. 12, 13.
Spirolina subarcuatula, Thorpe, 1844. Brit. Mar. Conch., p. 228.
— *carinatula*. Ibid., p. 229.
Orthocera bicarinata. Ibid., p. 225.
Spirolina subarcuatula, Brown, 1844. Illust. Conch., 2d Ed., p. 1, tab. i, fig. 27.

Cristellaria subarcuatula. Figs. 56—62.

Spec. Char. It is almost impossible, by any verbal description, to indicate the specific features of this most variable shell. It essentially consists of a few compressed, convoluted segments, with an additional series projected in a straight line, and also compressed. Sometimes the convoluted part consists of seven or eight segments, which form a complete convolution (figs. 58 and 60), approximating to young states of *C. Calcar;* a form represented in Walker's figure 66; at others, the primary segment is so nearly terminal as almost to resemble forms of *Dentalina Legumen*. The umbilical angles of the segments of the straight or projected part may all reach the convoluted ones, as in fig. 58; or they may be detached as in fig. 62, a thin lamellated carina fringing the posterior ones, alone indicating the tendency in this type to approximate towards the previous one. These modifications also affect the obliquity of the segments and septal lines, as well as the straightness or curvature of the produced part. Whilst the shell is always somewhat compressed laterally, it varies considerably in the thickness of the outer and inner margins, as also in the degree to which they become carinated. Sometimes both are thin and carinated, it is then the *N. bicarinatus* of Montagu; at others, the outer margin is carinated and the inner one obtuse, when it is the *N. subarcuatulus* of Montagu; more frequently both margins are obtuse, the inner one being much thicker than the outer one, so that the septal plane forms a broad triangle. A specimen from the cabinet of Mr. Jeffreys, represented in figs. 60, 61, exhibits an extreme modification of this type, where the inner margin is not only thick but concave, each of its two angles being carinated. In this specimen the outer margin is also carinated, a form that might be recognised as a distinct variety under the name of *C. subarcuatula*, var. *scapha*.

All these varieties are smooth on their external surfaces. The segments are usually flat, but sometimes slightly ventricose. Septal lines sometimes depressed; occasionally elevated into ridges. Septal orifice at the peripheral angle of the ultimate segment, in the centre of a small conical papilla, and surrounded by a well-defined coronal. Texture remarkably hyaline in young forms; septal lines becoming margined with milky white by age, and not unfrequently very old specimens occur which are opaque and of a dirty white.

The *Nautilus carinatulus* of various authors is but a very young individual of this species, in which but two or three triangular segments have been added to the ventricose primordial one. Fig. 57 represents a curious monstrosity, in which the development by gemmation has proceeded in the ordinary way through a succession of segments, but in the last two the direction has been reversed, their septal orifices being situated on the opposite margin to that which they occupy in all the preceding ones, the curvature of the shell and direction of the septal lines being likewise reversed. This specimen, which is from Lamlash Bay, is in the cabinet of Mr. Bean, of Scarborough. Fig. 58 displays some remarkable points of resemblance to a well-known geometric figure, the logarithmic spiral; the peripheral outline representing the curves, the interseptal lines the radii, and the segments the several areas.

Loc. Skye, Fowey, Arran, Shetland, Brixham, Burrow Island; Mr. George Barlee. Weymouth, Tenby, Swansea, Cork; Mr. J. G. Jeffreys. Scarborough; Mr. Bean. Southport; Mr. C. Clough. Plymouth Sound and Eddystone; Mr. S. Bate. Boston.

Cristellaria subarcuatula, *var.* costata. Figs. 63—67.

Spec. Char. Though the specimens represented by the above figures differ so materially from those just described, I have no hesitation in referring them to the same species. They exhibit less of the disposition to become convolute than is usual in the smooth varieties, but forms of the latter frequently occur in which the segments are scarcely, if at all, convoluted, and in which the primordial segment occupies the extremity of the shell as distinctly as in figs. 65 and 67. The latter, indeed, exhibits one of the most ordinary of the smooth contours. We have already seen that the presence or absence of costæ affords no evidence of specific distinction, and the variation of their number, from the three lateral ribs of fig. 63 to the numerous delicate lines of fig. 67, have their connecting links in figs. 64, 65, and 66. These forms manifestly establish the union of D'Orbigny's genus Marginulina with Cristellaria, since so large a proportion of the examples of *C. subarcuatula* ought, according to the French naturalist's definition of the genus Marginulina, to be placed in the latter. But a *species* cannot be split and distributed through different *genera*. Length, $\frac{1}{16}$—$\frac{1}{35}$.

Loc. Weymouth, Sandwich; Mr. J. G. Jeffreys.

I have not included several synonyms from the works of M. D'Orbigny in the list at the head of this species, not because I doubt the propriety of placing there several of the Marginulinæ and Cristellariæ, but from the utter impossibility of deciding upon the limits of variation in this marvellously protean shell; consequently I will not undertake to determine the relations of forms with which I am only acquainted through plates. There are some Foraminifera in which the varieties are so marked that it is almost impossible to avoid recognising them, even when imperfectly represented by the artist. But it is not so with the Cristellariæ, the most variable and ill-defined of all the groups. Some British examples occur which almost connect *C. subarcuatula* with *C. calcar*, but for the present we must regard the latter as distinct.

Genus—NONIONINA. *D'Orbigny.*

Nautilus, Linne, Walker, Gmelin, Adams, Montagu, Maton and Rackett, Pennant, Fichtel and Moll, Turton, Fleming, Brown, Wood. *Chrysolus, Melonis, Nonion, Macrodites, Florillus*, Montfort. *Cristellaria, Pulvinulus*, Lamarck. *Placentula*, Lamarck, Blainville. *Polystomella*, Blainville, Macgillivray, Thorpe. *Operculina*, D'Orbigny, Carter. *Nonionina*, D'Orbigny, Parker and Jones. *Assilina*, D'Orbigny. *Lenticulites*, Basterot.

Spec. Char. Shell free; spiral, regular, equilateral; orbicular, suborbicular, or discoidal. Peripheral margin rounded or angular. Inner convolutions usually exposed; sometimes hidden by the outermost one. Septal orifice single; at the inner border of the septal plane, contiguous

to the peripheral margin of the preceding convolution. Segments increasing regularly in size from the primordial to the ultimate one.

It will be observed that I have included in the genus Nonionina the Nonioninæ, Operculinæ, and Assilinæ of D'Orbigny, being convinced that it is impossible to separate them, save in the most arbitrary manner; the characters relied upon by M. D'Orbigny for that purpose being too variable and uncertain to justify a division. The genus thus constituted is readily recognised by its equilateral contour, by the position of its single septal orifice, and by its undivided segments. The only one with which it can be confounded is Nummulina, from which it differs in the absence of that contraction of the ultimate segments which gives to matured specimens of the latter their circular discoidal form.

NONIONINA BARLEEANA, *nob.* Figs. 68, 69.

Nonionina crassula, Parker and Jones, 1857, p. 14, pl. xi, figs. 6, 7.

Spec. Char. Shell spiral, equilateral, compressed, smooth, flattened; outermost convolution consisting of from nine to twelve smooth segments, which become truncated on each side before reaching the umbilicus, leaving a deep, abrupt, umbilical cavity, within which portions of antecedent convolutions are visible. Peripheral margin rounded. Septal plane with rounded margins; septal orifice in the median line, at the junction of the septum with the periphery of the preceding convolution; septal lines slightly curved, somewhat depressed, smooth, and often translucent. The rest of the parietes foraminated, giving the shell a slightly granular aspect. Hue, yellowish gray, frequently becoming ash-gray or lead-coloured; slightly glistening. Diam. $\frac{1}{40}$.

I have dedicated this species to Mr. George Barlee, to whose indefatigable employment of the dredge, British conchologists have been so largely indebted. When I first met with specimens in sands collected by that naturalist, they were apparently new to science; but since the above description was penned, Messrs. Parker and Jones have found the shell in Norwegian sands, and believing it to be identical with the *N. crassula* of preceding writers, they have assigned that name to it. With this conclusion I can scarcely agree, because of the wide difference between my specimens and Montagu's figure of *N. crassula*. The descriptions of the older writers are often so brief, that it is almost impossible to say what shells were indicated by them. Walker's specimens were obtained from Reculvers Bay, on which coast what I believe to be the true *crassula* is very abundant; whereas the present appears to be a northern species, Scarborough being the most southern locality whence I have seen it obtained, and there it is very rare—an additional reason for doubting the identity of the latter with *N. crassula*.

Loc. Skye, Stornoway, Shetland; Mr. George Barlee. Scarborough, very rare; Mr. W. Bean.

NONIONINA CRASSULA, *Walker*. Figs. 70, 71.

Nautilus, crassus utrinque umbilicatus geniculis lineatis, Walker, 1784. Test. Min. Rar., fig. 70, p. 20.
— *crassulus,* Turton, 1800-6. Lin. Syst. Nat.
— — Mont., 1803. Test. Brit., p. 191; 1808, Supplement, p. 79, tab. xviii, fig. 2.
— — Maton and Rackett, 1803. Lin. Trans., viii, p. 117.
— — Pennant, 1812. Brit. Zool., vol. iv, p. 248.
— — Turton, 1819. Conch. Dict., p. 119.
— — Wood, 1825. Index Test., p. 63.
Nonionina crassula, D'Orbigny, 1826. Tableau method., p. 294.
Nautilus crassulus, Fleming, 1828. Brit. Anim., p. 229.
Nonionina Germanica, Ehrenberg, 1840, Trans. Royal Acad. Berlin; 1840, Taylor's Scientific Memoirs, vol. iii, p. 357, tab. vi, fig. 1.
Polystomella depressula, Macgil., 1843. Moll. Anim. Aberdeen, p. 318.
— *crassula,* Thorpe, 1844. Brit. Mar. Conch., p. 241.

Spec. Char. Shell compressed, with about nine somewhat ventricose segments in each convolution. Umbilical borders of the segments not quite extending to the centre of the umbilical regions, but leaving a slight umbilical depression on each side of the shell. Internal convolutions usually concealed by the outer one, excepting when the transparency of the parietes admits of their being seen, as is occasionally the case. Peripheral margin thick, rounded, lobulate. Septal lines depressed, narrow, often sharply excavated near the umbilicus, and frequently presenting a dark line, bordered on each side with one of milky white. Septal plane cordate, convex. Septal orifice transversely oblong, close to the periphery of the preceding convolution. Texture sub-hyaline, translucent, excepting along the septa and the umbilical regions, which are white and opaque; the latter often slightly ferruginous. Diam. $\frac{1}{35}$.

This is one of the smallest as well as the most common of the equilateral nautiloid Foraminifera. Montagu does not appear to have distinguished between it and the *Polystomella umbilicatula,* confounding the two, and constituting out of their varieties his *N. umbilicatulus* and *crassulus*. Indeed it is very difficult to distinguish the Nonioninæ from the Polystomellæ in some instances, even with the aid of a good microscope; since in neither can the septal orifices be seen until sections of the shell are mounted in Canada balsam, and thus rendered transparent. The Nonionina may, however, be generally distinguished from the Polystomella by the absence of the transverse crenulations fringing the septal lines. In some specimens the diameter of each convolution is not above one fourth that of the entire shell, so that the umbilical region becomes very large. In this state it resembles Walker's defective figure 70, and is doubtless the *N. crassulus* of authors, and which Montagu describes as "pale brown," a hue which, as already observed, this shell sometimes presents. The sands brought from Beechey Island, by Dr. Sutherland, contain numerous specimens of a shell not distinguishable from this form; if it be the same, the Polar seas would appear to be the true home of the species, since it there attains a much larger

size than on our English coasts. In this, as in numerous other instances, I have observed that a species may exist in vast numbers in localities where the circumstances are unfavorable to the development of the individuals, which are all of small size. The post-tertiary deposit of Boston, so rich in beautiful forms, affords an illustration. In it, though such shells as *Rotalia Beccarii* and *Polystomella crispa* abound, they are none of them larger than the small specimens of the species under consideration, and which is abundantly associated with them. The conditions have not been favorable to their attaining their full development. The "minute pore" in the centre of the anterior septal plane of the ultimate segment, described by Professor Macgillivray, is accidental. I have not seen any specimens exactly answering to his *P. nautilina*, but suspect that it belongs to this species; as was certainly the case with his own examples, which, through the kindness of Miss Macgillivray, I have been permitted to see.

Loc. Found almost everywhere on the coast, though in unequal quantities. Abundant at Feversham; Mr. Matthew Marshall. Also on the Devonshire coast and in the Boston and March deposits.

NONIONINA JEFFREYSII, *nob.* Figs. 72, 73.

Spec. Char. Shell very much compressed; outer convolutions slightly embracing the more internal ones, and consisting of seven or eight flattened segments. Segments with their lateral surfaces triangular, suddenly constricted near each umbilical border by a peculiar inflexion of the septal lines, which are depressed and peculiarly flexuose. Umbilicus large, excavated, revealing some of the inner convolutions. Peripheral border rounded; slightly lobulated. Septal plane slightly cordate; convex; projected forward immediately external to the periphery of the antecedent convolution; its umbilical angles receding. Septal orifice small; transversely oblong; invisible, except when mounted in Canada balsam and viewed by transmitted light; surrounded by a thin margin, which projects forward like a short siphuncle. Texture arenaceous. Hue varying from a dirty grayish-yellow to the richest Sienna brown; the latter especially occurring in young shells. The grains of sand imbedded in the parietes appearing as dark translucent specks, inlaid in a brown opaque cement. Diam. $\frac{1}{30}$.

This beautiful species appears to be new to science; consequently I feel free to dedicate it to J. G. Jeffreys, Esq., late of Swansea, whose zealous and successful cultivation of conchological science is so well known in scientific circles. The striking contour, arenaceous texture, and rich colour of this shell at once distinguish it from all other species. In specimens received from Davis's Straits, the grains of sand are large, prominent, and irregular. In our British forms they are more usually minute flat scales, which do not mar the regular contour of the shell.

Loc. Skye, Arran, Fowey, Shetland, Brixham; Mr. George Barlee. Exmouth; Mr. W. Kane. Torquay; Mrs. Brett. Plymouth Sound; Mr. Spence Bate. Cullercoats; Mr. J. Alder. Southport; Mr. C. Clough. Whitehaven; Rev. Mr. Chalmers. Hunde Island, Davis's Straits; Dr. Sutherland.

Messrs. Parker and Jones have figured and described a Foraminifer (' Annals and Mag. Nat. Hist.,' 2d ser., vol. xix, p. 29, tab. x, figs. 13, 14) which appears closely related to the present species, though it is much less compressed than our British examples. The Arctic varieties above referred to are, in this respect, intermediate between the two. These authors remark that the convolutions "commence in a spiral arrangement, but sooner or later go off in a straight direction, with much irregularity. The aperture in the nautiloid forms is usually near the lower part of the chamber, but occasionally almost central." They also observe that "the aperture in the straight part of the crozier-shaped individuals is central and usually round. In all cases the aperture is faintly lipped."

The arenaceous texture and the marginated border of the septal orifice, referred to in this description, indicate the close relations of the Norwegian and British forms; but amongst the latter I have never seen an example presenting the crozier-shaped aspect or the central orifice, consequently I do not at present feel justified in removing them from the genus Nonionina. Messrs. Parker and Jones refer their shell to the genus Placopsilina, in which D'Orbigny has arranged some *fixed* Foraminifera. These authors append to their species the following synonyms:

Placopsilina Canariensis, Parker and Jones, *ut suprà*, p. 29, tab. x, figs. 13, 14.

Free.
- *Nucleus minusculus limosus*, &c., Soldani. Saggio. Orittograf., p. 99, tab. i, fig. 10.
- *Nonionina Canariensis*, D'Orb. Hist. Nat. Canaries, p. 128, pl. ii, figs. 33, 34.
- *Spirolina æqualis, S. lagenalis, S. irregularis*, Roemer. Nord. Kreid., p. 98, pl. xv, figs. 27—29.
- *Spirolina irregularis*, Reuss. Böhm. Kreid., i, p. 35, pl. viii, figs. 62—66, 75.
- — *agglutinans*, D'Orb. Foss. Vien., p. 137, pl. vii, figs. 10—12.
- — *Humboltii*, Reuss. Zeitsch. deutsch. geol. Ges., iii, p. 65, pl. iii, figs. 17, 18.

Nonionina silicea, Schultze. Müller's Archiv f. Anat., 1856, pl. 171, p. vi B, figs. 4—6.

Œufs de Mollusques, Cornuel. Mém. Soc. Géol. France, 2 sér., iii, pl. iv, fig. 36.

Placopsilina scorpionis? D'Orb. Prodrome Paléont., i, p. 259, No. 283.

— *Cenomana?* Ibid., p. 185, No. 758.

— — Reuss. Vienna Trans., vii, p. 71, pl. xxviii, figs. 4, 5.

NONIONINA ELEGANS, *nob.* Figs. 74, 75.

Operculina complanata, 1857, Parker and Jones, p. 13, tab. xi, figs. 3—4.

Spec. Char. Shell much compressed, equilateral, revealing all the convolutions and even the primary segment. Convolutions slightly clasping; outermost one consisting of from nine to twelve segments, which are more or less ventricose laterally, and separated from each other by very thick, elevated septal ridges. Segments opaque, and of a dirty-white hue. Raised septal lines usually dark and translucent, often flexuose, their thickened ridges being prolonged round the peripheral margin of each segment, and combining to form a thick, obtuse, translucent peripheral carina to the entire shell. Septal plane oblong, with thickened margins. Septal orifice oblong, transverse, contiguous to the peripheral margin of the preceding convolution. Diam. $\frac{1}{45}$.

This shell combines some of the characteristics of D'Orbigny's genera Assilina and Operculina. It has the transverse septal plane of the former, and very frequently the peculiar abrupt constriction of the segments near the septal aperture, which, with the triangular septal orifice, characterises the latter. The fact that this constriction is as often absent as present in the same species destroys its generic value; and as I cannot assign a greater value to the triangular form of the aperture, I am led to conclude that Assilina and Operculina ought not to be disunited from Nonionina.

Nonionina elegans will be readily distinguished from all other English forms by its flattened contour; its visible central convolutions, its thick, pellucid, usually dark-coloured, undulating, septal ridges, and its thickened peripheral margin. Messrs. Parker and Jones found this species in Norwegian sands, and believed it to be identical with the fossil Tertiary *Operculina complanata*. None of the numerous specimens of *Nonionina elegans* in my cabinet tend to confirm this identification; consequently I have retained the species as a new one.

Loc. Skye, Arran, Stornoway Shetland; Mr. George Barlee. Scarborough; Mr. Bean.

Genus—NUMMULINA. *D'Orb.*

Nautilus, Soldani, Forskall, Fichtel and Moll. *Ammonites,* Planchus, Soldani. *Helicites,* Gesner, Guettard, Bosc, De Blainville. *Camerina,* Bruguière, Bosc, Cuvier, Hericort de Thury. *Discolithes,* Fortis. *Phacites,* Blumenbach. *Nummulites,* Lamarck, De Roissy, Defrance, Joly and Leymeric, D'Orbigny, Catullo, Michelotti, De Blainville, Deshayes. *Nummulina,* D'Orbigny, D'Archiac and Haime, Michelotti, Bronn, Galeotti. *Lenticulites,* Schlotheim, Lamarck, Defrance, Rütimeyer. *Nummularia,* Sowerby, Parkinson. *Egeon,* De Montfort, *Assilina,* D'Orbigny.

Shell free, spiral, equilateral, regular, discoidal; the convolutions usually very narrow. Convolutions embracing; the last hiding the preceding ones by its extension to each umbilicus. Segments numerous; short, narrow; those last formed in matured shells being contracted at their peripheral margin, causing the ultimate convolution to lose itself in the penultimate one. Septal orifice single at the inner border of the septal plane, and in contact with the peripheral margin of the preceding convolution.

In thus continuing to separate Nummulina from Nonionina I have rather evaded difficulties than removed them. I doubt the propriety of the measure. D'Archiac and Haime, with other authorities, have distinguished the former from the latter by the rapid construction of the ultimate segments in the matured shell—a character sufficiently important for the purpose, if restricted to the true Nummulinæ, since it indicates a point in the growth of the organism at which development is permanently arrested; whereas in Nonionina such obviously arrested growth is of rare occurrence. But it is occasionally seen in that genus; consequently I should unhesitatingly have incorporated

Nummulina with Nonionina, but for other difficulties rendering such a course undesirable. The abandonment of the generic term, Nummulina, would, as D'Archiac and Haime have suggested (op. cit., p. 70), introduce serious confusion amongst the geologists by whom the word is and has long been universally employed; indeed, I doubt if such a change would have been possible, however strong the abstract reasons for it. Consequently, as the character relied on by D'Orbigny, D'Archiac and Haime, and others, is of more frequent occurrence in Nummulina than in Nonionina, I have retained the genus for the present. At the same time it must be remembered that *young* Nummulinæ are in all essential respects undistinguishable from Nonioninæ. MM. D'Archiac and Haime believe that Nummulina differs from all recent Foraminifera in possessing no septal aperture in the septal plane of the ultimate segment, which condition would prevent all communication between the external world and the contained sarcode, save what took place through the protruded and coalesced pseudopodia. The aperture, though minute, and consequently readily masked by the process of fossilization, certainly exists as in the Nonioninæ.

The diversified layers of which the shell consists, according to Messrs. Joly and Leymerie and D'Archiac and Haimes, have no existence in the recent species, in which the texture is homogeneous as in the other Foraminifera. The "vitreous layer" of the above authors is merely a condition due to fossilization, as the latter writers have suggested may be the case (op. cit., p. 60). The parietal canals described in fossil Nummulites by Dr. Carpenter, and by myself in some other recent Foraminifera, appear in the recent Nummulite. It follows from the above observations that the only characters distinguishing Nummulina from Nonionina and other Foraminifera are those indicated by M. D'Orbigny, viz., the tendency to assume a lenticular form, and the disposition to a gradual restriction of the ultimate segment *in adult animals*—characters of doubtful value in the establishment of separate genera.

NUMMULINA PLANULATA, *Lam.* Figs. 74, 75.

Helicites, Guettard, 1770, vol. iii, pl. xiii, fig. 28.
— Burtin, 1784, pl. xxii, figs. *a? r, c.*
Phacites fossilis, Blumenbach, 1796-9, pl. xl, fig. 1.
Discolithes γ, Fortis, 1802, vol. ii, p. 99, pl. i, figs. *e, f, g.*
Lenticulaire numismale, Deluc, 1803, vol. 56, p. 339.
Lenticulites planulata, Lam., 1804, vol. v, p. 187, No. 1.
— *variolaria.* Ibid., p. 187, No. 2.
— *variolaris*, Schlotheim, 1820, p. 92.
— *planulata.* Ibid., p. 94.
— — Defrance, 1822, fig. 1 *a, b*, p. 452.
— *variolaria.* Ibid., p. 452.
Nummulina planulata, D'Orb., 1826, vol. vii, p. 129.
Nummularia variolaria, Sowerby, 1829, vol. vi, p. 76, pl. dxxxviii, fig. 3.
— *elegans.* Ibid., p. 76, p. dxxxviii, fig. 2.
Nummulina — Galcotti, 1837, vol. xii, p. 141.
— *planulata.* Ibid., p. 141.
Lenticulites variolaria, Bronn, 1838, p. 1142.

Lenticulites variolaria, D'Archiac, 1837 and 1839, vol. ix, p. 68, and vol. x, p. 200.
Nummulites planulata. Ibid., 1839, vol. x, p. 183.
— *elegans*. Ibid., 1846.
— *variolaria*. Ibid., vol. ii, p. 199.
— *planulata*, Rouhault, 1850, vol. iii, p. 465.
— *variolaria*, Rütimeyer, 1850, p. 102.
— *planulata*, D'Orbigny, 1850, vol. ii, p. 335.
— — Rütimeyer, 1850, p. 102.
— *elegans*. Ibid., p. 102.
— *variolaria*. Ibid., p. 102.
— — D'Archiac, 1850, vol. iii, p. 244.
— *elegans*. Ibid., p. 236.
— *planulata*. Ibid., pp. 240 and 304 *h*.
Nummulites variolaria, D'Orbigny, 1850, vol. ii, p. 427.
— — D'Archiac and Haime, 1853, p. 142, tab. ix, figs. 5—10.
— *planulata*. Ibid., p. 146, tab. ix, fig. 13.

Shell lenticular, smooth. Outermost convolution entirely investing, and projecting but little beyond those previously formed; consisting of numerous narrow segments; in large specimens from twenty-two to twenty-four segments appearing in each convolution. Septal lines smooth, or but little raised; translucent; often dark; radiating; straight; disappearing at the peripheral margin. Umbilical region prominent; truncate; consisting of smooth, transparent shell, from which the translucent septal lines radiate, and within which traces of the internal convolutions are perceptible. Septal plane highly sagittate. Umbilical angles long, narrow, reaching to the umbilicus, though the internal cavity of each segment stops short of it; the remaining prolongation consisting of solid transparent shell, through which the details of the next convolution are distinctly visible (see fig. 74). Umbilical margins of the segments sometimes stopping very far short of the umbilicus, such segments being intercalated between others which approximate near the umbilicus, thus causing some of the septal lines to dichotomize as they proceed to the periphery. Peripheral margin narrow, but obtuse and rounded. Septal orifice close to the peripheral margin of the preceding convolution, and surrounded by a thickened margin; but, from its small size, rarely visible until the specimens are mounted in balsam. Diam. $\frac{1}{12}-\frac{1}{16}$.

This elegant little species is at once distinguished from all other British types by its lenticular form, its smooth exterior, translucent radiating septal lines, bright brown colour, translucent, truncate umbilicus, and the very trifling projection of the outermost convolution beyond its predecessor. In some specimens the septal plane of the last segment is much smaller than in the one delineated, causing the convolution almost to appear continuous with that which it encloses. Sections of the shell reveal all the branching intra-septal and parietal tubes which Dr. Carpenter has shown to exist in the fossil Nummulites. ('Proceedings of the Geological Society of London,' May, 1849; and which I have described in connection with Faugasina and other genera, 'Trans. Microscopic. Soc.,' Lond., vols. iii and iv.)

These facts leave no room for doubting that this little shell is really a living, and the only recorded, representative of a genus which constitutes so important and widespread a feature in the

fauna of the Tertiary epoch. But further than this; I am quite satisfied that the form is undistinguishable from one occurring in the Tertiary strata of Bracklesham, Ernsworth, Belgium, and Vienna, and which has received the several names of *N. elegans*, *planulata*, *variolaria*, and *radiata*. That the first two of these are identical is recognised by Mr. Rupert Jones and Sir Charles Lyell;[1] but I am also convinced that *N. planulata* and *variolaria* are mere varieties of the same, the small superficial tubercles of the latter being but irregular developments of the septal lines of the former. Illustrations of the extent to which this irregular development may be carried within the limits of one species, is well shown in the fine Operculina so common in the Indian seas and in the vicinity of the Philippine Islands; these shells display every condition intermediate between those specimens in which all the septal lines are smooth, depressed, and translucent, and others in which they appear as moniliform ridges; a similar series can be shown to unite the two Nummulites in question. *Nummulina radiata* of M. D'Orbigny is undoubtedly the *Nummulites planulata* of previous writers.

This identification of a living British species with forms hitherto thought to characterise some of the lower, or Eocene, members of the Tertiary strata,[2] is a fact of some value to geologists, warning them against precipitate conclusions respecting the vertical range of any species, deduced from the study of limited geographical areas. *Nummulina planulata* lived in the seas flowing over England and Belgium, when its companions were the Gavials, the sea-serpents, and the gigantic sharks of that Tropical period. These have disappeared under chilling influences which have been equally fatal to the Cones, the Cerithia, the Mitres, and the Volutes, by which they were surrounded The microscopic Nummulite, less affected by external conditions than its extinct and more highly organized contemporaries, still lingers amidst the new inhabitants of its ancient home. But where it once abounded it is now rare; like the scattered remnants of some ancient race, struggling in unequal conflict with advancing civilization, having a glorious history, but doomed to destruction.

Loc. Portsmouth; Mr. J. G. Jeffreys. Scarborough; Mr. Bean.

Genus—POLYSTOMELLA, *Lamarck.*

Nautilus, Linnæus, Favanne, Walker, Soldani, Adams, Gmelin, Schreibers, Fichtel and Moll, Montagu, Maton and Rackett, Pennant, Parkinson, Turton, Brown, Fleming. *Andromedes*, *Cellanthus*, *Sporilus*, *Themeon*, *Pelorus*, *Geoponus*, *Elphidium*, Montfort. *Polystomella*, Lamarck, D'Orbigny, Risso, Deshayes, Poitiez and Michaud, Williamson, Brown, Macgillivray, Thorpe. *Vorticialis*, Blainville. *Geoponus*, Ehrenberg. *Polystomatium*, Ehrenberg.

Shell free; equilateral; regular; nautiloid; consisting of numerous convolutions; the outermost convolution usually embracing all the preceding ones. Each convolution containing numerous segments, the posterior margins of which are more or less adorned with many transverse crenu-

[1] Lyell on the Tertiary Strata of Belgium and French Flanders, 'Quarterly Journal of Geol. Soc.,' London, vol. viii, p. 350.

[2] Sir C. Lyell, op. cit., p. 336.

lations, which terminate abruptly at the preceding septal line. The elevated ridges of these crenulations indicate the position of tubular retral prolongations of the internal cavity of the segment, which are occupied by corresponding prolongations of sarcode. Umbilical region often marked with small depressed pits, the orifices of vertical internal passages, through which pseudopodia are probably protruded. Septal orifices numerous, arranged in a continuous angular line along the inner border of the septal plane, extending from one umbilical angle to the other, and so close to the periphery of the preceding convolution as to be almost hidden from view.

In its numerous septal apertures Polystomella approaches Dendritina and Peneroplis, but differs from both in having these apertures arranged, in an arcuate or angular line, close to the preceding convolution, instead of being dispersed over the septal plane. M. D'Orbigny describes them as arranged in two lines forming a triangle, and "se montrant encore ouvertes dans les fossettes suturales des dernières loges." ('Foram. de Vienne,' p. 121.) This, however, as I have elsewhere shown ('Trans. Mic. Soc. of London'), is not the case in the true Polystomellæ.

Polystomella crispa, *Lin.* Figs. 78—80.

Planchus, 1739. Conch., p. 10, tab. i, ii.
Gualtieri, 1742. Test., tab. xix, figs. A, D.
Ginnani, 1757. Mare Adriad., tab. xiv, fig. 112.
Planchus, 1760. Conch. Ed. Rom., p. 10, tab. i, fig. 1.
Ledermüller, 1764. Micros., tab. viii, fig. 6.
Nautilus crispus, Linné, 1767. Syst. Nat., Ed. 12, p. 1162.
Martini, 1769. Conch. Cab. 3, p. 248, tab. xx, figs. 172, 173.
Le Nautile microscopique granuleux, Favanne, vol. i, p. 728, tab. vii, fig. B, and tab. lxix, fig. D 2.
Schröter, 1783. Einleit., b. i, p. 10.
Nautilus spiralis geniculis crenatis, Walker, 1784, p. 18, tab. iii, fig. 65.
— *crispus,* Adams, 1787. Micros., p. 640, tab. xiv, fig. 30.
— — Gmelin, 1789. Syst. Nat., p. 3370.
— *striatus communis,* Sold., 1789. Test., i, p. 54, tab. xxxiii, fig. F; tab. xxxiv, figs. G, H, I.
— *crispus,* Schreibers, 1793. Conch. Vien., b. i, p. 3, sp. 3.
— — Dorset Catalogue, 1799, p. 42, tab. xix, fig. 29.
— — Fichtel and Moll, 1803. Test. Micros., p. 40, tab. 4, figs. D, E, F.
— — Montagu, 1803. Test. Brit., p. 187, Suppl., 1808, tab. xviii, fig. 5.
— — Maton and Rackett, 1807, p. 115.
Themeon rigatus, Montfort, 1808, p. 202.
Nautilus crispus, Parkinson, 1811, Org. Rem., tab. xi, fig. 25. Pennant, 1812, vol. iv, p. 247.
— — Dillwyn, 1817. Descript. Cat., p. 341.
Polystomella crispa, Lam. Anim. sans Vert., vii, p. 625.
Nautilus crispus, Turton, 1819. Conch. Dict., p. 119.

Vorticialis crispa, Blainv., 1825. Malac., p. 375.
Polystomella crispa, D'Orb., 1826. Tableau, p. 117.
— — Risso, 1826. Eur. Mér., iv, p. 20.
Nautilus crispus, Brown, 1827. Conch. Illust., 1st ed., tab. lii, fig. 6.
— — Fleming, 1828. Brit. Anim., p. 228.
Polystomella crispa, Deshayes, 1832. Enc. Méthod., tab. iii, p. 808.
Vorticialis crispa, Blainville. Faune Française, p. 77.
Polystomella crispa, Poitiez and Michaud, 1838. Gal. des Moll., t. i, p. 35.
— — Williamson, 1838. Trans. Micros. Soc. Lond., vol. ii, p. 159.
— — Michelotti, 1841. Sagg. Stor., p. 35.
— — Brown, 1843. Fossil Conch., p. 22, tab. ii, fig. 15.
— — Macgillivray, 1843. Moll. Aberd., p. 33.
— *Gulielminæ.* Ibid., p. 315.
— *crenulata.* Ibid., p. 316.
— — Thorpe, 1844. Brit. Mar. Conch., p. 239.
— *Gulielminæ.* Ibid., p. 241.
— *crispa.* Ibid., p. 241.
— — D'Orb., 1846. Foram. de Vienne, p. 125.
— *flexuosa.* Ibid., p. 127.
? — *Antonina.* Ibid., p. 128.
— *regina.* Ibid., p. 129.
— *Josephina.* Ibid., p. 130.
— *aculeata.* Ibid., p. 131.
— *strigilata,* Schultze, 1854. Uber den Organ. der Polythal., tab. iv, 5.

Shell spiral; equilateral; compressed laterally; lenticular; revealing only the outermost convolution, which consists of from twelve to thirty narrow, arcuate, flexuose segments; the anterior border of each segment prominent, smooth, forming a raised septal line; the central portion and posterior border more depressed, sometimes concave, and sculptured into numerous transverse alternate elevations and depressions, which are most conspicuous near their junction with the antecedent segment. Each segment sometimes arcuate, with its convexity directed forwards; at others exhibiting a sigmoid flexure, each raised septal line then becoming concave anteriorly, as it approaches the umbilicus. Umbilicus variable in size and aspect; sometimes smooth, with a few small depressions, the orifices of deep vertical canals; at others appearing rough and tuberculate. Peripheral margin slightly sinuated; usually thin and angular, but obtuse, though sometimes acutely carinated; often with small obtuse tubercles projecting from the septal ridges of a few of the posterior segments. Young shells (fig. 180) with these tubercles developed into long-pointed transparent spines, projecting from each of the segments, those of the outermost convolution being the longest and most acute. Septal plane sagittate. Septal orifices numerous, arranged in a line which runs close to the surface of the antecedent convolution, and forming two lateral series  meeting at an acute angle at the peripheral border of the latter. Texture subhyaline, especially at the septal ridges and anterior portions of the segments. The remainder of the shell opaque, and of a dirty white. Very finely foraminated. Diam. $\frac{1}{16}$ to $\frac{1}{25}$.

Loc. Generally diffused along the coast. The finest from Guernsey (Mr. W. Bean). Young shells abundant amongst the small corallines at the root of a large floating Laminaria at Falmouth; Mr. J. G. Jeffreys. Levant, Dardanelles, Moreton Bay (Australia).

This exquisite species appears to have attracted the attention of a larger number of conchologists than any other of the Foraminifera; a circumstance not surprising when we bear in mind its conspicuously striking aspect and its wide diffusion. There is no difficulty in identifying it with the figure and descriptions of the various writers down to M. D'Orbigny. Professor Macgillivray's three species are mere varieties of the same shell, as I was enabled to ascertain from an examination of his original specimens, kindly lent to me, along with the whole of the Foraminifera collected by that able naturalist, by his daughter, Miss Macgillivray. I have also ventured to unite with this species several of the Polystomellæ, described by M. D'Orbigny, from the tertiary strata of the Vienna basin. One of these species is based on the smoothness of the umbilical disk and the flexuose form of the segments (*P. flexuosa*); another on the large size of the segments, and the existence of tubercles on the umbilicus (*P. Antonina*). Some others appear to be established on characters equally variable and non-persistent. The *P. regina, Josephina,* and *aculeata,* are merely spined forms, resembling my fig. 180, a condition chiefly depending on the age of the shell.[1] In the first-named of these species the spines project from the periphery of each *segment;* in the second, they are prolongations of the *septa;* whilst the third differs from the second only in having more numerous segments and a granulated umbilicus. These are all features displayed by the varieties of *P. crispa* occurring on our coast; hence I presume they are insufficient foundations whereon to establish new species.

The septal apertures in this shell are so small and contiguous to the preceding convolution, that they are rarely visible in ordinary states. It is only when transverse sections have been made and mounted in Canada balsam, that they distinctly appear. This remark also applies to the pseudopodian Foramina, with which the parietes are perforated.

Polystomella strigilata of Fichtel and Moll, D'Orbigny, and Schultze, is apparently undistinguishable from the above shell.

POLYSTOMELLA UMBILICATULA, *Walker.* Figs. 81, 82, 82 *a.*

Nautilus spiralis, umbilicatus geniculis sulcatis, 1784, Walker. Test. Min. Rar., fig. 69, p. 19.
— *umbilicatulus,* 1800-6, Turton. Lin. Syst. Nat., iv, p. 306.
— — 1803, Mont. Test. Brit., p. 191, 1808; Suppl., p. 78, tab. xviii, fig. 1.
— — 1803, Maton and Rackett. Lin. Trans., viii, p. 115.
— — 1812, Pennant, vol. iv, p. 246.
— — 1819, Turton. Conch. Dict., p. 119.
— — 1825, Wood. Index Text., p. 64.

[1] See my Memoir on the Structure of the Shell and soft Animal of *Polystomella crispa,* 'Transactions of the Microscopical Society of London,' vol. ii, p. 163, tab. xxviii, fig. 2.

Nautilus umbilicatulus, 1828, Flem. Brit. Anim., p. 228.
Geoponus stella borealis, 1840, Ehrenberg, C.G. Trans. Royal Acad. Berlin; and Taylor's Scientific Memoir, vol. iii, p. 357, tab. v.
Polystomella umbilicatula, 1843, Macgill. Moll. Aberd., p. 317.
— *nautilina*. Ibid., p. 317.
— — 1844, Thorpe. Brit. Mar. Conch., p. 241.
— *umbilicatula*. Ibid., p. 240.
— *gibba*, 1854, Schultze. Uber den Org. der Polythal., tab. xvii, figs. 1—4.
— *stella borealis*. Ibid., tab. xvii, figs. 5, 6.
— *venusta*. Ibid., tab. xvii, figs. 7, 8.

Shell sub-compressed laterally; roundish; the outermost convolution concealing the rest, and containing from ten to fourteen segments. Segments convex, often highly ventricose; rarely depressed; smooth anteriorly, but with deep, longitudinal, alternating elevations and depressions posteriorly, as in *P. crispa*: slightly arcuate, and occasionally flexuose. Peripheral margin more or less lobulated. Septal lines depressed; masked by the crenulations furrowing the posterior border of each segment; septal plane cordate, turgid; septal apertures several, arranged in an arcuate row close to the preceding convolution. Umbilicus slightly depressed; tuberculated. Texture hyaline, highly translucent, and glossy, except at the umbilicus and along the septal lines, which are opaque and of a dirty white. Parietes perforated by innumerable very minute, white foramina. Diam. $\frac{1}{50}$.

Some matured specimens of this shell are very difficult to distinguish from young spineless varieties of *P. crispa*, in which latter the peripheral margin is less compressed and acute than usual; and the question of their distinctness or otherwise depends upon the value we assign to the form of this margin. I have found some few cases in which transitional conditions appeared to exist. I have not, however, been enabled to satisfy myself that the present shell is merely a variety of *P. crispa*, and have, consequently, retained it as a separate species.

M. D'Orbigny figures a shell under the name of *Polystomella articulata*,[1] which appears identical with this, only he describes it as having numerous septal apertures dispersed irregularly over the entire plane, instead of being confined to a single row, as in our form. A second species, described under the name of *P. Polyana*,[2] and said to be closely allied to *P. articulata*, displays an equally close resemblance to our species, but also differs in the alleged arrangement of its septal apertures, which, in addition to those of *P. umbilicatula*, form a prolonged series round the acute margin of the septal plane. Mr. Hyndman, of Belfast, forwarded to me a large number of specimens of this shell, obtained from the stomach of a shelldrake shot in Belfast Bay. They were unmixed with any other species of Foraminifera, though along with them were numerous specimens of one species of marine Entomostracous crustacean. We can scarcely suppose that the bird had been naturalist enough thus to select individuals of so minute a species by way of *bonne bouche*; it is more probable that they had previously been devoured by some of the marine Mollusca or Acalephæ, which had subsequently fallen a prey to the feathered biped. But the animal, whatever it was, obviously

[1] 'Voyage dans l'Amérique Mérid.,' p. 30, tab. iii, figs. 9, 10.
[2] 'For. de Cuba,' p. 55. tab. vi, figs. 25, 26.

distinguished between Polystomella and other Foraminifera. I have never met with any form in such numbers, and so free from admixture of other species, as to enable an undiscriminating feeder thus to fill its stomach with it. Is this a collateral testimony to the reality of the species?

I have already pointed out the fact that Montagu confounded this species and a Nonionina under the names of *Nautilus umbilicatulus* and *crassulus*. I have confined his references and those of his copyists to my description of *Nonionina umbilicatula*. But the same references are equally applicable here, owing to his obvious confusion of the two types.

Loc. Torquay; Mrs. Brett. Skye, Arran, Stornoway Shetland, Fowey, Brixham; Mr. George Barlee. Whitehaven; Rev. Mr. Chalmers. Exmouth; Mr. W. Kane. Clairnclough Bay, Antrim, and Belfast Bay; Mr. Hyndman. Southport; Mr. C. Clough. Alnwick, Mouth of Thames, Tenby; Mr. Rupert Jones. Abundant in the oyster-ooze, Feversham; Mr. Matthew Marshall and Mr. Warrington. Plymouth Sound and Eddystone; Mr. Spence Bate. Colne tidal river, Essex; Mr. J. Brown. Shetland, Hunde and Beechey Islands.

POLYSTOMELLA UMBILICATULA, *var.* INCERTA. Fig. 82 *a*.

This variety differs from the typical form in the smaller number of the transverse crenulations along the septal lines, in their less uniform aspect, and more unequal size. Sometimes they form long radiating grooves, especially near the umbilicus; at others they appear as small oval pits, the long axes of which are also parallel with the septal line; and not unfrequently they are so slight as to be scarcely visible. In such examples it is exceedingly difficult to distinguish this shell from *Nonionina umbilicatula*, except by preparing a transverse section of the specimen, and mounting it in Canada balsam, so as to bring the septal apertures into view. I have met with single specimens of this variety in several localities, but I have only found it to be the prevalent form at Scarborough.

Genus—PENEROPLIS, *Montfort*.

Nautilus, Linnæus, Fichtel and Moll. *Peneroplis*, Montfort, Buffon (De Sonnini), Blainville, D'Orbigny. *Cristellaria*, Lamarck. *Renulites*, Lamarck. *Renulina*, Blainville.

Shell free; equilateral; regular; much compressed; variable in form both at different ages and in various individuals. Each convolution enclosing the preceding ones when young; in matured shells, the outermost convolution is broad, flat, thin, disposed to project in a straight line, and with its umbilical border stopping short of the umbilical centre. Often obliquely striated. Each convolution consisting of numerous narrow, arcuate, undivided segments. Septal orifices scattered over the long narrow septal plane; single in very young shells, but gradually becoming more numerous with advancing growth.

This genus differs from Polystomella in the position of its septal apertures; from Dendritina in these apertures being numerous and detached instead of coalescing to form one large ramifying aperture. It frequently bears a close resemblance to some varieties of Orbiculina; but differs in each segment presenting a single undivided cavity, instead of being divided by transverse calcareous pillars and partitions extending from one septum to another.

PENEROPLIS PLANATUS, *Ficht.* and *Moll.* Figs. 83—85.

Schröter, N. litterat, 1784, i, p. 314, tab. i, fig. 7 ?
Soldani, 1789, i, p. 73, tab. 64, figs. *m* to *s*.
Nautilus planatus, Ficht. and Moll, 1803, p. 91, tab. xvi, figs. *a—i*.
Peneroplis planatus, Montf., 1808. Conch., gen. 65, p. 258.
— — Buffon de Sonnini, 1802-5. Moll., vol. iv, p. 1, pl. xlii.
Cristellaria squammula, Lam., 1815-22. Anim. sans Vert., vii, p. 607, No. 1.
— *planata*, Ibid., Enc. Méthodique, tab. cccclxvii, fig. 1, *a, b, c* (ex Ficht.)
— *dilatata*. Ibid., tab. cccclxvii, fig. 2, *a, b, c* (ex Ficht.)
Peneroplis dilata, Blainville, 1825. Malac., p. 372, 2me groupe.
— *pulchellus*, D'Orbigny, 1847. Voyage dans l'Amérique Méridionale, t. v, part v, p. 32, tab. iii, figs. 5, 6.
— *planatus*, Ehrenb., 1858. Berl. Trans., pl. ii, fig. 1.
Cristellaria squamula, Brown, 1841. Fossil Conch., pl. ii, fig. 27.
— *plumula*. Ibid., pl. iii, fig. 14.

Shell compressed; nearly equilateral; the outer convolution almost concealing the internal ones, and, in matured shells, increasing rapidly in diameter, at the same time showing a tendency to abandon the spiral contour and become developed in a straight line, as in Cristellaria. Segments narrow, covered with distinct, numerous oblique centrifugal sulci, resembling in their arrangement the curves of water thrown off from a revolving wheel. Septal lines curved, depressed, smooth. Septal plane almost linear in old shells; slightly concave, with raised margins. Septal apertures numerous, irregularly scattered over the entire septal plane. Septal angle often approaching nearer to the umbilicus on one lateral surface than on the other. Peripheral margin rounded. Umbilical region concave, smooth. Texture porcelainous, smooth. Hue white, shining. Young shells differ from matured ones in being more nautiloid in form, the anterior segments not increasing in size in so rapid a ratio as at a more advanced stage of growth; also in having a broader septal plane and fewer septal apertures. In very young shells there is but *one* aperture in each septum, and they gradually increase in number as new segments are added.[1] Diam. $\frac{1}{20}$.

Only a few examples of the young state of this shell have been found on our coasts by Mr. George Barlee and Mr. J. G. Jeffreys, in sand dredged by the former gentleman at the Shetland Islands. The species is a widely diffused one, occurring in the Mediterranean, at the Phillipine Islands, Australia, and abundantly in the Gulf of Mexico. It is not improbable that

[1] On some of the Microscopical Objects found in the Mud of the Levant, 'Memoirs of the Literary and Philosophical Society of Manchester,' 2d Series, vol. viii, figs. 31, 32, 1847.

our British examples have travelled from the latter locality, availing themselves of the locomotive facilities afforded by the Gulf-stream. Amongst the multitude of West Indian seeds and other light objects thus thrown upon our north-western shores, it was to be expected that some of the tropical Foraminifera would be entangled, and such may have been the case with the species under consideration. When this description was written the matured form had not been met with in our seas, consequently, in figs. 84, 85, I gave delineations of one of its most common varieties (less highly magnified than the drawing of the young shell, fig. 83) to guide British naturalists in a further search for this interesting shell. Since then Mr. Jeffreys has succeeded in meeting with it. In one of Mr. Barlee's specimens the septal lines are nearly black, and the internal convolutions much more fully exposed than in fig. 83.

M. D'Orbigny's *P. pulchellus* appears to be merely a young form of this common American species.

Genus—PATELLINA, *nob.*

Shell free; conical; trochoid; crenulated on its entire upper surface; commencing its growth as an undivided spiral organism, but soon developing crescentic segments, each of which occupies rather more than half the circumference of the shell. Segments arranged in two opposed alternating series. Internal cavities of the segments narrow, crescentic; divided into numerous quadrangular compartments by small calcareous septa prolonged from the peripheral margin, and reaching *nearly* to the umbilical border, where these compartments are connected together by a narrow, undivided area. Calcareous layers extending from the inferior umbilical borders of the segments combine to fill up the concave inferior lateral surface of the shell. Septal aperture uncertain.

This genus obviously belongs to the class to which M. D'Orbigny has assigned the name of Enthomostègues, characterised by the existence of transverse partitions to the segmental cavities; but it differs wholly from such genera as have hitherto been established. Its contour is not unlike that of a Rotalina, but closer examination shows that the segments are arranged in two opposite series as in Textularia. It differs from that genus in the form of the segmental cavities, which, instead of reaching the umbilicus on the inferior surface, stop far short of it; the prolongation in that direction consisting of solid calcareous laminæ. This condition wholly precludes the possibility of the septal apertures being arranged as in Textularia; consequently, I conclude that they occupy the overlapping extremities of the crescentic segments, being probably situate beneath and a little within the peripheral margin.

PATELLINA CORRUGATA, *nob.* Figs. 86—89.

Shell with the superior lateral surface conical; concave inferiorly; orbicular; composed of numerous narrow segments arranged alternately on opposite sides of the shell. Segments crescentic or semicircular, but a small portion of each being visible on the superior or convex side; the remainder extending as a lamina of shell halfway across the inferior surface, where it seems to merge in the other segments, forming no definite outline, but producing a

number of irregular gyrate elevations; each segment marked on its superior crescentic surface by numerous radiating elevations and depressions resembling those of crimped muslin, the elevations indicating corresponding vertical septa dividing the interior of the segment into compartments; these septa radiate from the peripheral margin of the segmental cavity, but stop short of the umbilical one, where all the compartments communicate (see fig. 89). Primordial segment spiral (fig. 89*a*), with about two convolutions. Septal aperture not visible. Texture hyaline, especially when young; becoming white and frosted with age. Diam. $\frac{1}{80}$.

There is no other British species with which this rare and hitherto undescribed shell can possibly be confounded. In the division of its segments into compartments it resembles the foreign genera Alveolina and Orbiculina, and constitutes the only representative of that type of structure hitherto found on our coasts. But in its alternate, opposed segments it is more nearly allied to the Textillariæ. Indeed it appears to inosculate the "Enallostègues" of M. D'Orbigny with his "Hélicostègues." Though its segments are arranged in two opposed series, we learn from the structure of its primordial segment (fig. 89*a*) that its tendency is to develop in a spiral direction, and consequently conclude that the alternation of its segments is the result of a similar tendency, in which each segment describes what is equivalent to half a circle. The internal structure of this shell is shown in fig. 89, which represents a specimen mounted in Canada balsam and viewed by transmitted light; the vague and indefinite centre represents the spire of the shell, which, from its height, is out of the focus of the instrument, the latter being adjusted to the plane of the outermost segments.

Loc. Arran, Skye, Shetland, Brixham, Fowey; Mr. George Barlee. Hunde Island, Davis's Straits; Dr. Sutherland. Boston.

Genus—ROTALINA, *D'Orbigny.*

Nautilus, Linnæus, Walker, Adams, Gmelin, Montagu, Maton and Rackett, Pennant, Parkinson, Turton, Brown. *Rotalia,* Lamarck, D'Orbigny, Fleming, Thorpe, Wood. *Discorbis,* Lamarck, Blainville, Macgillivray. *Rotalites,* Lamarck, Parkinson. *Gyroidina,* D'Orbigny. *Rosalina,* D'Orbigny. *Turbinolina,* D'Orbigny. *Valvulina,* D'Orbigny. *Rotalina,* D'Orbigny. *Planulina,* D'Orbigny.

Shell sometimes parasitic, but usually free; trochoid; spiral; with a depressed spire; truncate or conical. All the convolutions visible on the superior lateral surface; the opposite surface nearly or entirely occupied by the last convolution. Segments numerous. Septal orifice single; sometimes a small perforation, at others a long narrow fissure; occasionally a combination of both; situated at the junction of the septal plane with the inferior lateral surface of the preceding convolution.

I have united the genera Rotalina and Rosalina from my conviction of the utter impossibility of retaining them apart. The common and almost typical example of Rosalina, *R. concamerata,* becomes in its mature form an equally good Rotalina! retaining none of the characters by which M. D'Orbigny has distinguished the former genus. No distinctions can be retained as generic

which mere difference of age suffices to destroy. However inconvenient, the genera resting on so uncertain a basis must be united; and since there is no reasonable ground for doubting that the distinctions in question are of this nature, I have united several genera under the common name of Rotalina.

The desirableness of adopting this course in reference to the genus Valvulina may be more open to diversity of opinion. But it appears clear that the thin opercular valve covering the umbilicus, upon which M. D'Orbigny relies as the distinguishing feature of the genus, is a very uncertain character. It is present in my *Rotalina oblonga*, but is absent from *R. turgida*, being represented in the latter shell by the highly ventricose, umbilical angle of the last segment; yet from the close general resemblance of these two shells, it would be most improper to disunite them. Another shell, obviously belonging to the same group, has already been made a Rotalina (*R. sagra*) by M. D'Orbigny. On the whole, it appears to me safer to unite all these shells with Rotalina rather than risk the adoption of a new genus, the boundaries of which are incapable of being even approximately defined. The strong disposition of Valvulina to run into Rosalina has been recognised and admitted even by M. D'Orbigny.[1] The latter genus, according to that writer, establishes the transition of the former one to the Rotalinæ.

The only genera with which Rotalina can well be confounded are Truncatulina and Globigerina. From Truncatulina is at once distinguished by the visibility of all the convolutions in the trochoid spire, of which the primordial segment constitutes the apex. Globigerina differs in the remarkable ventricosity of its segments, and in its large septal orifice being placed immediately above the umbilicus, at the umbilical border of the segment, which it renders somewhat truncate. Some of M. D'Orbigny's Valvulinæ approach Bulimina; but the latter may always be recognised by their oblong spire, as distinguished from the trochoid form of the Rotalinæ.

ROTALINA BECCARII, *Lin.* Figs. 90—92.

? Hooke, 1665. Micrographia, tab. vi, fig. 10, p. 80.
Planchus, 1739. Tab. i, fig. 1.
Gualt., 1742. Tab. xix, figs. H, H, I.
Nautilus Beccarii, Linn., 1767. 12th edit., p. 1162.
Martini, 1769. Conch., i, tab. xix, figs. 178, 179; tab. xx, figs. 175—177.
Favanne, 1780. Conch., tab. 69, D 1; tab. 7, B 2.
Nautilus spiralis umbilicatus, Walker, 1784, p. 18, fig. 63.
— *Beccarii perversus*. Ibid., fig. 64.
— *Beccarii*, Gmelin, 1789. Linn., p. 3370.
— — Adams, 1798. Essays, p. 640, tab. xiv, fig. 29.
— — Mont., 1803. Test. Brit., p. 186; Supplement, 1808, p. 74, tab. xviii, fig. 4.
— — *perversus*. Ibid., p. 1807.
— — — Maton and Rackett, 1807, p. 116. Pennant, 1812, vol. vi, p. 247.
— *Beccarii*. Ibid. Ibid.

[1] 'Foram. de Vienne,' "Valvulina."

Nautilus Beccarii, Parkinson, 1811. Org. Rem., tab. ii, figs. 25—28.
— — Turton, 1819. Conch. Dict., p. 119.
Rotalia — D'Orbigny, 1826. Tableau, p. 275.
— *Beccaria,* Fleming, 1828. Brit. Anim., p. 232.
— *Beccarii perversus.* Ibid.
— — Macgillivray, 1843. Moll. Anim. Aber., p. 35.
Discorbis pulchellus. Ibid., p. 318.
Rotalia Beccaria, Thorpe, 1844. Brit. Mar. Conch., p. 228.

Spec. Char. Shell trochoid; convex superiorly; flattened at its inferior lateral surface; composed of several convolutions gradually increasing in size; all the convolutions visible superiorly, but only the outermost seen inferiorly; external one consisting of from nine to eleven convex segments, separated by depressed septal lines. Inferiorly, the umbilical margin of each segment is drawn out in an acute angle, and usually separated from its neighbours by deeply excavated septal grooves, the margins of which are rendered very irregular by calcareous incrustations, as if invested by crystallizations of alum or ice. Similar incrustations invest much of the inferior surface of the shell. In the central convolutions seen on the superior lateral surface the segments are more depressed, whilst the septal lines are even raised and translucent. Peripheral margin lobulated. A deep umbilicus exists at the inferior surface, from the centre of which usually projects an irregular semi-crystalline pillar often surrounded by minor projections and incrustations. The chief part of each new segment is applied to the inferior surface of the pre-existing ones, hence each successive growth takes place below the plane of the primary segment, and the trochoid form is produced. Septal plane obliquely pyriform; septal aperture contiguous to the preceding convolution, a little below its peripheral margin (see fig. 92). Texture semi-hyaline, densely foraminated between the septal lines with very minute foramina. Hue white in young shells, grayish white in old ones. Diam. $\frac{1}{25}-\frac{1}{30}$.

Most of the British conchologists, from Walker to Fleming, have made two species of this shell, from the circumstance that in half the individuals the spiral growth proceeds from right to left, whilst in the remainder it is reversed. In fact all the Foraminifera display this irregularity, but in the equilateral species it is not obvious, owing to the impossibility of distinguishing the two sides of the shell, and it was with the equilateral forms chiefly that these writers were familiar. The present species, owing to its size and abundance presented a conspicuous exception to what they regarded as the ordinary condition, hence their arrival at the conclusion just referred to. Regarding these objects as Mollusca, they viewed them with conchological eyes, and applied to their descriptions and definitions conchological maxims. Whereas, on this point, as well as on many others, the Foraminifera avail themselves of their liberty as belonging to the lowest group of animal forms by wandering so far from their specific types that the family likeness disappears. Had the parent been endowed with consciousness it must often have found it difficult to recognise its own offspring. No wonder, therefore, that the task of identification becomes impossible to poor mortals unaided by such discriminating powers as the parental στοργή would develop.

Rotalina Beccarii is the most common of the British Foraminifera, occurring in varying degrees of abundance on every part of the coast. The *Discorbis pulchellus* of Dr. Macgillivray

appears to be merely a *Rotalina Beccarii*, which he has turned upside down. In sand from Kurachee, on the coast of Scinde, I have found a beautiful depressed carinated variety of this species. Another modification of it is very abundant in the Levant. The species has a very wide geographical range, but each individual locality appears to be characterised by the prevalence of some one variety.

ROTALINA INFLATA. Figs. 93, 94.

Nautilus inflatus, Mont., 1808. Test. Brit. Supplt., p. 81, tab. xviii, fig. 3.
— — Pennant, 1812, vol. iv, p. 247.
— — Turton, 1819. Conch. Dict., p. 120.
Rotalina inflata, Fleming, 1828. Brit. Anim., p. 232.
— — Thorpe, 1844. Brit. Mar. Conch., p. 238.

Shell trochoid; depressed; consisting of about three convolutions. The outermost convolution containing five or six very ventricose segments, with deeply excavated septal lines. The anterior segment appearing more highly globular than the rest. Inferiorly the segments appear triangular, separated by straight radiating septa, the outermost convolution alone being visible. Umbilicus on the inferior lateral surface small. Peripheral margin lobulated. Septal aperture, close to the preceding convolution, a little below its peripheral margin. Hue pale brown, opaque; the small primary segments forming the innermost convolution usually very much darker than the rest. Texture finely arenaceous. Diam. $\frac{1}{35}$.

This very distinct species was discovered by Montagu, on the coast of Devon, since which time it appears to have escaped the attention of collectors, until rediscovered by Dr. Fleming and Mr. J. G. Jeffreys. It is a very rare species. The few adult specimens contained in Mr. Jeffrey's cabinet, and a small number of very young states which I have met with in sands sent me by Mr. George Barlee, constitute the sole examples I have seen of it.

Loc. Weymouth, Swansea, Sandwich; Mr. J. G. Jeffrey. Skye, Arran, Shetland; Mr. George Barlee.

ROTALINA TURGIDA, nob. Figs. 95—97.

Shell equilateral when young, becoming inequilateral as it advances in growth; containing about two convolutions; the outermost consisting of nine or ten segments, which increase rapidly in breadth as they increase in number; the ultimate one being the broadest. Segments slightly ventricose; at the superior lateral surface they are abruptly truncated at a little distance from the centre of the umbilical region, leaving a defined umbilical cavity, in which the second convolution is visible; inferiorly the last few segments are largely developed, becoming remarkably ventricose, especially at their umbilical margins, where they are broad and prominent; the ultimate one concealing a considerable part of the shell. Peripheral border rounded, and but slightly

lobulated. Septal lines slightly depressed. The posterior ones a little arcuate; the anterior ones straight, except at their peripheral extremities. Septal plane oblong, rounded, obtuse, greatly prolonged inwards at its inferior umbilical angle (fig. 96). Septal aperture minute, situate close to the second convolution, a little below its periphery. Texture hyaline, transparent, whitish, very delicately foraminated. Diam. $\frac{1}{70}$ — $\frac{1}{80}$.

This elegant shell approaches the *Valvulina excavata* of D'Orbigny ('Foram. des Canaries,' pl. i, fig. 43); but in his specimens from Teneriffe the enlarged umbilical angle of the ultimate segment, instead of covering the umbilical region, passes in front, between it and the peripheral border.

Loc. Skye, Arran, Shetland (abundant); Mr. George Barlee. Whitehaven (rare); Rev. Mr. Chalmers.

ROTALINA OBLONGA, *nob.* Figs. 98—100.

Shell inequilateral, consisting of rather less than two complete convolutions, both of which are visible superiorly; the outermost consisting of about eight somewhat arcuate segments, which increase rapidly in length as they approach the ultimate one. Superior lateral surface smooth and almost flat. Segments but slightly ventricose, and with little or no umbilical depression. Inferior lateral surface with the segments more ventricose, especially the ultimate one, from the inferior umbilical border of which a small flat lamina projects, covering the inferior umbilicus, but usually leaving a narrow space beneath the two portions. Septal lines, which diverge from the umbilicus, deeply and abruptly excavated at their umbilical extremities, causing the angular inferior umbilical margins to be prominent and well defined. Septal plane forming part of the convex inferior surface of the segment. Septal orifice narrow, crescentic, situate close to the preceding convolution, between its periphery and the projecting umbilical lamina of the segments. Peripheral border slightly lobulate, somewhat angular or even carinated, especially at the anterior border of the ultimate segment. Texture semi-hyaline, beautifully foraminated. Hue pale olive. Diam. $\frac{1}{30}$.

In its general contour, and especially in the lamellar expansion from the inferior umbilical margin of the ultimate segment, this shell approximates to *R. turgida*. It differs, however, in its more robust habit, larger size, want of a distinct umbilical depression on its upper surface; smaller size of the central convoluted portion relatively to the broad ultimate segments, and in the carinated anterior border as well as comparatively small inferior umbilical expansion of the ultimate segment. It approaches closely to the *Valvulina æqualis* of D'Orbigny ('Voyage dans l'Amérique Méridionale,' tom. v, part v, p. 48, tab. vii, fig. 10—12); but differs in the presence of the small umbilical lamina, which is wanting in the latter. It also resembles the *Valvulina oblonga*, but in the latter the anterior segment is rounded and turgid, instead of being thin and carinated. Future discoverers may unite all these species.

Both this and the preceding species belong to a group, out of some forms of which M.

D'Orbigny has constructed his genus Valvulina. It is characterised by the unusual development of the last segment, especially on one side and at its umbilical margin. A shell of the same class is figured by Soldani ('Testaccog. et Zooph.,' tab. xli, vas. 165 *c*). D'Orbigny's *Rotalia sagra* ('Foram. de Cuba,' p. 77, tab. v, fig. 13, 14) is closely allied to the group, but as it does not present the small thin umbilical plate, it is not admitted by that author amongst the Valvulinæ. The same characteristic feature is wanting in my *Rot. turgida;* hence it, too, would be excluded by him from that genus. But no doubt can be entertained of the impropriety of separating *R. turgida* from *R. oblonga;* and as the position of the septal aperture in both so closely corresponds with that of the *Rotalinæ*, especially the section hitherto called *Rosalina*, I have no hesitation in adding our two shells to that comprehensive genus, in preference to adopting that of Valvulina, which appears to me imperfect and indefinite.

Loc. Guernsey, Loch Fine, Shetland, Skye (chief locality); Mr. George Barlee. Cork, Rossily, Swansea, Caswell Bay, Tenby; Mr. J. G. Jeffreys. Eddystone (rare); Mr. Spence Bate. Boston. M. D'Orbigny found this shell in sand from Teneriffe.

ROTALINA CONCAMERATA. Figs. 101—105.

Serpula concamerata, Mont., 1808. Test. Brit. Supplt., p. 160.
— — Pennant, 1812, vol. iv, p. 366.
Nautilus dissimilis, Turton, 1819. Conch. Dict., p. 120.
Rosalina globularis, D'Orbigny, 1826. Tableau, p. 271, pl. xiii, figs. 1, 2, 3, 4.
— — Modèles, No. 66, IIIème livraison.
Lobatula concamerata, Fleming. Brit. Anim., p. 233.
Rotalia ligata, Woods, MSS. Morris's Catalogue of British Fossils.
Rotalina Boueana, D'Orb., 1846, For. de Vienne, p. 152, tab. vii, figs. 25—27.

Matured shell. Trochoid; consisting of about two and a half visible convolutions, all apparent on the superior lateral surface; the outermost alone seen on the opposed surface. Outermost convolution consisting of six or seven slightly convex segments. *Superiorly* the septal lines are in the form of strong, broad, smooth, elevated ribs, which being prolonged round the peripheral margin of each segment, combine to form an obtuse peripheral carina surrounding the entire shell; this keel is prolonged on the upper surface of the shell as a thick, raised, connecting spiral, separating the contiguous convolutions, being the least conspicuous where it borders the ultimate segment. Superior lateral surfaces of the segments covered with large depressed tubercles, those of the ultimate segment being the least prominent. *Inferiorly* the segments are but slightly convex, the last two or three being the most so. Septal lines scarcely discernible, excepting the two or three anterior ones. Tubercles similar to those of the upper surface, but less conspicuous, are sometimes seen near the peripheral margins of the more anterior segments. Septal aperture on the antero-inferior surface of the segment, midway between the peripheral margin and the umbilicus; usually round, but sometimes with an oblong prolongation on each side, parallel with the contiguous inferior surface of the preceding convolution. Umbilicus irregular. Peripheral margin almost entire, the first and

second segments alone producing a somewhat lobulate outline. Hue dirty white; opaque; dull; very rarely glossy. Diam. $\frac{1}{25}$.

Young shells. Trochoid; convex superiorly; concave inferiorly; with about two convolutions, the primary segment being visible on the superior lateral surface. Outermost convolution with about six segments, which are convex superiorly, separated by deeply constricted, arcuate, septal lines. *Inferiorly* the segments are irregular, each one having convex and concave portions. The septal lines highly flexuose; little more than the outer convolution visible. Peripheral margin slightly lobulate and thin, but obtuse. Septal aperture variable; often difficult to detect; but usually an irregular slit of variable length extending from the umbilicus towards the peripheral margin, close to the inferior surface of the preceding convolution. Texture hyaline, glossy, perforated on its upper surface by numerous very large foramina. No foramina inferiorly, where it is smooth. Hue often a rich brown, dependent on the animal matter occupying the interior of the segments which shines through the transparent shell. With increase of age the shell becomes thicker, more opaque, and white; the foramina smaller, and appearing as if farther apart. Diam. $\frac{1}{35} - \frac{1}{60}$.

In its young state, and when this shell is often parasitic upon other bodies, it is the *Rosalina globularis* of D'Orbigny. In its matured state, when it is free, it assumes so entirely different an aspect that no one has hitherto recognised even the generic identity of the two forms. It is then a Rotalina of D'Orbigny, and as such has received from Mr. Searles Wood the MS. name of *R. ligata*. I suspect that it does not really differ from the *Rotalina Boueana*, D'Orb. ('Foram. de Vienne,' tab. vii, figs. 25—27, p. 152.) We have here clear proof that the genera Rosalina and Rotalina ought not to be separated, since no well-defined characters distinguish them, save such as difference of age alone may produce. I am indebted to Mr. Hyndman, of Belfast, for specimens of a matured variety from Belfast Bay, which is smooth and glossy; the septal lines not being *raised,* but on a level with the septa, and beautifully translucent; nevertheless the existence of intermediate states demonstrates their connection with the present species.

The cabinet of Mr. Jeffreys contains some curious and irregular Rotalina, which bear a close resemblance to young forms of *R. concamerata,* but in which the Foramina are either wholly wanting or are very minute. Young forms of this variety would readily be mistaken for *R. nitida.* Still I think the above two species are distinct and may, even under these non-foraminated conditions, be identified by the differences between their respective inferior surfaces. I have seen forms from the Mediterranean intermediate between Mr. Jeffreys' specimens and the common type. Soldani represents either the matured state of *R. concamerata,* or of a very closely allied shell, in his Testaceog. and Zootograph., tab. xxxvii, fig. B.

The matured forms of the species under consideration owe their peculiar aspect to the rapid development of the solid shell at their superior lateral surface. The convolutions, as in all the trochoid Foraminifera, extend themselves in the direction of the inferior lateral aspect, or below the plane of the primordial segments; but as each segment has been formed, it has contributed a layer of shell to the entire surface of the organism, as I have elsewhere shown to be common, if not general amongst the Foraminifera;[1] but in the present species the laminæ added to the superior lateral surface are much thicker than those on the opposite surface; hence, not-

[1] On the Minute Structure of the Calcareous Shells of some recent Species of Foraminifera, 'Trans. Mic. Soc. Lond.,' vol. iii.

withstanding the unilateral development of the convolution, which would arrange all the newer segments *below* the plane of the primordial one, a horizontal section made in the plane of the primordial segment, would leave nearly one third of the entire diameter of the shell *above* that segment. In *Rotalina Beccarii* opposite conditions obtain; the *inferior* lateral surface being the one to which the chief additions are made to the thickness of that shell.

Loc. Young state: almost universal.—*Matured state:* Whitesand Bay, Dublin Bay; Mr. J. G. Jeffreys. Scarborough; Mr. W. Bean. Shetland, Skye, Fowey; Mr. George Barlee. Belfast Bay; Mr. Hyndman.

ROTALINA NITIDA, *nob.* Figs. 106—108.

Shell trochoid; depressed; very smooth; with from two to three convolutions; each convolution containing about six smooth, depressed, trapezoidal segments of somewhat variable proportions of length and breadth in different specimens; the ultimate one with a convex antero-peripheral border, giving a slightly lobulated outline to the thin margin of the shell. Septal lines slightly depressed superiorly; often appearing to be double; those of the inferior surface being then seen through the transparent shell. Inferiorly the segments are slightly concave; triangular; reaching nearly to the umbilicus, and having often a peculiar constriction near the umbilical border, which appears as a small obtuse mamilla, projecting into the umbilicus. Texture exquisitely hyaline and transparent; in some specimens very finely foraminated. Young specimens either colourless or of a bluish tint. Matured ones often exhibiting a pale ferruginous hue near the umbilical region, especially visible on the upper or convex side, and caused by the brown animal matter contained within the colourless shell. In some instances the inferior umbilicus is occupied by a distinct and prominent umbo. Diam. $\frac{1}{180}$. Height, $\frac{1}{260}$.

Loc. Cullercoats; Mr. Joseph Alder. Plymouth Sound; Mr. Spence Bate. Whitehaven; Rev. Mr. Chalmers. Shetland, Arran, Skye; Brixham; Mr. Barlee. Torquay; Mrs. Brett. Boston.

ROTALINA MAMILLA, *nob.* Figs. 109—111.

Spec. Char. Shell trochoid; conical, with an obtuse spire; consisting of three or four convolutions, each of which contains about four segments. Segments convex on their anterior and peripheral borders, which combine to describe about the third of a circle, giving a lobulate outline to the obtuse peripheral margin of the shell. The same thickened borders overlap the posterior border of each segment next in front, which latter seems to emerge from under the former. Inferiorly, the outlines of the segments are less distinct; each one usually extends to the umbilical centre; its central portion is ventricose, though as a whole the shell is concave inferiorly. Septal aperture, a long, narrow, arched fissure, occupying the inner half of the inferior umbilical border (fig. 110) of the ultimate segment. Texture hyaline; with a few whitish foramina; usually with a very distinct row of them a little within and above the thick anterior and peripheral borders

of each segment. Occasionally a distinct prominent umbo exists in the centre of the inferior umbilicus. Diam. $\frac{1}{60}$ — $\frac{1}{80}$.

This shell sometimes bears a close resemblance to *R. nitida;* but it may generally be distinguished by its more robust habit, thick, prominent anterior and peripheral borders of the segments, its irregular inferior surface, and the marginal row of elongated white foramina. Its inferior surface often bears considerable resemblance to that of young states of *Rosalina globularis.*

Loc. Arran, Fowey (abundant), Shetland; Mr. George Barlee. Sandwich, Swansea, Tenby, Falmouth, Torbay, Weymouth, Bantry Bay; Mr. J. G. Jeffreys. Exmouth; Mr. W. Clarke.

ROTALINA OCHRACEA. Figs. 112, 113.

Shell trochoid; depressed; slightly convex and smooth superiorly, correspondingly concave inferiorly; with about two and a half convolutions. Segments eight or nine in each convolution; arcuate; filled with brown animal matter, which is pale and translucent in the ultimate segments, but very dark and opaque in those near the umbilicus. Septa smooth in one specimen, a little elevated in another; broad, and of a light ochraceous yellow, contrasting richly with the dark tint of the segments. The connecting spiral has the same ochraceous hue. *Inferiorly* the segments of the last convolution extend nearly to the umbilicus, concealing the rest. Segments depressed or concave. Septal lines arcuate, flexuose, and very prominent. Peripheral margin entire, or but slightly lobulated at the ultimate segments. Diam. $\frac{1}{100}$.

Of this curious and elegant little organism I have but seen three specimens, all of which I found in Mr. Barlee's sand from Shetland. In that sent me by the same gentleman from Brixham I met with a single shell closely resembling the above, only of larger size, and pellucid. Whether it was a variety, or belonged to some other form, I am unable to determine.

ROTALINA FUSCA. Figs. 114, 115.

Shell trochoid; convex superiorly; flat inferiorly; with two or three convolutions, each consisting of about two and a half large crescentic segments. Each segment convex superiorly; its anterior and peripheral borders together describing more than half a circle. Inferiorly each segment is nearly flat, occupying rather more than half the entire inferior surface of the shell, and concealing the anterior half of the preceding segment. Inferiorly each border is somewhat obtuse and rounded. Septal plane merely a portion of the inferior surface. Septal orifice indistinct. Texture arenaceous; hue brownish. Diam. $\frac{1}{60}$.

This curious species is distinguished from all its allies by its distinctly arenaceous texture, its brown hue, the small number of segments composing each convolution, and their peculiar arrangement on the inferior surface of the shell.

Loc. Skye (not uncommon), Exmouth; Mr. George Barlee. Weymouth, Sandwich, Swansea; Mr. P. G. Jeffreys. Exmouth; Mr. S. Bate.

Genus—GLOBIGERINA, *D'Orbigny.*

Shell free; spiral; spherical; consisting of a few highly ventricose segments, forming about two convolutions. Segments almost orbicular. Septal orifice large, on the inferior surface of the shell and at the umbilical border of the ultimate segment close to the centre of the shell. Sometimes, according to D'Orbigny, a similar orifice is visible in several of the segments.

This genus is at once recognised by the extreme sphericity of its segments, resembling, as M. D'Orbigny has correctly remarked, a spiral mass of little globes. It can only be confounded with Rotalina, from which it differs in the feature just referred to and in the position of its septal orifice. There are nevertheless some forms, especially amongst fossil species, which unite these genera closely together.

Globigerina bulloides. Figs. 116—118.

Polymorphia tuberosa et globulifera, Soldani, 1789, tom. i, p. 117, tab. cxxiii, fig. l.
— *globulifera,* Soldani, 1798, tom. ii, p. 58, tab. xiii, fig. *d.*
Globigerina bulloides, D'Orbigny, 1828. Tab. de Ceph., tom. iii, No. 1, p. 111.
— — D'Orbigny, 1839. For. des Canaries, p. 132, pl. ii, figs. 1—3.
— — D'Orbigny. For. de l'Amérique Mérid., p. 37.
— — D'Orbigny. For. de Vienne, p. 163, tab. ix, figs. 4—6.
— — Parker and Jones, 1857. Annals and Mag. Nat. Hist., 2d Series, vol. xix, p. 19, tab. xi, figs. 11, 12.

Shell spiral; consisting of about two convolutions, composed of highly globular segments, which increase very rapidly in size; the outermost convolution containing four segments, visible on the inferior surface; the remainder visible only on the superior surface. Septal lines deeply constricted; a deep umbilicus on the inferior surface. Septal aperture very large on the inferior umbilical margin of the remarkably ventricose ultimate segment. Texture arenaceous, granular. Hue yellowish-grey. Diameter, which exceeds the height, $\frac{1}{133}$.

Of all the species of Foraminifera this is, along with *Orbulina universa,* the most complete Cosmopolite. I have found it in sands from every part of the British coasts, but in the greatest abundance in those dredged from deep water at Shetland, by Mr. G. Barlee. It occurs in marvellous profusion in the depths of the Atlantic, predominating, according to Dr. Bailey, in the exclusively Foraminiferous sands brought up by Lieutenant Berryman, from depths of from 1000 to 2000

fathoms.[1] M. D'Orbigny obtained it on both the eastern and western coasts of South America, as well as in the Mediterranean and Indian Oceans. Parker and Jones found it in sands from the Norwegian coast. It exists in Dr. Sutherland's sands, brought from a depth of 100 fathoms at Hunde Island, Davis's Straits; and it occurs fossil in the Boston deposit, in the Tertiary strata of the Vienna basin (M. D'Orbigny) as also, according to Mr. Searles Wood, in the Suffolk Crag.

Messrs. Parker and Jones regard this species as identical with the fossil *Globigerina cretacea*, D'Orb., so common in the Chalk. Such may be the case, but I have not yet seen satisfactory proof of it.

Genus—PLANORBULINA, *D'Orb.*

Shell probably parasitic, but doubtful; discoid; highly depressed; very flat and truncate on its inferior surface; irregular, or somewhat concave superiorly; consisting of very numerous segments, which are arranged on one plane, spirally in the centre of the disc, but clustered irregularly towards its circumference. Each segment reposing obliquely upon its predecessors; flat and smooth below; convex or ventricose above; perforated on both sides by numerous large pseudopodian foramina. Septal orifice single, semilunar, rather large, situate at the junction of each segment with those previously formed. The isolated segments at the periphery usually furnished with a septal orifice at each extremity.

This genus approaches Truncatulina, especially when very young; but it may always be distinguished by the circumstance that all its segments are visible on *both sides* of the disc. In the latter shell, also, the septal orifice is distinctly extended along the *superior* umbilical borders of the last two or three segments in an almost continuous line. This is never the case in Planorbulina.

Planorbulina vulgaris, *D'Orb.* Figs. 119, 120.

Soldani, iii, tab. clxii, fig. H, p. 238, and tab. clxi, figs. E, F, G.
Planorbulina mediterranensis, D'Orb., 1825. Tableau Méthod., p. 114, No. 2.
— — D'Orb. Modeles, 79, 4me livraison.
— *vulgaris*, D'Orb., 1839. For. de Cuba, p. 85, tab. vi, figs. 11—15.
— — D'Orb., 1839. For. des Canaries, p. 134, tab. ii, figs. 22—24.
— *mediterranensis*, D'Orb. Foram. de Vienne, p. 165, tab. ix, figs. 15—17.

[1] I am indebted to Dr. Bailey for some of these sands, and find specimens of this Globigerina very abundant in them.

Shell orbicular; much depressed; slightly convex but with a depressed centre superiorly; flat inferiorly; consisting of numerous segments. Primordial segments arranged in a regular spiral, especially visible at the flat inferior surface, which spiral becomes more irregular in the latter convolutions, and finally disappears; the newest segments arranged irregularly round the periphery. Each segment nearly square; convex superiorly, flat inferiorly; its umbilical border concave; its peripheral one convex. Each segment reposes obliquely upon the preceding convolution; its peripheral border, which is in the plane of the inferior surface of the shell, projecting further from the central primordial segment than its upper and umbilical border; the former often fringed by a thin peripheral carina. Septal lines sinuous and irregular. Septal plane scarcely perceptible; narrow. Septal orifice scarcely traceable in the inner convolutions; but oblong, and placed a little above the peripheral carina. The irregular segments which form the outermost convolutions have a septal orifice at their posterior as well as their anterior border. Texture hyaline; perforated both above and below with numerous conspicuous foramina, which give to the shell a whitish, frosted aspect. The central segments often somewhat tinged with brown, especially on their flat inferior surface. Diam. $\frac{1}{30} - \frac{1}{50}$.

Readily distinguished from all other British species by its large size, numerous segments, depressed form, and flat inferior surface. It approaches nearest to some forms of *Truncatulina lobatula*, especially in young states; but is readily distinguished by its hyaline aspect, and by the irregularity of the connecting spiral, even at the inferior surface, and especially by the distinct visibility of the numerous internal convolutions at the superior one. In its growth it presents irregularities of a peculiar kind, which I have noticed in a previous publication,[1] germination taking place from various parts of its sloping peripheral border, without reference to the primary spiral mode of growth. It is also interesting as being one of the widely diffused species, having been obtained by M. D'Orbigny from the Antilles, the Gulf of Mexico, Cuba, Teneriffe, and the Mediterranean. I have numerous specimens from the last locality, especially from the neighbourhood of the Dardanelles, which only differ from our British forms in being of larger size. M. D'Orbigny also found it in a fossil state in the Tertiary strata at Mussdorf, in Austria.

M. D'Orbigny originally designated this shell *P. mediterranensis*, but in his 'Foraminifera of Cuba' he changed this name to *P. vulgaris*, from the discovery that the species was not confined to the Mediterranean Sea—surely an insufficient reason for altering a specific name; but as the former one was merely given in a catalogue, without either figure or description, whereas both these requirements of the Committee of the British Association, in their report on Scientific Nomenclature,[2] accompany the latter, this takes precedence.

Loc. Brixham, Skye, Fowey, Shetland (rare); Mr. George Barlee. Scarborough, Sandwich, Torbay, Weymouth, Tenby, Manorbeer, Cork, Swansea; Mr. J. G. Jeffreys. Alnwick; Mr. Rupert Jones. Exmouth; Mr. W. Kane. Southport; Mr. Clough. Whitehaven; Rev. Mr. Chalmers. Eddystone (abundant and fine); Mr. Spence Bate. Boston. Levant.

[1] See Memoir on some of the Microscopical Objects found in the Mud of the Levant, 'Trans. Lit. and Phil. Soc. of Manchester,' new series, vol. viii, p. 43, fig. 28.

[2] 'Report of the British Association for the Advancement of Science for 1842,' p. 105.

Genus—TRUNCATULINA, *D'Orbigny.*

Hammonia, Soldani. *Nautilus,* Walker, Adams, Gmelin, Fichtel and Moll, Maton and Rackett, Pennant, Dillwyn, Turton. *Polyxenes, Cibicides,* Montfort. *Discorbites, Discorbis,* Lamarck. *Discorbis,* Blainville, Macgillivray. *Lobatula,* Fleming, Thorpe. *Truncatulina,* D'Orbigny.

Shell parasitic; spiral; outermost convolution alone visible on the inferior lateral surface; all the convolutions, including the ultimate segment, seen on the truncate superior surface, by which it fixes itself to foreign bodies. Segments numerous; convex below, flat and truncate above. Septal orifice single; in front of the ultimate segment close to the carina of the preceding convolution, and continued, as a fissure, along the superior connecting spiral at the expense of the superior umbilical borders of the last two or three segments, but closed in by superimposed layers of shell in all the remaining ones.

This shell can only be confounded with Planorbulina and with some forms of Rotalina. From the former it differs in the features referred to in our description of that genus. From the latter it is distinguished by its flat or even concave superior surface, and by the prolongation of the septal orifice along the superior connecting spiral.

TRUNCATULINA LOBATULA, *Walker.* Figs. 121—123.

Nautilus spiralis lobatus, Walker, 1784, tab. iii, fig. 71, p. 20.
Serpula nautiloides, Schröter, 1784-7. Neue Litt., iii, p. 283, pl. iii, figs. 22, 23.
Hammonia tuberculata, Sold., 1789, i, pp. 57, 58, tab. 43, 44, 45.
Gmelin, 1789. Linn. Syst. Nat., p. 3739.
Adams, 1798. Essays, p. 642, tab. xiv, fig. 36.
Nautilus lobatulus, Turton, 1800-6. Lin. Syst. Nat., vol. iv, p. 307.
Serpula lobata, Mont., 1803. Test. Brit., p. 515; Suppt., 1809, p. 160.
Nautilus farctus, Fichtel and Moll, 1803, p. 64, tab. ix, figs. *g, h, i.*
— *lobatulus,* Maton and Rackett, 1807, p. 117.
Polyxenes cribratus, Montfort, 1808. Conch., p. 139.
Nautilus lobatulus, Pennant, 1812, vol. iv, p. 248.
— — Dillwyn, 1817. Descript. Cat., p. 344.
— — Turton, 1819. Conch. Dict., p. 120.
Truncatulina tuberculata, D'Orbigny, 1826. Tableau Méthod., p. 279.
Lobatula vulgaris, Fleming, 1828. Brit. Anim., p. 232.
Truncatulina lobata, D'Orbigny, 1839. Foram. des Canaries, p. 134, tab. ii, figs. 22—24.

Truncatulina lobatula, D'Orbigny, 1839. Foram. de Vienne, p. 168, tab. ix, figs. 18—23.

Discorbis lobatulus, Macgillivray, 1843. Moll. Anim. Aberd., p. 34.

Lobatula vulgaris, Thorpe, 1844. Brit. Mar. Conch., p. 235.

Shell suborbicular; irregular; convex inferiorly, truncate or concave superiorly; consisting of from two to two and a half convolutions, of which the outermost is alone visible at the lower lateral surface. Each convolution composed of seven or eight segments. Segments ventricose inferiorly, where their umbilical borders converge at a small umbilical depression; flat and truncate superiorly; often slightly carinated at their peripheral margin. Inferior septal lines radiating from the centre to the margin, and more or less deeply depressed. Septal plane tumid; semicrescentic. Septal orifice large; single; at the inner margin of the septal plane, adjoining the preceding convolution, and prolonged across the truncated superior surface of the segment, parallel with and contiguous to the connecting spiral, where it is usually visible in the two or three newest segments. Texture semi-hyaline, especially in a very young state; soon becoming opaque or merely translucent. In a young state it is distinctly foraminated. When mature the foramina are less conspicuous, but the entire surface is covered with little protuberances, which give the shell a frosted appearance. Diam. $\frac{1}{20}$.

In the days when all the Foraminifera were admitted by conchologists amongst the Cephalopoda, this shell was a stumbling-block and a bone of contention. It is a parasitic species, attaching itself to shells, lurking amongst the roots of Laminariæ, or more especially clustering round the larger corallines, which it often does in vast numbers. The form of the truncated superior disc is of course modified by the contour of the object to which it adheres. Montagu removed it from the Nautili on the ground that it was sessile, "which forbids its claiming a place amongst the Nautili."[1] Turton, followed by Maton and Rackett, restored it to its old place, on the ground that its structure was wholly dissimilar from that of a Serpula, whilst it was that of a Nautilus! Such were the perplexities of the earlier conchologists, when, as was not unfrequently the case, the evidence of their senses contradicted the dogmas of the systematists, but without leading them to the truth.

This shell abounds on all parts of the coast of Great Britain and Ireland, occurring as a parasite under the circumstances mentioned above. But dead shells are also of common occurrence amongst the shelly shore-sand. To obtain it in its living state, the dredge must be employed in the marine zone to which the late Professor Forbes assigned the name of "Coralline."

M. D'Orbigny found it fossil in the Tertiary strata of Mussdorf and Corocina, and Mr. Searles Wood obtained it from the English Crag. It is abundant in the Levant, and I have found it in sand from Manilla.

Messrs. Parker and Jones (op. cit.) are disposed to regard *Planorbulina vulgaris* (*P. mediterranensis*, D'Orb.) and *Rotalina concamerata* as mere conditions of growth of Truncatulina. I must confess I see no sufficient grounds for uniting these three forms.

[1] 'Test. Brit.,' p. 517.

Genus—BULIMINA, *D'Orbigny.*

Shell free; trochoid; spiral; the spiral contour occasionally indistinct; spire usually much prolonged, rendering it irregularly cylindrical. The septal plane of each segment generally directed inwards towards the central umbilical axis. Septal orifice single; round or oblong; often oblique, one of its lips passing behind the other at its umbilical margin.

In its general contour Bulimina bears considerable resemblance to Uvigerina, but differs in the septal orifice being placed at the umbilical border of each segment, instead of at its anterior extremity. How far Robertina (D'Orb.) is entitled to rank as a distinct genus I am not prepared to say. It differs merely in having the cavities of the segments partitioned (cloisonné). If some specimens of my *Bul. pupoides*, var. *convoluta*, are really entitled to be called Robertina, then there can be no doubt of the propriety of uniting the two genera.

It would have facilitated the reader's apprehension of what I believe to be the true relation of Bulimina, as well as of Uvigerina, Polymorphina, and Textularia, to the ordinary trochoid Foraminifera, such as Rotalina, if the figures belonging to all these four genera had been inverted in the plates. The drawings were all completed before I had clearly seen that relationship. Hence, in order to place them in the same relative positions as the other drawings, they require to be turned upside down. This would bring them into harmony with the descriptions where spines and appendages directed towards the primordial segment are spoken of as tending upwards, whereas in the illustrations of these genera they are directed towards the lower part of each plate. The question has already been discussed in the introduction to this volume.

BULIMINA PUPOIDES, *D'Orb.* Figs. 124—133.

Bulimina pupoides, D'Orb., 1846. Foram. de Vienne, p. 186. tab. xi, figs. 11, 12.
— *ovata*. Ibid., p. 185, tab. xi, figs. 13, 14.
— *elongata*. Ibid., p. 187, tab. xi, figs. 19, 20.
— *patagonica*, D'Orb., 1839. Voyage dans l'Amérique Mérid., tome v, p. 50, tab. i, figs. 8, 9.
— *ovula*. Ibid., tab. i, figs. 10, 11.
— *caudigera*. Ibid., p. 270.
— *marginata*, 1826. Tableau Méthod., p. 269, tab. xii, figs. 110—112.
— — Parker and Jones, 1857. Annals and Mag. Nat. Hist., 2d ser., vol. xix, p. 24, tab. xi, figs. 35—40.

Bulimina pupoides, typica. Figs. 124, 125.

Shell oblong; obtuse, especially at the inferior lateral surface; composed of numerous segments, arranged in an indistinct spiral, and exhibiting a tendency to form three oblique vertical rows. Segments remarkably ventricose and prominent; the anterior one usually more oblong than the rest, from its anterior part not being embraced, as in all the preceding ones, by the next segment. Septal plane convex; semilunar. Septal orifice single, placed near the umbilical border of the septal plane, and usually characterised by a curious obliquity at its inner part, owing to the two lips of the orifice not meeting at their umbilical extremities, but passing one behind the other. Texture hyaline; transparent; when examined, after being mounted in Canada balsam, through a high power, it is seen to be perforated by innumerable minute foramina. Hue delicately bluish or milky-white; becoming more opaque after the specimens have been some time in the cabinet. Long. $\frac{1}{50}$.

Though the name of *B. marginata* was given to one form of this species long prior to that of *B. pupoides*, I have selected the latter in preference, because the *B. pupoides* of M. D'Orbigny appears to represent the typical form of the species, whilst *B. marginata* represents the variety next described. The claim of priority is thus set aside to avoid confusion to those who prefer regarding my varieties as distinct species, using the sub-specific names to represent them. The nomenclature adopted will thus agree with that of M. D'Orbigny. The same reasoning applies to his *B. patagonica*.

Bulimina pupoides, *var.* marginata. Figs. 126, 127.

This variety differs from the last in having the free border of each segment angular and marginated, with a deep sulcus between it and the segments behind it, thus having the connecting spiral "canaliculated." This margin is usually crenulate or serrate. Sometimes all the segments present the crenulated margin; at others only a few of the primary ones do so, those of more recent growth being rounded, as in the typical figs. 124, 125. The primordial segment often furnished with a large calcareous mucro, projecting upwards in a straight line.

Bulimina pupoides, *var.* spinulosa. Fig. 128.

This is merely an exaggerated form of the last variety, in which the marginal crenulations are developed into long transparent spines. In the specimen from which the figure was taken, *three* large spines projected upwards from the primordial segment. More frequently there exists but one, which is conspicuous from its large size.

Bulimina pupoides, *var.* fusiformis. Figs. 129, 130.

Though in the general arrangement of its segments this shell resembles figs. 124, 125, it differs in being smaller, slightly compressed laterally, and a little twisted. The segments are more elongated, and less tumid. The shell is also more fusiform, being less obtuse at the two extremities. The segments are chiefly added in *two* instead of *three* oblique series, hence its compressed form. Long. $\frac{1}{80}$.

Bulimina pupoides, *var.* compressa. Fig. 131.

This variety bears the same relation to the last that *Lagena vulgaris*, var. *clavata*, does to the typical *L. vulgaris*. All the segments are elongated and narrow; hence the altered contour of the shell. It appears identical with the *B. compressa* of Bailey.[1] Long. $\frac{1}{40}$.

Bulimina pupoides, *var.* convoluta. Figs. 132, 133.

This curious type presents almost as many modifications as I have seen examples of the variety; but they all agree in displaying a slight tendency to become convoluted in their early growth. In the other forms, the primordial segment is the terminal one at the posterior extremity of the shell; but in var. *convoluta* the second and third segments project beyond the first, owing to the disposition referred to. In the specimen figured the segments are arranged in two nearly parallel series, but more usually they resemble the typical *B. pupoides*. The segments are generally somewhat less ventricose, and the septal lines are often bordered on each side by a narrow, opaque, milky streak. The specimen figured like many others which I have seen, looks as if each segment were divided by an oblique septum. Viewed by transmitted light they present a more amber-coloured hue than the other varieties, indicating a somewhat different texture.

Varied as are the forms just described, I have little hesitation in referring them all to one species; since I have seen abundant intermediate links uniting them in one unbroken series. That which I have selected as the simplest form, and consequently adopted as the type of the species, appears to present no specific difference from the *B. pupoides* of M. D'Orbigny; and as his *B. ovata* and *B. elongata* differ only in the length and number of the segments, which characters, as we have seen, are subject to great variations—there appears no ground for doubting that these all belong to the same specific type.

The var. *convoluta* is probably one of those modifications on which M. D'Orbigny has established his genus Robertina. The var. *marginata* is evidently M. D'Orbigny's *Bulimina marginata;* and his *B. patagonica* appears to be a less developed example of my var. *spinulosa*.

[1] 'Microscopical Examination of Soundings made off the Coast of the United States by the U.S. Coast Survey.' Smithsonian Contributions. Vol. ii, figs. 35—37

I am unacquainted with those which he respectively designates *B. echinata, aculeata, lævigata,* and *elegans;* and consequently cannot determine how far they are distinct from the above forms.

None of our British conchological writers appear to have noticed any species of the genus Bulimina, which is remarkable, since they are far from uncommon on the south coasts of England, with which Montagu and others were so familiar.

Loc. B. pupoides.—Torbay, Swansea, Manorbeer, Tenby; Mr. J. G. Jeffreys. Skye, Lamlash, Stornoway, Brixham; Mr. George Barlee. Plymouth Sound and Eddystone; Mr. Spence Bate. Southport; Mr. C. Clough. Scarborough; Mr. J. Williamson. Whitehaven; Rev. Mr. Chalmers. Cairnclough Bay, Antrim; Mr. Hyndman. Boston.

B. pupoides, var. *marginata.*—Skye (abundant), Stornoway, Arran; Mr. George Barlee. Lamlash; Mr. Bean. Plymouth Sound and Eddystone; Mr. Spence Bate. Scarborough; Mr. J. Williamson.

B. pupoides, var. *spinulosa.*—Skye; Mr. George Barlee. Scarborough; Mr. J. Williamson.

B. pupoides, var. *fusiformis.*—Arran, Skye, Shetland (abundant); Mr. George Barlee. Exmouth; Mr. W. Kane. Boston, March.

B. pupoides, var. *elongata.*—Skye, Shetland; Mr. George Barlee. Plymouth Sound (abundant); Mr. Spence Bate.

B. pupoides, var. *convoluta.*—Shetland, Skye; Mr. George Barlee.

Bulimina elegantissima, *D'Orbigny.* Figs. 134, 135.

Bulimina elegantissima, D'Orbigny, 1839. Voyage dans l'Amérique Mérid., p. 51, tab. vii, figs. 13, 14.

Shell oblong; spiral, with from two to three convolutions; the outermost occupying about nine tenths the entire length of the shell, and consisting of from seven to ten oblique segments, of which the breadth far exceeds the length. Septal lines flexuose, slightly depressed, crossing the long axis of the shell at a very acute angle. Septal plane oblong; somewhat pyriform; broadest at its anterior extremity, where it presents a deep depression, in which is the oblong septal aperture. Texture hyaline. Hue bluish-white; densely perforated by innumerable minute, white foramina, which give it a delicate frosted aspect. Length $\frac{1}{80}$.

This beautiful little species exhibits the usual variations in its contour, affecting the length of what conchologists would term its spire, the relative length and breadth of the segments, the obliquity of its septal lines, and the acuteness or the reverse of its two extremities. It cannot, however, be mistaken for any other British species, since the great breadth of the oblique segments, in proportion to their length, as well as its symmetrically spiral contour, at once distinguish it from all other allied forms. The species appears to have a very wide range. D'Orbigny has found it at several remote localities on the western coast of South America, and at a depth of 160 metres off Cape Horn.

Loc. Isle of Man; Mr. J. Ashworth. Torquay; Mrs. Brett. Shetland, Skye, Brixham; Mr. George Barlee. Exmouth; Mr. W. Kane. Boston.

Bulimina scabra, *nob.* Figs. 136, 137.

Shell oblong, obtuse, and tumid, especially at its inferior extremity; consisting of numerous segments forming an irregular spiral, and arranged in three longitudinal series. Segments ventricose, large. Septal lines depressed. Septal plane directed towards the central axis of the shell. Septal aperture single, indistinct; situated at the inner portion of the septal plane, and adjoining the preceding segment. Texture very rough; consisting of numerous translucent grains of sand agglutinated by a light-brown animal substance. Length, $\frac{1}{10}$.

In its form this shell closely resembles the typical *B. pupoides*, differing only in its more turgid contour and in the less ventricose character of its segments; but it is at once distinguished by its rough arenaceous texture and light-brown hue. Sometimes the imbedded grains of sand are very minute, rendering the surface of the shell comparatively smooth; at others, they are large and prominent. This object, so far as its structure is concerned, belongs to the same curious class of Foraminifera as the Proteoninæ already described, in which the soft animal is protected by a case formed of agglutinated sand, instead of the ordinary calcareous investment, resembling in this respect the Sabelliform Annelides.

As this sheet was passing through the press I received from Mr. Jeffreys some curious abnormal varieties of this shell, in which the segments appeared to be arranged as in a Nodosaria. We have already seen that in the Buliminæ they may be disposed in one, two, or three series, as in figures 133, 129, and 124; arrangements dependent on the degree in which each newly added segment overlaps its predecessors. In Mr. Jeffreys' specimens this overlapping of segments is reduced to its minimum, hence their apparently linear arrangement. They tend to confirm my impression that my *Proteonina fusiformis* may but be a monstrous form of *Bulimina scabra*.

Schultze has figured a shell under the name of *Polymorphina silicea* ('Uber den Organ. der Polyth.,' tab. vi, figs. 10, 11), which I should conclude to be identical with our present form, but for the great difference between the large, open, circular septal orifice which he delineates, and the smaller and involuted one found in our shell. If Schultze's figure is correct, the two are distinct. It is possible, however, that such may not be the case.

Loc. Sandwich, Cork, Dublin Bay; Mr. J. G. Jeffreys. Scarborough; Mr. Jeffreys and Mr. Rupert Jones. Skye, Shetland; Mr. George Barlee. Plymouth Sound; Mr. Spence Bate.

Genus—UVIGERINA, *D'Orbigny.*

Shell free; indistinctly spiral; with an oblong spire. Segments numerous, ventricose or angular. The anterior extremity of the ultimate segment prolonged into a cylindrical tube, at the extremity of which is the round septal aperture.

This genus could only be confounded with Bulimina, from which it is at once distinguished by the tubular prolongation of the anterior part of the ultimate segment, somewhat resembling that of a Lagena or a Nodosaria.

UVIGERINA PYGMÆA, *D'Orb.* Figs. 138, 139.

Polymorphina pineiformia, Soldani, t. i, p. 118, tab. 126, fig. *x x*, *y y*, *z z*; tab. 130, fig. *s s*.

— — Ibid., t. ii, p. 21, tab. vi, fig. *k k*, *l l*.

Uvigerina pygmæa, D'Orbigny, 1825. Tableau Méthod., p. 268, pl. xii, figs. 8, 9.

— — Ibid., 1846. For. de Vienne, p. 190, tab. xi, figs. 25, 26.

— *bifurcata*. Ibid., 1839. Voyage dans l'Amérique Mérid., tab. vii, fig. 17.

— *pygmæa*, Parker and Jones, 1857. Ann. and Mag. Nat. Hist., 2d series, vol. xix, p. 25, tab. xi, figs. 41—43.

Shell oblong, obtusely ovato-acuminate, broadest in the middle, consisting of numerous segments arranged in an obscure spiral. Segments ventricose; their breadth much exceeding the length, with the exception of the ultimate one; each segment marked with strong arcuate costæ, which tend towards parallelism with the long axis of the shell. Costæ sometimes continuous along the entire length of the organism; at others discontinuous, alternating at each septal line; occasionally extending over but a portion of each segment. Ultimate segment prolonged forwards into a short, straight, narrow tube, at the extremity of which is the round septal orifice. Opaque, and of dirty yellowish-gray hue. Length, $\frac{1}{33}$.

This exquisite little species appears identical with the *U. pygmæa* of M. D'Orbigny, though his figure in the 'Tableau Méthodique' represents a specimen with a longer neck, and with less distinct costæ on the two ultimate segments than my specimens present, but this is a common variation in many species of Foraminifera. I see no sufficient reason for separating *U. bifurcata*, D'Orb., from *U. pygmæa;* the only distinction upon which that author relies is a slight one in the arrangement of the costæ, which "au lieu de se continuer sur tout l'hauteur de chaque loge, sont interrompues, ou bifurquées, caractère constant chez tous les individus."[1] That the character in question should be constant in all the specimens found at any given locality is not improbable, since I have found numerous illustrations of the tendency of one variety to prevail over local areas; but I cannot conclude that the difference is sufficient to constitute a specific distinction. We have already seen, from the examination of *Lagena vulgaris*, of how little specific value costæ of any kind are; still less so are trivial modifications of their position.

Loc. Skye, Shetland; Mr. George Barlee. Malouine Islands and Adriatic; M. D'Orbigny. Fossil at Baden and Nussdorf, in Austria; Idem.

[1] 'Voyage dans l'Amérique Mérid.'

Uvigerina angulosa, *nob.* Fig. 140.

Uvigerina pygmæa, var., Parker and Jones. Annal. Nat. Hist., vol. ix, p. 25.

Shell ovato-oblong; rudely triangular; composed of several segments arranged somewhat unsymmetrically. Segments of nearly equal length and breadth, marked with irregular costæ; those in the centre of each segmemt being much more developed than the rest, forming a prominent angle interruptedly continuous along the entire length of the shell, which exhibits three such angles. Ultimate segment prolonged into a short straight tube, terminated by the septal aperture. Texture semi-hyaline, and very finely foraminated. Hue a pale dirty-white. Length, $\frac{1}{40}$.

I have strong suspicions that, as Messrs. Parker and Jones imagine, this is but another variety of the *U. pygmæa*, but having found it much more widely diffused than the latter shell, and yet having failed to obtain undoubted transitional forms, I have not ventured to assert its identity. With the exception of the strong angular costæ, which being interruptedly continued from segment to segment give the triangular contour to the shell, the ribs are much less conspicuous, and very much less regular than in that species. The entire organism is smaller, more hyaline, and altogether less symmetrical and elegant than the *U. pygmæa*. The first examples which I met with I regarded as mere monstrosities of that species; but having since found it at many localities, and everywhere maintaining the same unsymmetrical, angular contour, I have provisionally admitted it as a new form.

Loc. Torquay; Mrs. Brett. Arran, Shetland, Scilly; Mr. George Barlee. Ireland; Mr. J. G. Jeffreys. Boston.

Genus—CASSIDULINA, *D'Orbigny.*

Shell suborbicular; free; spiral; nearly equilateral; the convolutions more or less embracing. The segments inequilateral, each consisting on one side of a large oblong or crescentric surface, extending from the peripheral margin to the umbilicus, and on the other of a small triangular area, which stops considerably short of the umbilicus, being intercalated between the divergent peripheral portions of two crescentic segmental surfaces. Each of these surfaces presents itself alternately to the opposite sides of the shell. Septal plane long and narrow, intersecting the central plane of the disciform shell very obliquely. Septal aperture an oblong curved slit, occupying the umbilical half of the septal plane. (Figs. 142 and 144.)

This curious genus resembles Heterostegina and Asterigerina, when an example of either of the latter genera is viewed only on the inferior lateral surface of the shell, but they both differ from Cassidulina in having the opposite surface flat, truncated, revealing even the primordial segment,

making them conspicuously inequilateral, as in Truncatulina. They all differ from Truncatulina in the position of their septal orifices.

CASSIDULINA LÆVIGATA, *D'Orb.* Figs. 141, 142.

Cassidulina lævigata, D'Orb., 1826. Tableau, p. 282, pl. vi, figs. 4, 5.
— — D'Orb. Modèles, No. 41, 2de Livraison.
? — *pulchella*, D'Orb., 1839. Voyage dans l'Aérique Mérid., p. 57, tab. viii, figs. 1—3.
— *lævigata*, Parker and Jones, 1857. Ann. Mag. Nat. Hist., New Series, vol. xix, p. 23, tab. 11, figs. 17, 18.

Shell sub-orbicular, lenticular, spiral; consisting of numerous investing convolutions, of which the outermost is alone visible; thick at the umbilicus; thin and often sharply carinated at the peripheral margin, which is more or less scalloped. Outermost convolution consisting of about eight inequilateral, slightly ventricose, segments; of these, four on each side are curved and obtusely crescentic or pyriform, covering the umbilicus at their umbilical borders, and reaching the periphery at their opposite margins. The anterior and peripheral margins of each segment combine to form one semicircular curve, having its convexity directed forwards. Each of the four intermediate segments *on the same side* is much smaller than the others, forming a small triangle, of which the convex base contributes to the peripheral outline of the shell, whilst its umbilical apex terminates somewhat short of midway between the periphery and the umbilicus, the triangle being intercalated between the two contiguous larger reversed segments. On the opposite side of the shell the same arrangement occurs, but in an inverted order; the large segmental areas are now represented by the small triangular ones, and the triangles by crescentic ones. Septal plane somewhat crescentic; oblique; its long axis intersecting the peripheral plane of the shell at a very acute angle, and facing alternately towards opposite sides; whence the peculiar arrangement of the segments. Septal orifice a curved slit, extending about halfway across the septal plane, commencing at the junction of the latter with the preceding convolution. Texture beautifully hyaline in young specimens, becoming more milky in older ones; smooth, glossy, and perforated with numerous very small, white, scattered foramina. Diam. $\frac{1}{60}$.

This, which is one of the most delicately beautiful of the British Foraminifera, is at once distinguished from all others, excepting the succeeding species, by the curious alternation of its segments. My cabinet contains an elegant variety of it, which I found in sand[1] brought from Hunde and Beechey Islands by Dr. Sutherland, in which, though the exterior of the shell is as smooth as in our British forms, the cavities of the segments stop short of the umbilicus; which latter is occupied by perfectly transparent carbonate of lime, but through which the inner segments, including even the primordial one, can be clearly seen; a structure reminding us of some forms of *Cristellaria Calcar*.

Loc. Arran (not uncommon), Skye, Shetland; Mr. G. Barlee.

[1] For which I am indebted to Professor Dickie, of Belfast, and Mr. Brightwell, of Norwich.

Cassidulina obtusa, *nob.* Figs. 143, 144.

This shell corresponds with *C. lævigata* in every respect, except that it is smaller in size, and has an obtuse, rounded, peripheral margin, instead of a thin carinated one. In other points the two appear identical. I have long been disposed to regardthem as mere varieties of one species, but our opinion of their identity or difference depends partly upon our response to a previous question, viz., whether or not the form of the periphery is a sufficient basis upon which to build a species. The case is analogous to that of the two Polystomellæ, as well as to that of the typical *Lagena vulgaris*, with its rounded base and its relation to the acuminated variety *Clavata*. If we admit the Lagena as typical of all the rest of the Foraminifera, the question becomes settled; since in that case we undoubtedly possess all the links connecting the two extreme forms and establishing their unity as a species. But though there are many reasons for supposing that the Lagena is to be regarded as the type of each isolated segment of the compound Foraminifera, we are scarcely in a position dogmatically to affirm it, and must consequently fall back for guidance in each instance upon the existence or non-existence of intermediate, inosculating links. In the case of the Cassidulinæ I have failed to discover such links; consequently, for the present, I have recognised *Cassidulina obtusa* as a new species. At the same time we must remember that some new locality may probably supply specimens demonstrating it to be merely a variety of *C. lævigata*.

M. D'Orbigny figures a shell under the name of *Cassidulina crassa*,[1] which approaches very near to this, but differs in the form of the septal orifice, which, instead of merely being slightly arcuate, bends suddenly back upon itself at an acute angle towards its outer portion, which thus returns towards the umbilical region of the organism.

Loc. Shetland (abundant), Fowey, Brixham; Mr. George Barlee. Hunde Island, Davis's Straits; Dr. Sutherland.

Genus—POLYMORPHINA, *D'Orbigny.*

Serpula, Walker, Adams, Maton and Rackett, Pennant. *Vermiculum*, Montagu, Fleming, Macgillivray. *Arethusa*, Montfort, Fleming, Thorpe. *Polymorphina*, D'Orbigny, Macgillivray. *Guttulina*, *Globulina*, D'Orbigny. *Renoidea*, Brown.

Shell free; spherical or oblong. Visible segments varying in number from two to many. Segments sometimes ventricose, in others plane; arranged in an obscure spiral; sometimes in two opposed series; more or less embracing and closely investing the previous segments, each segment doing so more on one side than on the other, rendering the shell inequilateral. Septal lines sometimes depressed, at others only distinguished by white milky lines without depressions. (fig.) 155. Septal orifice at the mamilliform anterior extremity of the ultimate segment; round;

[1] 'Voyage dans l'Amérique Méridionale,' p. 56, tab. vii, figs. 18—20.

usually surrounded by coronal of strongly-defined, radiating grooves; often prolonged inwardly through a tube projecting into the segment, as in Entosolenia.

In the description of *P. lactea* my reasons will be found for uniting Polymorphina, Guttulina, and Globulina, into one genus. There is no other with which this can well be confounded; the terminal position of the septal orifice distinguishes it from all spiral forms, excepting Unigerina, from which it differs in the absence of the long anterior tube, and in the more closely investing segments.

POLYMORPHINA LACTEA, *Walker*. Figs. 145—152.

Serpula tenuis ovalis lævis, Walker, 1784, p. 2, tab. i, fig. 5.
— *lactea,* Adams, 1798. Essays, p. 634, tab. xiv, fig. 4.
Vermiculum lacteum, Mont., 1803. Test. Brit., p. 522.
Serpula lactea, Maton and Rackett, 1807, p. 246.
— — Pennant, 1812, vol. iv, p. 363.
— — Turton, 1819. Conch. Dict., p. 156.
Guttulina communis, D'Orbigny, 1826. Tableau Méthod., p. 266, tab. xii, fig. 14.
Arethusa? lactea, Fleming, 1828. Brit. Anim., p. 234.
Vermiculum lacteum, Fleming. Wern. Mem., iv, p. 566, tab. xv, fig. 6.
? *Guttulina vitrea,* D'Orbigny, 1836. For. de Cuba, p. 133, pl. ii, figs. 1—3.
— *Planchii,* D'Orbigny, 1839. Voyage dans l'Amérique Mérid., p. 60, tab. i, fig. 5.
Renoidea oblonga, Brown, 1839. Conch. Illust., p. 3, tab. lvi, figs. 16—17.
Vermiculum lacteum, Macgillivray, 1843. Moll. Aberd., p. 37.
Polymorphina lactea. Ibid., p. 320.
Arethusa lactea, Thorpe, 1844. Brit. Mar. Conch., p. 233.
Guttulina communis, D'Orbigny, 1846. Foram. de Vienne, tab. xiii, figs. 6—8.
— *austriaca.* Ibid.
Globulina gibba. Ibid., tab. xiii, figs. 13, 14.
— *æqualis.* Ibid.
— *tubulosa.* Ibid.
Polymorphina communis, Parker and Jones, 1857. Annals and Mag. Nat. Hist., vol. xix, p. 11.

POLYMORPHINA LACTEA, typica. Figs. 145—147.

Shell ovato-oblong, usually broadest superiorly; composed of a very variable number of oblong embracing segments, which are usually more ventricose inferiorly than superiorly, where they thin out, though occasionally terminating abruptly; two sides unequal, owing to the oblique position of the segments, which invest one side more completely than the other; leaving in the latter case more of the preceding segments exposed than in the former. Segments sometimes very prominent,

especially the oblique ones often seen in the centre (see fig. 147); the greater number of them reaching nearly to the superior extremity of the shell. Septal lines sometimes deeply indented; in other cases, especially in old shells, the organism presents an even surface, having the septal lines scarcely depressed and nearly obliterated. Segments arranged in an indistinct spiral, each one being carried forward in its growth through rather more than half a circle; hence they are rarely opposite each other. Septal orifice single, round; visible at the mamilliform anterior extremity of the ultimate segment; surrounded by a small circular coronal of radiating grooves, and often opening into a short tube, which projects into the interior of the segment, as in Entosolenia. Texture smooth, glossy; in young shells, beautifully hyaline; the septal lines and peripheral margin being white and milky (fig. 147); but in older examples becoming more opaque, and of a dirty yellowish-white; perforated by innumerable very minute foramina, scarcely visible except when the shell is mounted in Canada balsam, and viewed as a transparent object. Long, $\frac{1}{20}$.

Loc. Skye, Arran, Shetland, Fowey, Brixham; Mr. George Barlee. Exmouth; Mr. Kane. Cairnclough Bay, Antrim; Mr. Hyndman. Whitehaven; Rev. Mr. Chalmers. Southport; Mr. C. Clough. Eddystone, Plymouth Sound; Mr. Spence Bate. Scarborough; Mr. J. Williamson. Copeland Islands, County Down; Professor Patterson. Boston, Manilla.

POLYMORPHINA LACTEA, *var.* ACUMINATA. Fig. 148.

Oblong; acuminated, especially at its superior extremity; consisting of several elongated segments, of which none but the earliest ones reach the superior extremity of the shell. Segments arranged in two opposed series, but differing on opposite sides. Septal lines slightly depressed; oblique.

Loc. Skye; Mr. George Barlee. A rare variety.

POLYMORPHINA LACTEA, *var.* OBLONGA. Fig. 149, 149 *a*.

Shell oblong; ovate; of nearly equal diameter throughout its entire extent; rounded at each extremity; compressed; consisting of numerous, narrow, oblong segments, arranged in two opposed alternate series; each segment extending nearly to the superior extremity of the shell; not reaching the median line, but leaving uncovered nearly all the preceding convolutions. Septal orifice round; at the obtuse anterior extremity of each segment; surrounded by a large coronal of radiating grooves. Septal plane oblong, narrow, convex. Septal lines scarcely depressed, but distinct. Texture hyaline when young, becoming more opaque with age. Long, $\frac{1}{35}$.

Loc. Southport (abundant); Mr. C. Clough. Brixham (abundant), Skye (rare), Shetland; Mr. G. Barlee. Scarborough, Manorbeer; Mr. J. G. Jeffreys. Whitehaven; Rev. Mr. Chalmers. Eddystone (abundant); Mr. Spence Bate. Copeland Islands, County Down; Professor Patterson. Boston.

POLYMORPHINA LACTEA, *var.* FISTULOSA. Fig. 150.

Differs only in having the outermost segment much enlarged, and developed into numerous irregular expansions and tubular growths. The extremities of these tubes, which frequently dichotomize, are often open; but I believe this to be the result of accident, and that in their normal state they are mere cul-de-sacs. Length, $\frac{1}{18}$.

Loc. Skye; Mr. George Barlee. Scarborough; Mr. Bean. Loch Fine; Mr. J. G. Jeffreys. Fossil in the Crag; Mr. Searles Wood.

POLYMORPHINA LACTEA, *var.* CONCAVA. Figs. 151, 152.

This curious variety partakes of some of the peculiarities of the last. Its centre consists of a small hyaline shell of the ordinary type, but the last segment is spread out into a thin marginal expansion; highlyconcave on one surface, where the previous segments are but faintly visible (fig. 152), and equally convex on the other, where the earlier segments of the shell are more conspicuous. The periphery is always sinuous, and though very thin, is rounded and obtuse. The last segment presents no visible septal orifice. I am disposed to believe that, during the formation of the ultimate segment, the individuals belonging to this variety may have become parasitic upon some other rounded bodies; an opinion to which the variable contour of the peripheral segment, contrasted with the uniform appearance of the central ones, affords some countenance.

Loc. Brixham; Mr. George Barlee.

POLYMORPHINA LACTEA, *var.* COMMUNIS. Figs. 153—155.

Shell almost spherical; obtuse; somewhat constricted at its inferior extremity; consisting of from three to six segments; the two last investing the greater part of the shell. Septal lines often scarcely depressed; but sometimes, when the segments are more convex, the septal lines are distinct. Septal orifice round; surrounded by a radiating coronal. Texture hyaline in young shells, with the margin and septal lines white (fig. 155); the translucent area diminishes with age, and the whole shell ultimately becoming opaque and cream-coloured. Surface very glossy; finely foraminated when examined under a high power.

Loc. Northumberland; Professor King. Lamlash; Mr. Bean. Southport; Mr. C. Clough. Plymouth Sound and Eddystone; Mr. Spence Bate. Skye, Arran, Shetland, Brixham (abundant); Mr. George Barlee. Copeland Islands, County Down; Professor Patterson. Manilla, Levant, Dardanelles.

Notwithstanding the diversified forms of the objects here brought together, and although they

have been divided by M. D'Orbigny into three distinct genera, viz., Polymorphina, Guttulina, and Globulina, I have no hesitation in uniting them. It would be utterly impossible to separate the specimens in my cabinet into distinct groups, capable of being represented by recognisable definitions. Typical forms, such as are delineated in my figures, may easily be selected and described as so many distinct species; but it would be almost impossible to meet with one example in a thousand, that would exactly correspond with any of these figures. No two shells appear precisely alike, yet their points of difference are very trivial. Varieties are almost as numerous as the specimens, yet they appear to be of about equal value. Consequently we must either admit their unity as a species, or accept the alternative of recognising as many species as there are individuals, which would be absurd. The variations affect alike the number of the segments, their length and breadth, their prominence, and their transparency. Sometimes, as in the variety *oblonga*, the segments are arranged in two nearly opposed series, constituting one of M. D'Orbigny's typical Polymorphinæ. But it is no uncommon circumstance to meet with specimens which, after growing for some time according to this plan, throw out two or three large spirally disposed segments, thus uniting figs. 145 and 146 with 148 and 149. In other cases, the opposite plan is pursued, the spiral arrangement being the earliest, and the opposition of the segments the later condition. Similar inosculating examples link the other varieties together; but I believe, that in all, the spiral mode of development is followed. Supposing the transverse section of the entire shell to represent a circle, in some cases each new segment describes half the circle, producing the type with opposed segments; in others the new segment appears to advance more than half a circle beyond its predecessor. Hence the irregular alternation which so commonly prevails, depending upon the number of degrees which each segment traverses—a condition of things analogous to the leaf-arrangement of the botanists.

In uniting *Guttulina vitrea* and *Planchii*, as well as *Globulina gibba* and *æqualis* of D'Orbigny, with his *Guttulina communis*, and regarding the whole as forms of *Polymorphina lactea*, I have been guided by the considerations already enumerated. The differences upon which that author bases these species are such as I find insufficient to constitute specific distinctions amongst our British examples, and presume that their merely foreign habitat does not give them any additional claim to specific rank, or absolve them from subordination to what appear to be general laws.

It is interesting to find that the curious variety *fistulosa* (fig. 150) occurs fossil in the Crag, where it was discovered by Mr. Searles Wood. The *Globulina tubulosa* of M. D'Orbigny appears to be a similar modification of the *Globulina gibba* of that author, but which he regards as distinct. It is evident that most if not all the varieties of *P. lactea* display a tendency towards an irregularity of form in the ultimate segment. Figs. 151 and 152 are but additional examples of the same tendency, only assuming a new direction.

POLYMORPHINA MYRISTIFORMIS, *nob.* Figs. 156, 157.

Shell nearly spherical, consisting usually of two, but sometimes of three or four visible segments. Each segment fitting closely to its predecessors at their broadest part, thus maintaining the spherical contour of the shell. Occasionally, when three or four segments are visible, the inner ones are turgid and elevated. Surface of the shell marked by numerous longitudinal, interrupted, translucent, raised costæ. Septal lines very faint; often represented by an obscure, milky

streak. Septal orifice at the anterior extremity of each segment, surrounded by a coronal of raised ridges. Texture hyaline, or semi-hyaline; perforated by numerous minute foramina. Hue whitish. Length, $\frac{1}{10}$.

Remarkable for its exceeding lightness and delicacy, causing it to fly off at the slightest touch or the faintest breath; as I have often found to my cost. An elegant species, and though nowhere common, occasionally met with at several distant localities. Hence probably a widely diffused form.

Loc. Arran, Shetland, Roundstone, Guernsey; Mr. George Barlee. Oxwich, near Swansea, Manorbeer, Cork; Mr. J. G. Jeffreys. Eddystone; Mr. Spence Bate. Tenedos (Levant).

Genus—TEXTULARIA, *Defrance.*

Textularia, Defrance, D'Orbigny, Macgillivray, Thorpe, Rupert Jones.

Shell free; regular; equilateral; conical, oblong, or cuneiform. Segments numerous; arranged in two parallel series; each one usually having its umbilical margin intercalated between two contiguous ones of the opposite series. Hence a lateral zigzag chain of septal lines usually extends along each side, from the umbilical angle of the ultimate segment to the primordial one at the apex of the spire. Septal orifice round or transversely oblong, at the centre of the umbilical margin of the last segment, close to its junction with the antecedent segment in the opposed series.

This genus is readily distinguished from most others by having its segments arranged in two parallel series, and by the position of the septal aperture at their inner or umbilical margins. M. D'Orbigny's genus Bolivina differs in having the septal aperture prolonged in the opposite direction to that of Textularia, or vertical, corresponding with the long axis of the shell. I have not seen any species of this genus, consequently cannot presume to give a decisive opinion respecting it; but from the irregularity commonly attending mere differences in the form of the aperture, I am disposed to doubt the propriety of establishing a genus on this foundation.

Textularia cuneiformis, *D'Orb.* Figs. 158—161.

Textularia cuneiformis,[1] D'Orb., 1839. Foram. de Cuba, p. 147, tab. i, figs. 37, 38.
— *conica.* Ibid., tab. i, figs. 19, 20.

[1] Mr. Rupert Jones has applied this name to a Permian species of Textularia, in Professor King's work on the 'Permian Fossils of England,' without being aware of its previous application by M. D'Orbigny to a different shell.

? *Textularia gramen*, D'Orb., 1846. Foram. de Vienne.
? — *abbreviata*. Ibid.
— *obtusa*, Macgillivray, 1843. Moll. Aberdeen, p. 320.
— *oblonga*. Ibid., p. 38.
— *obtusa*, Thorpe, 1844. Brit. Mar. Con., p. 237.
— *oblonga*. Ibid., p. 237.
— *sagittula*, Parker and Jones, 1857. Annals and Mag. Nat. Hist., 2d Series, vol. xix, p. 25, tab. xi, figs. 44, 45.

TEXTULARIA CUNEIFORMIS, typica. Figs. 158, 159.

Shell oblong; compressed; cuneiform; truncated anteriorly; thickest down the centre; becoming thinner towards the margins, which are irregularly lobulated; the latter sometimes carinated; at others obtuse and rounded. Segments numerous in matured shells; slightly convex; at first increasing rapidly in size (hence the triangular form of the young shells), but soon ceasing to do so; the ultimate segments, in elongated examples, becoming even contracted to a smaller size than those at the centre of the shell. Septal plane flat; sagittate; with rounded margins. Septal lines slightly depressed and arcuate, bending somewhat towards the primordial segment as they pass to the periphery. Septal orifice transverse; oblong; at the umbilical margin of the segment, and contiguous to the central axis of the shell. Texture arenaceous. Hue pale dirty brown or yellowish white; sometimes olivaceous. Length, $\frac{1}{20}$.

Loc. Arran, Skye, Stornoway, Bulmacaria, Shetland, Brixham; Mr. George Barlee. Lamlash; Mr. Bean. Poole Bay; Mr. Rupert Jones. Portsmouth, Scarborough, Weymouth, Falmouth, Sandwich, Isle of Wight, Torbay, Swansea, Manorbeer, Cork, Dublin Bay, Exmouth; Mr. J. G. Jeffreys. Cullercoats; Mr. J. Alder. Plymouth Sound and Eddystone; Mr. Spence Bate. Cairnclough Bay, Arran, and Belfast Bay; Mr. Hyndman. Copeland Islands, County Down; Professor Patterson. Levant, Kurachee, Coast of Scinde.

TEXTULARIA CUNEIFORMIS, *var.* CONICA. Figs. 160, 161.

Differs from the typical form in being cylindrical instead of compressed. Hence the orbicular form of its inferior lateral aspect, produced by the apposition of the semicircular septal planes of the ultimate and penultimate segments.

I am fully satisfied that the two preceding forms belong to the same species which, as usual, presents a wide limit of variation, ranging from the thin, oblong, compressed shell with carinated margins, to the rounded trochoid form of figs. 61, 62; which latter appears identical with the *T. conica* of D'Orbigny. After examining thousands of specimens, I am satisfied that no distinction can be drawn between these two extreme varieties, owing to the imperceptible way in which other specimens establish the transition from the one to the other. Such being the case, it of necessity follows that the characters enumerated as distinguishing the *T. articulata*, *T. subangulata*,

T. gramen, and *T. abbreviata*, of M. D'Orbigny, and probably of some other species, are insufficient to justify the separation of these forms. All these shells belong to one group of arenaceous Textulariæ, which appears to have a wide diffusion; and that any one of these cosmopolites should have its segments a little more ventricose, or be more acutely margined, or a little more oblique, is surely an insufficient reason for raising it to the rank of an independent species. These would be doubtful distinctions, even amongst the more constant forms of the Mollusca; but amongst the very variable shells of the Protozoa, such distinctions are entirely valueless. Not having seen several of the above species, and being acquainted only with M. D'Orbigny's figures of them, I would avoid speaking with undue positiveness respecting their identity with our British forms; but I do not see how they are to be distinguished from the latter examples.

It is curious that so common a shell should have escaped the notice of Montagu and his coadjutors. No British naturalist appears to have described any Textulariæ prior to Professor Macgillivray, and his two supposed species are merely slight varieties of the present shell.

TEXTULARIA VARIABILIS, *nob.* Figs. 162—168.

TEXTULARIA VARIABILIS, typica. Figs. 162, 163.

Shell oblong; sub-compressed; with rounded and crenulated margins. Segments more or less turgid; of nearly equal length and breadth. Septal lines depressed; sometimes straight, but more frequently a little arcuate, and bending towards the primordial segment; those of one longitudinal series of segments opposed to the centres of the segments in the other series, producing a longitudinal zigzag line in each peripheral aspect, sometimes excavated into a deep and conspicuous groove with prominent margins. Septal orifice conspicuous; at the umbilical border of each segment, close to the preceding one. Texture hyaline, or sub-hyaline; conspicuously foraminated; foramina sometimes placed at the bottom of deep hexagonal pits, which render the shell rugose and semi-opaque. Hue a dirty white. Length, $\frac{1}{45}$.

Loc. Torquay; Mrs. Brett. Arran, Skye, Fowey, Shetland, Brixham; Mr. George Barlee. Whitehaven; Rev. Mr. Chalmers. Exmouth; Mr. W. Kane. Plymouth Sound and Eddystone; Mr. Spence Bate. Boston, Levant, Dardanelles.

TEXTULARIA VARIABILIS, *var.* SPATHULATA. Figs. 164, 165.

Shell oblong; much compressed; broad and rounded at the anterior, lanceolate at the posterior extremity; thin, with sharp, smooth, entire margins. Segments arcuate; flat or but slightly convex; their breadth greatly exceeding their length; their peripheral margins tapering backwards and outwards to a point. Septal lines curving backwards; slightly depressed. Texture highly hyaline; with minute scattered foramina; the latter often absent from some portions of the parietes, which are then clear and transparent. Long, $\frac{1}{40}$ — $\frac{1}{60}$.

A much more delicate and less robust variety than the last.

Loc. Torquay; Mrs. Brett. Arran, Shetland; Mr. George Barlee. Boston.

TEXTULARIA VARIABILIS, *var.* DIFFORMIS. Figs. 166, 167.

In this variety the peripheral margins are irregularly dentate, owing to the corresponding margin of each segment being prolonged into an irregular projecting mucro. These sometimes consist of solid, transparent carbonate of lime; at others the cavity of the segment extends into them; but they are in all respects very irregular, and give to the shell an appearance of deformity.

TEXTULARIA VARIABILIS, *var.* LÆVIGATA. Fig. 168.

Differs from the typical form (fig. 151) in the surfaces of its segments being scarcely raised above the septal lines. Hence its outline is but little, if at all, lobulated. The smooth appearance thus produced is increased by the exceeding minuteness of its foramina. In a large number of the specimens I have seen, the segments are so nearly opposite one another as to appear arranged in pairs.

Loc. Brixham, Shetland, Arran; Mr. George Barlee. Boston.

I can scarcely suppose that this very common species has escaped the attention of all previous writers, though it has not been noticed by any of our British conchologists. I have no doubt that it is one of those enumerated in M. D'Orbigny's list published in 1826; but as no descriptions are appended, I am unable to identify it with any of the latter. It approaches very closely in its general form to his *Textularia agglutinans*;[1] but that shell is described as consisting of agglutinated grains of sand, which our species does not. Many of the specimens *appear* to be so, owing to the areolar excavations which so often make the parietes look tuberculated and irregular; but their texture is calcareous and hyaline; being very different from that of *T. cuneiformis* and other true arenaceous Foraminifera. The variety *lævigata* appears undistinguishable from M. D'Orbigny's *T. lævigata*.[2] If they are identical, the laws of nomenclature require that I should adopt D'Orbigny's name for the entire species; but I have refrained from doing so, for two reasons. The name would give an erroneous idea of a shell which is ordinarily anything but smooth; and I am not quite certain of the identity of my recent specimens with the fossil ones of M. D'Orbigny, not having seen the latter; consequently I propose only to adopt his name for that variety of our species with which the fossil one appears to be identical, and thus avoid confusion for those who may still prefer regarding it as distinct.

Since writing the above, the Memoir of Parker and Jones, on some Foraminifera from the

[1] 'For. de Cuba,' p. 144, pl. i. figs. 17, 18, 32—34.

[2] 'For. de Vienne.'

Coast of Norway has reached me. It is possible that they include some of the above varieties amongst those described under the name of *T. sagittula*.

Genus—BILOCULINA, *D'Orbigny*.

Frumentaria, Soldani. *Miliolites, Miliola*, Lamarck, Parkinson. *Biloculina*, D'Orbigny, Brown. *Lagenula*, Fleming. *Renoidea*, Brown. *Nummulina*, Macgillivray, Thorpe.

Shell free; equilateral; regular; consisting of numerous concavo-convex segments, arranged in two alternating, opposite series, their free margins being always in the same plane. Segments successively enclosing rather more than half the pre-existing shell, each one in turn concealing the antepenultimate and usually the peripheral margin of the penultimate one, so that but two segments are visible externally; these alternately presenting their peripheral surfaces in opposite directions. Septal aperture single, large, round, oblong, or linear; provided with a tooth-like appendage; alternately occupying opposite extremities of the shell.

Biloculina is a convolute shell, winding regularly, and in the same plane, round an imaginary central axis; each segment not only occupies rather more than half a convolution, but extends laterally, concealing the umbilicus and all the preceding convolutions. In the latter feature it differs from Spiroloculina, in which, the segments being narrow, all the preceding convolutions are visible on each side, occupying distinct umbilical depressions. From Miliolina it differs in never revealing more than two segments externally.

Biloculina ringens, *D'Orb.* Figs. 169—176.

Planchus, 1739, tab. ii, fig. 4. (Tab. iii, fig. ii, Edit. Romæ, 1760.)
Frumentaria ovula, Soldani, 1789, p. 228, tab. cliii, figs. r, s.
Walker, 1784. Test. Minut. rar., p. 2, tab. i, fig. 7.
Miliolites ringens, Lamarck, 1804. Fossiles env. Paris, and Ann. Mus., v, p. 351; ix, pl. xvii, fig. 1.
— — Parkinson, 1811. Org. Rem., vol. iii, p. 162, tab. xi, fig. 11.
Biloculina ringens, D'Orb., 1826. Ann. Sc. N., vii, p. 297.
— *bulloides*. Ibid., p. 297, tab. xvi, figs. 1—4; Modèles, No. 90.
— *lævis*. Ibid., p. 298.
— *aculeata*. Ibid., p. 298; Modèles, No. 81.
— *depressa*. Ibid., p. 298; Modèles, No. 91.
Pyrgo lævis, Defrance. Dict. de Sciences Naturelles, pl. lxxxviii, fig. 2.
Renoidea marginata, Brown, 1827. Illust. Conch., tab. i, fig. 25.
Lagenula marginata, Fleming, 1828. Brit. Anim., p. 235.

Biloculina subspherica, D'Orb., 1839. For. de Cuba, p. 162, tab. viii, figs. 25—27.
— *carinata*. Ibid., p. 64, tab. viii, fig. 24, and tab. ix, figs. 1, 2.
— *patagonica*, Ibid. Voyage dans l'Amér. Mérid., p. 65, tab. iii, figs. 15—17.
— *Peruviana*. Ibid., p. 65, tab. ix, figs. 1—3.
— *Bougainvillei*. Ibid., p. 67, tab. viii, figs. 22—24.
— *inornata*, Ibid., 1846. For. de Vienne, p. 266, tab. xvi, figs. 7—9.
— *simplex*. Ibid., p. 264, tab. xv, figs. 25—27.
— *clypeata*. Ibid., p. 263, tab. xv, figs. 19—21.
Nummulina marginata, Macgil., 1843. Moll. Aberd., p. 34.
— — Thorpe, 1844. Brit. Mar. Conch., p. 242.
Biloculina ringens, Parker and Jones, 1857. Ann. and Mag. Nat. Hist., 2d ser., vol. xix, p. 26, tab. x, figs. 28—33.

BILOCULINA RINGENS, typica. Figs. 169—171.

Shell oval; spherical; its ultimate segment projecting at each extremity beyond the penultimate one; with a rounded or but slightly angular margin. Septal aperture round or transversely ovate; at the anterior extremity of the ultimate segment, which is obliquely truncated by it. A small tooth, usually more or less bifid, but of variable form, projects from the inner and inferior border of the septal aperture. Texture porcelainous; hue, opaque; white; glossy. Long, $\frac{1}{20}$.

Loc. Scarborough; Mr. Bean and Mr. J. G. Jeffreys. Lamlash; Mr. Bean. Loch Fine, Whitesand Bay, Tenby, Oxwich, Cork, Bantry Bay; Mr. J. G. Jeffreys. Exmouth; Mr. Clarke. Whitehaven; Rev. Mr. Chalmers. Plymouth Sound and Eddystone; Mr. S. Bate. Cairnclough Bay, Antrim, Belfast Bay; Mr. Hyndman. Copeland Islands, County Down; Professor Patterson. Manilla, Havannah.

BILOCULINA RINGENS, *var.* CARINATA. Figs. 172—174.

Shell orbicular; compressed. The free surface of the ultimate segment (fig. 174) convex, surrounded by a thin, narrow, concave margin or carina. On its umbilical surface (fig. 173) this margin is considerably broader than externally; within it is a prominent orbicular ridge, surrounding a convex centre, which latter previously constituted the outer surface of the antecedent segment, the orbicular ridge having been its peripheral carina. Septal aperture a long, narrow, transverse slit (figs. 172—174), placed on the umbilical side and a little below the anterior extremity of the ultimate segment; with but slight traces of an internal tooth; where such exists it merely forms a somewhat thickened internal lip to the septal aperture. Texture porcelainous, opaque. Hue dead white, but appearing of a rich amber colour when viewed by transmitted light. Diam. $\frac{1}{20}$.

Loc. Isle of Man; Mr. J. Ashworth. Scarborough; Mr. Bean and Mr. J. Williamson.

Exmouth; Mr. Clarke. Arran, Shetland, Skye; Mr. George Barlee. Sandwich; Mr. J. G. Jeffreys. Cairnclough Bay, Antrim, Belfast Bay; Mr. G. C. Hyndman. Whitehaven; Rev. Mr. Chalmers. Plymouth Sound and Eddystone; Mr. Spence Bate. Copeland Islands, County Down; Professor Patterson. Boston.

None of the Foraminifera are more liable to variation than those comprehended in the Lamarckian genus Miliolites; and the present species is no exception, varying from orbicular to oblong, and from spherical to lenticular. Sometimes, especially in the spherical type, its anterior extremity is narrow and constricted compared with the opposite one. In this state it is the *B. inornata* of M. D'Orbigny; when this modification is excessive, it is the *B. patagonica* of the same author, a state resembling my figures 175, 176, and which does not differ from the *Miliolites ringens* of Lamarck and Parkinson.

Two other characters, besides external contour, have been relied upon by M. D'Orbigny in establishing his various species of Miliolæ; viz., the form of the tooth in the septal aperture, and the degree of angularity presented by the peripheral margin of the last segment. I am satisfied that upon the former of these no reliance whatever can be placed. Sometimes the tooth appears as a straight lamina, projecting upwards and outwards from the penultimate segment; the shell is then the *B. bulloides* (D'Orbig.) In *B. Bougainvillii* this tooth is slightly bifid at its extremity—still more so in *B. patagonica* and *peruviana;* whilst in *B. clypeata* and *inornata* the transverse portions are somewhat recurved. In *B. simplex* the straight thin plate of the *B. bulloides* is expanded into a thick truncated projection, nearly filling up the septal aperture, but without any transverse lamina at its extremity. In *B. canariensis* this latter form is developed laterally into a long, narrow tooth, nearly filling up the corresponding long, straight, transverse fissure now representing the round aperture of *B. bulloides;* a state closely approximating to the form of aperture found in my variety *carinata* (figs. 172, 174). The two extremes of these conditions are sufficiently distinct; but I am convinced that they pass into one another, though the bifid tooth of *B. patagonica* and *peruviana* prevails most in the examples found on our own coasts.

The roundness or angularity of the outer margin appear to be equally variable. This angularity is at its minimum in *B. inornata,* and gradually increases as we pass successively through *B. patagonica, simplex, clypeata,* and *canariensis.* I am satisfied that it is wholly impossible to distinguish species of Miliolæ by these slight variations, bearing in mind the way in which the peripheral borders of many other forms may be round, carinated, or developed into peripheral spines without destroying specific unity. Consequently, where the differences are so slight, and the transitions so gradual, we can scarcely avoid admitting all the varieties into one specific group, instead of dividing them into many. It is true that in my variety *carinata* there is a great advance in the development of the peripheral carina upon that of the *B. canariensis* of M. D'Orbigny; but this is merely a question of degree. The increased length and narrowness of the septal aperture is but another result of the same compression and consequent centrifugal lateral development that has produced this modification.

I must acknowledge that the variety *carinata,* which is the most common one in these islands, long appeared to me a distinct species, and though I have now ventured to unite it with the true *B. ringens,* I do so with some little hesitation. I have, however, been led to adopt the latter course by two circumstances. My specimens have the sharp keel of *B. carinata* (D'Orb.), but they have not the large septal aperture and strong tooth represented in M. D'Orbigny's figure. On the other hand,

the *B. canariensis* of that author, which has not the sharp thin carina of our shell, *has* its oblong narrow mouth. Thus we find the characters on which we might rely for distinguishing the shells with thin margins from those with rounded ones, so indiscriminately mingled, that it seems impossible to deduce order out of the confusion, otherwise than by regarding them as modifications of a common form. Some previous writers have confounded *Biloculina ringens*, var. *carinata*, with *Entosolenia marginata*. Walker's figure and description obviously identify his "*Serpula* (*Lagena*) *marginata*" with my *Entosolenia marginata*, since he speaks of it as "*transparent*," which the Biloculina never is. Montagu, Maton and Rackett, and Turton, followed in the steps of Walker; but Dr. Fleming speaks of "the partitions of chambers" existing in his *Lagenula marginata*, which never occur in the *Entosolenia marginata*. He has evidently had the present shell before him. His error has been repeated by Brown, whose *Renoidea marginata*, as Professor Macgillivray has correctly stated, is not the *Entos. marginata* which his references indicate, but *Biloculina ringens*, var. *carinata*.

Parker and Jones have figured several intermediate forms[1] from Norway, which appear distinctly to connect Lamarck's *Miliolites ringens* with several of the Biloculinæ of D'Orbigny, referred to above. They quote as synonyms *B. lævis*, *aculeata*, *depressa*, *contraria*, *clypeata*, *simplex*, *inornata*, *bulloides*, and *ringens*; and acting upon the conviction of their identity they assign the specific name of *ringens* to the entire group.

Genus—SPIROLOCULINA, *D'Orbigny*.

Frumentaria, Soldani. *Spiroloculina*, D'Orb., Macgillivray, Thorpe. *Miliola*, Brown.

Shell free; regular; equilateral; oblong; consisting of numerous segments, arranged spirally in one plane. Each segment projecting at both its extremities beyond the pre-existing shell; its umbilical surface applied to the periphery of its antepenultimate segment, but scarcely embracing it; hence all the segments are visible on each lateral face of the shell. Septal aperture large, alternately occupying the opposite extremities of the shell; usually furnished with an appendicular tooth.

Spiroloculina only differs from Biloculina in the restricted centripetal development of the umbilical margins of its segments; hence each one is merely applied to the periphery of its predecessor, which remains visible, instead of embracing and concealing it.

SPIROLOCULINA DEPRESSA, *D'Orb.* Figs. 177—179.

Frumentaria sigma, Sold., iii, p. 229, tab. clv, fig. K; i, p. 67, tab. lxi, figs. I, K, L, M.
Spiroloculina depressa, D'Orb., 1826. Tableau Méthod., p. 298.
— *nitida*. Ibid., p. 298.

[1] 'Annals and Mag. Nat. Hist.,' 2d series, vol. xix.

Spiroloculina limbata, D'Orb., 1846. Tableau Méthod., p. 299.
— *rotundata*. Ibid., p. 299.
— *plicata*. Ibid., p. 299.
Miliola concentrica, Brown, 1827. Illustrations, pl. i, fig. 22.
Spiroloculina cymbium, D'Orb., 1839. Foram. des Canaries, p. 140, tab. iii, figs. 5, 6.
— *concentrica*, Macgillivray, 1843. Moll. Aberdeen, p. 36.
— — Thorpe, 1844. Brit. Mar. Conch., p. 232.
— *canaliculata*, D'Orb., 1846. For. de Vienne, p. 269, tab. xvi, figs. 10—12.
— *badenensis*. Ibid., p. 269, tab. xvi, figs. 13—15.
— *dilatata*. Ibid., p. 269, tab. xvi, figs. 16—18.
— *excavata*. Ibid., p. 271, tab. xvi, figs. 19—27.

SPIROLOCULINA DEPRESSA, typica. Fig. 177.

Shell oblong; elliptical; depressed; concave on each side; consisting of about ten arcuate, often sigmoid, segments, each of which in turn invests half the circumference of the shell, in the direction of its long axis. Primordial segment usually small, spherical, and ventricose. Subsequent segments elongated, arcuate tubes; frequently square, and with a raised ridge both at the peripheral and umbilical margins, which ridge appears on each lateral face of the shell as a prominent, spiral, septal line, separating contiguous segments. Peripheral margin often with a deep longitudinal groove; sometimes flat or even convex. Where the peripheral ridges are absent, the inner margin of each segment is often bevelled. Septal aperture square; its diameter equalling that of the segment at the projecting anterior extremity of which it is placed; furnished with a narrow, sometimes simple, occasionally bifid, tooth, which projects from the umbilical margin of the aperture. Texture porcelainous, white, opaque, glossy. Long. $\frac{1}{15}$ — $\frac{1}{25}$.

SPIROLOCULINA DEPRESSA, *var.* ROTUNDATA. Fig. 178.

Resembles the preceding type in all respects, excepting in the form presented by transverse sections of the segments, which are round instead of being square, and in wanting the projecting ridges at the outer angles. It is usually shorter in proportion to its diameter than the last variety, and its segments are still less disposed to assume the sigmoid curves seen in fig. 179.

SPIROLOCULINA DEPRESSA, *var.* CYMBIUM. Fig. 179.

Corresponds closely with the typical form, only is more elongated, narrower, and with a sigmoid contour.

The variations of the tooth in the septal aperture of this shell confirm my previous remarks respecting its want of value as a specific character; sometimes it is straight and simple; at others it is deeply bifid at its outer extremity. We have also every intermediate form between the long,

narrow, sigmoid shell, represented in fig. 179, and the rounded elliptical one of fig. 178. When the elongated form of fig. 179 is accompanied by the marginal ridges of fig. 177, and has an undivided tooth, it is the *S. cymbium* of M. D'Orbigny. In this state it also differs very little from his *S. canaliculata*, in which the tooth is less conspicuous. When the peripheral margin is rounded, instead of being grooved, through the prominence of the marginal ridges, the shell is the *S. badenensis;* and when the external segments are larger than ordinary, and the tooth correspondingly developed, we have the *S. excavata*. All these distinctions are alike insignificant and valueless.

Loc. Skye, Arran, Shetland; Mr. George Barlee. Copeland Islands, County Down; Professor Patterson. Cairnclough Bay, Antrim, Belfast Bay; Mr. G. Hyndman. Sandwich, Falmouth, Scarborough, Isle of Wight, Langland near Swansea, Tenby, Dublin Bay, Cork, Loch Fine; Mr. J. G. Jeffreys. Exmouth; Mr. Clarke. Levant; Manilla; Kurrachee, Coast of Scinde; Moreton Bay, Australia. "Fossil in Tertiary strata at Baden; M. D'Orbigny."

Genus—MILIOLINA, *nob.*

Miliolites, Lamarck, Parkinson. *Miliola*, Lamarck, Parkinson, Brown, Blainville. *Vermiculum*, Montagu, Fleming, Macgillivray, Thorpe. *Serpula*, Maton and Rackett, Pennant, Adams, Turton, Linnæus. *Triloculina*, D'Orbigny, Brown. *Quinqueloculina*, D'Orbigny. *Adelosina*, D'Orbigny. *Lagena*, Brown.

Shell free; convoluted; inequilateral; usually oblong; consisting of numerous segments, each of which in turn extends over the entire length of the shell. Convolutions not disposed in the same plane, but constantly changing their direction, so that parts of from three to six visible segments contribute in various proportions to form the external surface of the shell. Septal orifice large, alternately occupying opposite extremities of the shell; furnished with an appendicular tooth.

This genus differs from Biloculina and Spiroloculina in the circumstance that the convolutions, instead of being wound in one plane, continually alter their direction. They may be compared with terrestrial parallels of longitude, since, whilst they intersect what may be termed the equatorial plane of the shell at different and constantly changing points, they always retain their parallelism with its polar axis. I have reunited Triloculina, Quinqueloculina, and Adelosina into one genus, being convinced that all the characteristic features of these genera frequently occur in one and the same species. I have rejected the first two generic names, because they are based upon the idea of a definite number of segments, which appears to form no characteristic feature of this genus. I have preferred Miliolina to Adelosina, as being better known, and as being really Lamarck's old and widely accepted term, only modifying its termination, conforming it to the usual generic nomenclature of the Foraminifera as established by M. D'Orbigny.

MILIOLINA TRIGONULA, *Lamarck.* Figs. 180—182.

Walker, 1784. Test. Min., tab. i, fig. 4.
Miliolites trigonula, Lamarck, 1801. Animaux sans Vertèb., vii, p. 622.
— — Lamarck, 1816. Encyc. Méthod., tab. ccccIxix, fig. 2.
— *cor-anguinum.* Ibid., tab. ccccIxix, fig. 3.
Vermiculum subrotundum, Mont., 1803. Test. Brit., p. 521.
Miliolites trigonula, Lam., 1804. Annales du Mus., vol. v, p. 351.
Serpula subrotunda, Maton and Rackett, 1807. Lin. Trans., viii, p. 245.
Miliolites trigonula, Parkinson, 1811. Org. Rem., tab. xi, figs. 17, 18.
Serpula subrotunda, Pennant, 1812, vol. iv, p. 362.
— *oblonga,* Turton, 1819. Conch. Dict., p. 155.
Vermiculum subrotundum, Fleming, 1822. Wern. Mem., iv, p. 565, pl. xv, fig. 5.
Miliolites trigonula, Brown, 1824. System, tab. i, figs. 5—7.
Miliola trigonula, De Blainville, 1825. Malac., p. 369.
Triloculina trigonula, D'Orbigny, 1826. Tableau, p. 299, pl. xvi, figs. 5—9.
Quinqueloculina subrotunda. Ibid., p. 302.
Vermiculum subrotundum, Fleming, 1828. Brit. Anim., p. 234.
— — Macgillivray, 1843. Moll. Anim. Aberd., p. 36.

Shell orbicular, consisting of three visible segments. The outermost segment with two thick rounded umbilical margins visible, and extending the length of the shell, enclosing portions of the second and third segments; the second segment having one rounded margin visible, and embracing the third, of which but a small oblong portion is seen in the centre of one side of the shell. Septal aperture more or less rounded; furnished with a usually bifid tooth. Texture porcelainous. Hue white, opaque, shining. Long. $\frac{1}{30}$.

Loc. Shetland, Arran, Skye, Brixham; Mr. George Barlee. Plymouth Sound; Mr. S. Bate. Scarborough; Mr. Bean. Levant, Loch Fine, Falmouth, Torbay, Swansea, Cork, Weymouth, Tenby, Bantry Bay, Caswell Bay, Sandwich, Manorbeer, Oxwich, Isle of Wight; Mr. J. G. Jeffreys. Copeland Islands, County Down; Professor Patterson.

I can perceive no real difference between the *Triloculina trigonula* of M. D'Orbigny and the *Vermiculum subrotundum* of Montagu, which latter M. D'Orbigny has made a Quinqueloculina, though Montagu expressly states that it is "composed of three compartments." I think the shell is probably a distinct species from *Miliolina seminulum,* since neither in British nor foreign specimens have I seen any inosculating examples. Its tumid, spherical form, and the regular number of its segments, appear to distinguish it; though amidst such protean objects it behoves observers to be in the highest degree cautious in affirming the absolute distinctness of any species.

MILIOLINA SEMINULUM, *Lin.* Figs. 183—189.

Planchus, 1739, tab. ii, fig. 4, p. 19.
Gualtieri, 1742. Ind. Test., tab. 10, fig. s?
Serpula seminulum, Linné, 1758. Syst. Nat., 10th ed.; ibid., 12th ed., p. 1264.
Fabricius, 1780. Fauna Groenl., p. 376.
Schröter, 1783. Einleit., p. 535.
Walker, 1784. Test. Min., tab. i, fig. 1?
Gmelin, 1789, p. 3739.
Frumentaria, Soldani, 1798, iii, p. 228, tab. clii, fig. A?
Pulteney, 1799. Dorset. Catalogue, p. 60, tab. xix, fig. 31.
Serpula ovalis, Adams, 1800. Trans. Lin. Soc., vol. v, p. 4, tab. i, figs. 28—30.
Vermiculum oblongum, Mont., 1803. Test. Brit., p. 522, pl. xiv, fig. 9.
— *intortum*. Ibid., p. 520.
Serpula seminulum, Maton and Rackett, 1807, Lin. Trans., viii, p. 245; Pennant, 1812, vol. iv, p. 362.
— *oblonga*. Ibid. Ibid.
Miliolites saxorum, Lamarck, 1816. Encyc. Méthod., tab. cccclxix, fig. 3.
Dillwyn, 1817. Descrip. Cat., p. 1070.
Serpula seminulum, Turton, 1819. Conch. Dict., p. 155.
— *oblonga*. Ibid., p. 155.
Vermiculum intortum, Fleming, 1822. Wernerian Memoirs, iv, part ii, p. 564, tab. xv, fig. 3.
— *oblongum*. Ibid., p. 565, tab. xv, fig. iv.
Quinqueloculina seminulum, D'Orbigny, 1826. Tableau Méthod., p. 303.
Triloculina oblonga. Ibid., p. 300.
Vermiculum intortum, Fleming, 1828. Brit. Anim., p. 233.
— *oblongum*. Ibid., p. 233.
Quinqueloculina magellanica, D'Orbigny, 1839. Voyage dans l'Amér. Mérid., p. 77, pl. ix, figs. 19—21.
— *cora*. Ibid., p. 76, pl. ix, figs. 16—18.
— *araucana*. Ibid., p. 76, pl. ix, figs. 13—15.
— *Gualtieriana*, D'Orbigny, 1839. For. de Cuba, p. 186, pl. xi, figs. 1—3.
— *Bosciana*. Ibid., p. 191, pl. xi, figs. 22—24.
— *Auberiana*. Ibid., p. 193, pl. xii, figs. 1—3.
— *candeiana*. Ibid., p. 199, pl. xii, figs. 24—26.
— *lævigata*, D'Orbigny. For. des Canaries, p. 143, tab. iii, figs. 31—33.
Triloculina Martiniana. Ibid., p. 141, tab. iii, figs. 16—18.
— *Chemnitziana*. Ibid., p. 141, tab. iii, figs. 19—21.
— *nitida*. Ibid., p. 141, tab. iii, figs. 22—24.
Vermiculum intortum, Macgillivray, 1843. Moll. Anim. Aberd., p. 37.

Vermiculum oblongum, Macgillivray, 1843. Moll. Anim. Aberd., p. 37.
— *disciforme*. Ibid., p. 319.
— *planatum*. Ibid., p. 319.
— *intortum*, Thorpe, 1844. Brit. Mar. Conch., p. 229.
— *oblongum*. Ibid., p. 230.
— *disciforme*. Ibid., p. 231.

Miliolina seminulum, typica. Figs. 183—185.

Shell oblong; subcompressed, especially on one side. Usually with five *visible* segments. On one side are seen the rounded ultimate and penultimate segments, and between these are a large portion of the antepenultimate and a small part of a fourth segment; the opposite side of the shell is chiefly occupied by the flattened surfaces of the ultimate and penultimate, with a very small part of the fifth segment occupying the centre; the two newest segments approximating nearer to one another on the latter side than on the former; not being quite opposite, but developing in a convoluted form round a central axis, and describing rather less than the half of a circle at each growth. Segments slightly ventricose; sometimes considerably so. Peripheral margin rounded. Septal lines more or less depressed. Septal aperture large; oblong; furnished with a long lamellar tooth, which is simple, sometimes prominent, and often slightly bifid. Texture porcelainous. Hue white; opaque; glossy. Long. $\frac{1}{20}$.

Miliolina seminulum, *var.* oblonga. Figs. 186, 187.

Resembles the last in its essential features; only it is much longer and narrower, with the newer segments more completely embracing those previously formed. Hence on one side the ultimate and penultimate segments are alone visible, whilst on the opposite side the antepenultimate one stands prominently out between them. The tooth in the septal aperture is often large; in some specimens common at Brixham it is so much developed at its upper extremity, as to appear like a large operculum or lid, closing the orifice of the shell, as represented in the figures. Long. $\frac{1}{20}$ — $\frac{1}{30}$.

Miliolina seminulum, *var.* disciformis. Figs. 188, 189.

In the arrangements of its segments this variety resembles the typical form; but it is much more orbicular and compressed, the segments being broader and shorter, and the entire shell thinner. Sometimes a sixth segment peeps out on one side of the shell, between the ultimate one and that ordinarily occupying the centre of the disc: (fig. 189.) The segments are very often emarginate at their umbilical borders, and almost always marked with transverse ridges and furrows resembling molluscous lines of growth. Long. $\frac{1}{30}$.

Loc. Every part of the coast, especially in shelly sand.

Many of the British conchologists have seen the difficulty of defining the species of the Miliolinæ, owing to their extreme variability. Montagu, describing the shell under consideration, remarks, that "this is so variable in its formation, that without great attention it might be formed into several species." ('Test. Brit.,' p. 521.) Maton and Rackett, writing four years later, and speaking of the four supposed species of "Serpula," viz., *seminulum*, *subrotundum*, *oblongum*, and *bicorne*, observe, "We may be permitted to express our doubts whether the last four Serpulæ ought not to be considered rather as varieties than as distinct species. Their form is very irregular and variable; and it is scarcely possible to give any permanent characters by which they may be satisfactorily discriminated." ('Linnean Transactions,' vol. viii, p. 246.) In like manner, some of my most able correspondents, who previously thought the species of Miliolinæ ought to be made much more numerous, on endeavouring to group the specimens in their cabinets according to such views, found their difficulties increase with the multiplication of their specimens. Unfortunately, Montagu's warning has been overlooked, and we have in consequence a row of synonyms which has few parallels in natural science. Montagu, and Maton and Rackett, arrived at their conclusions when the Foraminifera were supposed to occupy a much higher position in the zoological scale than is now assigned to them, and when consequently there was more reason than now for presuming that the boundaries of species would be clear and definite. But if these writers, with their strong prepossessions in the opposite direction, were compelled to arrive at the above-quoted conclusions, how much more are we justified in pursuing the same course. The Foraminifera are now known to occupy one of the lowest positions in the zoological scale; and it appears to be a characteristic of these and allied Protozoa, that they display great tendency to variation of form. Therefore, to retain conclusions based on the erroneous notions formerly prevailing respecting the nature of these organisms, would be to reject all the light which progressing science has thrown upon them.

My *Miliolina seminulum*, var. *oblonga*, is essentially the *Vermiculum oblongum* of other writers. In like manner, my var. *disciformis* is the *V. disciforme* of Macgillivray. In deciding to include the numerous species established by M. D'Orbigny, quoted in the list of synonyms, I have been guided by what I have seen of the variation of this species in sands from other countries as well as our own. It appears to be a thorough cosmopolite. I have received few sands in which it does not occur; consequently I have felt justified in concluding that what would not constitute a distinct species in English specimens would equally fail to do so anywhere else. Indeed I am fully convinced that if I have erred, it has been in excluding some that ought to have been introduced. I am far from certain that the following species is distinct, and that the suggestion of Maton and Rackett ought not to be acted upon so far as it is concerned.

MILIOLINA BICORNIS, *Walker*. Figs. 190—198.

Serpula bicornis ventricosa, Walker, 1784, p. 2, tab. i, fig. 2.
— *retorta*, Walker, 1784, p. 3, tab. i, fig. 10.
— *bicornis*, Adams, 1798. Essays on the Micros., tab. xiv, fig. 2.
— *perforata*. Ibid., fig. 3.
— *retorta*. Ibid., fig. 6.
— *bicornis*, 1800, Turton's Lin., iv, p. 609.

Serpula perforata, 1800, Turton's Lin., iv, p. 609.
— *retorta.* Ibid., p. 609.
Vermiculum bicorne, Mont., 1803. Test., Brit., 509.
— *perforatum.* Ibid., p. 509.
— *retortum.* Ibid., p. 524.
Serpula bicornis, Maton and Rackett, 1807, p. 246; Pennant, 1812, vol. iv, p. 363.
— *retorta.* Ibid., p. 248. Ibid., p. 365.
— — Turton, 1819. Conch. Dict., p. 158.
— *bicornis.* Ibid., p. 156.
Vermiculum bicorne, Fleming, 1828. Brit. Anim., p. 234.
Quinqueloculina flexuosa, D'Orbigny, 1839. Voyage dans l'Amérique Mérid., tab. iv, figs. 4—6.
— *Inca.* Ibid., tab. iv, figs. 20—22.
— *Poeyiana,* D'Orbigny, 1839. For. de Cuba, p. 191, tab. xi, figs. 25—27.
— *Guancha,* D'Orbigny, 1839. For. des Canaries, p. 143, tab. iii, figs. 34—36.

MILIOLINA BICORNIS, typica. Figs. 190—194.

Shell with five visible irregular segments, arranged as in *M. seminulum,* often contorted, and with an undulating outline, as if deformed; at others more regular, and approximating to the contour of figs. 183, 184. Segments variously grooved and striated; grooves sometimes equal in size and regular, at others the reverse. Septal aperture furnished with a thin, straight lamellar tooth. Primordial segment (fig. 193) often smooth, orbicular, lenticular, with a prolonged, grooved, retort-like beak, at the end of which is a rounded septal aperture. Second segment (fig. 194) usually oblong; half surrounding the first, and projecting beyond it at each extremity; deeply grooved; with the septal aperture at the opposite end of the shell to that of the first segment. Texture porcelainous. Hue dirty white. Long. $\frac{1}{20}$.

MILIOLINA BICORNIS, *var.* ELEGANS. Fig. 195.

Differs from the typical form in the symmetry of its contour and in the uniform size and regular parallelism of its longitudinal grooves.

MILIOLINA BICORNIS, *var.* ANGULATA. Fig. 196.

In this variety, whilst most of the grooves and costæ are small and comparatively obscure, some few of the latter rise up prominently, and give an angular contour to each segment. The number and position of these elevated ridges are rarely the same in any two specimens.

Loc. Scarborough, Lamlash, Guernsey; Mr. Bean. Cullercoats; Mr. J. Alder. Belfast Bay; Mr. G. Hyndman. Brixham, Arran, Shetland, Skye; Mr. George Barlee. Plymouth Sound and Eddystone; Mr. S. Bate. Falmouth, Isle of Wight, Sandwich, Swansea, Tenby, Bantry Bay, Cork, Loch Fine, Weymouth, Dublin Bay; Mr. J. G. Jeffreys.

The very large primordial segment of this most protean species is the *Serpula retorta* and *Vermiculum retortum* of several authors; and its form identifies this species with the genus Adelosina of M. D'Orbigny. It does not, however, appear to me that the primordial segment always exhibits this shape; numbers of the young shells which I have examined present no such peculiarity in their early growth. But wherever I have met with this retort-like primordial segment in British sands, the second segment has invariably presented the grooved aspect of fig. 194, and never the smooth contour of *M. seminulum*. It is this circumstance alone that has led me for the present to separate these grooved specimens from the latter shell; though in some of them the grooves are so faint, and even confined to one or two segments, that the difference between the two forms becomes very small. Had I seen one example of *M. seminulum* commencing its growth with a large retort-like primordial segment, I should unhesitatingly have regarded *M. bicorne* as a mere variety of that shell. The propriety of the latter course was suggested by Maton and Rackett, but opposed by Montagu, notwithstanding what the latter author had previously recorded respecting the variableness of *M. seminulum*, or, as he designated it, *Vermiculum intortum*.

The genus Adelosina of M. D'Orbigny differs from his Quinqueloculina only in possessing the peculiar retort-shaped primordial segment. But we have seen that this is not of constant occurrence in our English forms; hence it can barely be admitted to constitute even a specific distinction, much less a generic one. Should it ultimately be found that *M. bicorne* is merely a variety of *M. seminulum*, it will then stand as *M. seminulum*, var. *bicorne*, and the other varieties as *M. seminulum*, vars. *elegans* and *angulata*.

The shell represented by M. D'Orbigny (Modèles) as the *matured* state of his *Adelosina striata* is merely a shell which has developed its second segment, and consequently so far from being matured, is the young of a form closely resembling our British *M. bicornis*, if not identical with it.

Genus—VERTEBRALINA, *D'Orbigny.*

Shell compressed; consisting of several segments, of which the earlier ones are arranged spirally; the later ones projected in a straight line. Septal orifice linear; conspicuous; large; its length nearly identical with the breadth of the segment.

On a superficial glance, Vertebralina may be mistaken for some forms of Peneroplis and Spirolina, but it is at once distinguished by its large, linear orifice. D'Orbigny arranges this genus amongst his nautiloid Foraminifera; but its structure, and especially its large septal aperture, appears to me to identify it more closely with the Miliolæ, amongst which I have consequently placed it.

VERTEBRALINA STRIATA, *D'Orbigny*. Fig. 196 *a*, *b*.

Soldani, 1787. Test. et Zoot. parv., tab. lxvii, V. 209, *vv*, *xx*, *yy*, *zz*; tabs. lxviii, lxix, V. 210 G.

Vertebralina striata, D'Orb., 1826. Tableau Méthod.

— — D'Orb., 1826. Modèles, No. 81.

— *Cassis*, D'Orb., 1839. Hist. de Cuba; Foram., p. 51, tab. vii, figs. 14—15.

— *mucronata*. Ibid., p. 52, tab. vii, figs. 16—19.

Shell composed of several segments; the earlier ones disposed spirally; the later ones projected in a straight line. Each segment compressed laterally; often irregular in form; those composing the straight portion usually indented by a slight transverse depression, nearly parallel with the septal line. Surface marked by faint striæ; those of the spiral segments parallel and longitudinal; those of the anterior segments less regularly disposed, though also tending in the longitudinal direction. Anterior border of each segment smooth, arcuated; emarginate. Septal orifice linear; conspicuous; its length corresponding with the breadth of the anterior emarginate border of the segment. The smooth marginal border of the septal orifice generally visible only in the ultimate segment; those of the antecedent segments being generally hidden by the overlapping posterior border of the succeeding one; but in some varieties these margins are visible externally in most of the segments, and even project as curved processes, both at their peripheral and umbilical borders. Long. $\frac{1}{20}$.

Loc. Shetland; Mr. J. G. Jeffreys.

This is not an uncommon form amongst sands from the Mediterranean, the Gulf of Mexico, and the Philippine Islands, in all which localities it is associated with an abundance of *Peneroplis planatus;* but no British example presented itself until Mr. J. G. Jeffreys forwarded to me several specimens of the Peneroplis, from sand dredged at Shetland by Mr. Barlee; and amongst them I detected the single specimen of the Vertebralina figured in the plate. This association of two tropical or subtropical forms at so extreme a northern habitat again suggests the probable agency of the Gulf-stream, already referred to in the description of *Peneroplis planatus*. I should have little hesitation in adopting the above explanation of the occurrence of these shells on our north-western shores, were it not for some circumstances recorded by Mr. Jeffreys. He states, "that out of about 500 species of British Marine Testacea, one half are identical with those of the Mediterranean;"[1] and in a letter to me (December 3d, 1857), he further remarks, that in the sand which furnished the two Foraminifera in question he found an interesting Rissoa, "which is not uncommon in the Mediterranean, but hitherto unnoticed as British." These facts render caution necessary ere we assume a Mexican origin for the Peneroplis and Vertebralina, especially since in their general aspects the British Foraminifera much more closely resemble those of the Mediterranean than of the West Indies. At the same time, the apparent limitation

[1] On the Marine Testacea of the Piedmontese Coast, 'Annals and Mag. Nat. Hist.,' 1857, vol. xvii, p. 177.

of these species to so extreme a northern locality, and that in the direct line of one branch of the Gulf-stream, is a suggestive circumstance.

I have no hesitation in uniting *V. Cassis* and *mucronata* with *V. striata*. The former of these is apparently but a young example, in which none of the segments have, as yet, been projected in a straight line. The second is the variety in which the thickened margins of the septal apertures, besides being externally visible in most of the segments, are prolonged so as to project at the peripheral and umbilical margins. Foreign specimens present all intermediate gradations between these extreme forms.

Genus—SPIRILLINA, *Ehrenberg*.

Spirillina, Ehrenberg, Rupert Jones. *Orbis*, Phillipi. *Operculina*? D'Orbigny. *Cornuspira*, Schultze.

Shell, consisting of a simple, spiral, undivided tube wound round an axis in one plane. The convolutions in contact, and sometimes very slightly embracing; no septal divisions into segments. Septal aperture simple; the entire diameter of the tube.

Spirillina foliacea, *Phillipi*. Figs. 199—201.

Orbis foliacea, Phillipi, 1844. Enum. Moll. Sicil., vol. ii, p. 147, tab. xxiv, fig. 25.
Cornuspira planorbis, Schultze, 1854. Uber. den Org. der Polyth., tab. ii, fig. 21.

Shell compressed; thin. Internal convolutions very numerous and narrow, with slightly convex surfaces; central ones more translucent than the rest. External convolution broad and flat; increasing rapidly in size; with an uneven surface, marked by numerous irregular depressions and arcuate lines of growth (?), forming parallel ridges and depressions, of which the convexities are directed forwards. Septal aperture long, narrow, the entire size of the convolution. Texture porcelainous; hue, white, more or less opaque, slightly glossy. Diam. $\frac{1}{24}$.

Young shells (fig. 201), with a few narrow rounded convolutions of equal size, with a more rounded septal orifice, and a more translucent shell; primordial convolution often globular.

Loc. Falmouth; Mr. J. G. Jeffreys. Arran, Shetland, Fowey, Brixham; Mr. George Barlee. Torquay; Mrs. Brett. Cullercoats; Mr. J. Alder. Southport; Mr. Charles Clough. Eddystone and Plymouth Sound; Mr. S. Bate. Cairnclough Bay, Antrim, Belfast Bay; Mr. Hyndman. Boston.

Soldani, in his 'Testaceographiæ et Zootographiæ parvæ,' figures several shells which appear related to this genus. Some of these are described as highly irridescent (Sold., tab. xlvii, figs. G, H), which is not the case with any I have hitherto met with; but he also figures another (tab. liii c) which he describes as being "Albocalcareæ," and even adds "earum substantia

videtur persimilis illi, quam constanter habeat Frumentaria," further comparing it to the appearance well known to characterise the "dead-shells" of mollusca, which conchologists usually reject from their cabinets. This recognition of their affinity with the "Frumentariæ," by which term he designates the Miliolinæ, is interesting, since, prior to seeing Soldani's book, notwithstanding their different growth and general aspect, I had arrived at the conclusion that our *Spirillina foliacea* was closely allied to these common organisms. Phillipi, though possessed of but one specimen of the Spirillina, which he obtained from the sabelliform case of an Annelid, also expressly notices its resemblance to the Miliolinæ; as also do Parker and Jones. The distinct recognition of this relation by so many independent observers is of some importance in deciding upon the respective values of form and texture as guides in establishing genera; for whilst *Spirillina foliacea* and the two succeeding species belong to one common type of growth and structure, being spiral and devoid of septa, they respectively display three very distinct kinds of texture; one being white and porcelainous, another arenaceous, and a third hyaline.

The matured shells of this species with the broad external convolution are rare; young specimens, on the other hand, are not uncommon. In the former the outer convolution is often constricted at some part of its circumference, as in fig. 199, a condition of frequent occurrence in many other Foraminifera.

Schultze's *Cornuspera planorbis* is merely the young state of this form.

Spirillina perforata, *Schultze*. Fig. 202.

Spirillina vivipara, Ehrenberg, 1841. Verbreitung, &c., p. 442, tab. iii, fig. 441.
Williamson, Mic. Organisms of Levant Mud, p. 45, tab. ii, fig. 34.
Cornuspira perforata, Schultze. Organ. Polyth., p. 41, pl. ii, fig. 22.
Spirillina vivipara, Parker and Jones, 1851. Annals and Mag. Nat. Hist., 2d ser., vol. xix, p. 12, tab. xi, fig. 46.

Shell compressed; thin; consisting of several flat convolutions of nearly uniform diameter throughout their entire extent; sometimes almost carinated at the periphery. Texture hyaline; transparent; perforated by numerous large foramina. Septal orifice, the diameter of the convolution at the extremity of which it is placed. Diam. $\frac{1}{80}$.

In his account of the recent Polythalmia and Infusoria of North and South America,[1] Professor Ehrenberg has figured and described the present shell; he having obtained it from Vera Cruz. He assigns to it the trivial name of Vivapara, owing to the circumstance that just within the septal orifice of his specimen he found two small spiral shells which had obviously found their way there through accident; from this unimportant circumstance he concluded that the shell was vivaparous ("passim testulis pullis fœta"). But as we have not the slightest evidence that such is the case I had, prior to the publication of Schultze's work, discarded Ehrenberg's specific name as calculated to mislead, and substituted that of *perforata* as indicating the obvious distinction between this and the other British species of the genus. That

[1] Verbreitung und Einfluss de mikroscopischen Lebens in Süd und Nord Amerika, 'Abhand. König. Akad. Wissenschaften,' 1841.

the German naturalist should, independently, have done precisely the same thing is a confirmation, of the propriety of the change.

Loc. Sandwich, Weymouth, Rossilly near Swansea, Manorbeer; Mr. J. G. Jeffreys. Torquay; Mr. J. Ashworth. Arran, Shetland, Skye; Mr. George Barlee. Levant, Moreton Bay, Australia.

Spirillina arenacea, *nob.* Fig. 203.

Martini, 1769. Conch. Cab. p. 58, tab. iii, fig. 20 E.
? *Operculina incerta,* D'Orbigny, 1839. Foram. de Cuba, p. 49, tab. vi, fig. 16.

Shell spiral; compressed; thin; consisting of numerous narrow rounded convolutions of nearly uniform size. Septal aperture round. Texture arenaceous; hue yellow or pale brown; opaque. Diam. $\frac{1}{30}$.

I have met with isolated examples of this object in nearly every British sand which I have examined, but have nowhere found it in abundance. M. D'Orbigny has figured a shell in his Foraminifera of Cuba, under the name of *Operculina incerta* (p. 49, tab. vi, fig. 16). He thinks that it presents traces of two septa in each convolution, but is not certain; and speaks with great hesitancy respecting its entire history, not being satisfied with his knowledge of the very few specimens which he obtained from Cuba and Martinique. I have little doubt that his hesitation was just; and that the object was an unsegmented Spirillina, possibly of the same species as the one under consideration.

Spirillina Margaritifera, *nob.* Fig. 204.

Shell, consisting of numerous narrow, somewhat convex convolutions. The outer one smooth; the inner ones obscured by numerous projecting tubercles, arranged in one or two series: in some parts these are most conspicuous along the centre of the convolution; in others, along the spiral septal lines. Texture hyaline. Diam. $\frac{1}{30}$.

Of this shell I have seen but a single specimen in the collection of Mr. Jeffreys, who sent it to me amongst several Spirillinæ of the three last-described species; consequently I do not know the exact locality whence it was obtained. It displays faint traces of the irridescence which Soldani noticed in some of his specimens from the Mediterranean, and especially approximates to his fig. G, tab. cxlvii, allowing for the rude and inaccurate character of his drawings. It differs from *S. perforata* in the absence of the large foramina so conspicuous in that shell, as well as in the presence of the small protuberances. How far these are permanent characters I am unable to say; any species founded on a single specimen can only be accepted as a provisional one awaiting further elucidation.

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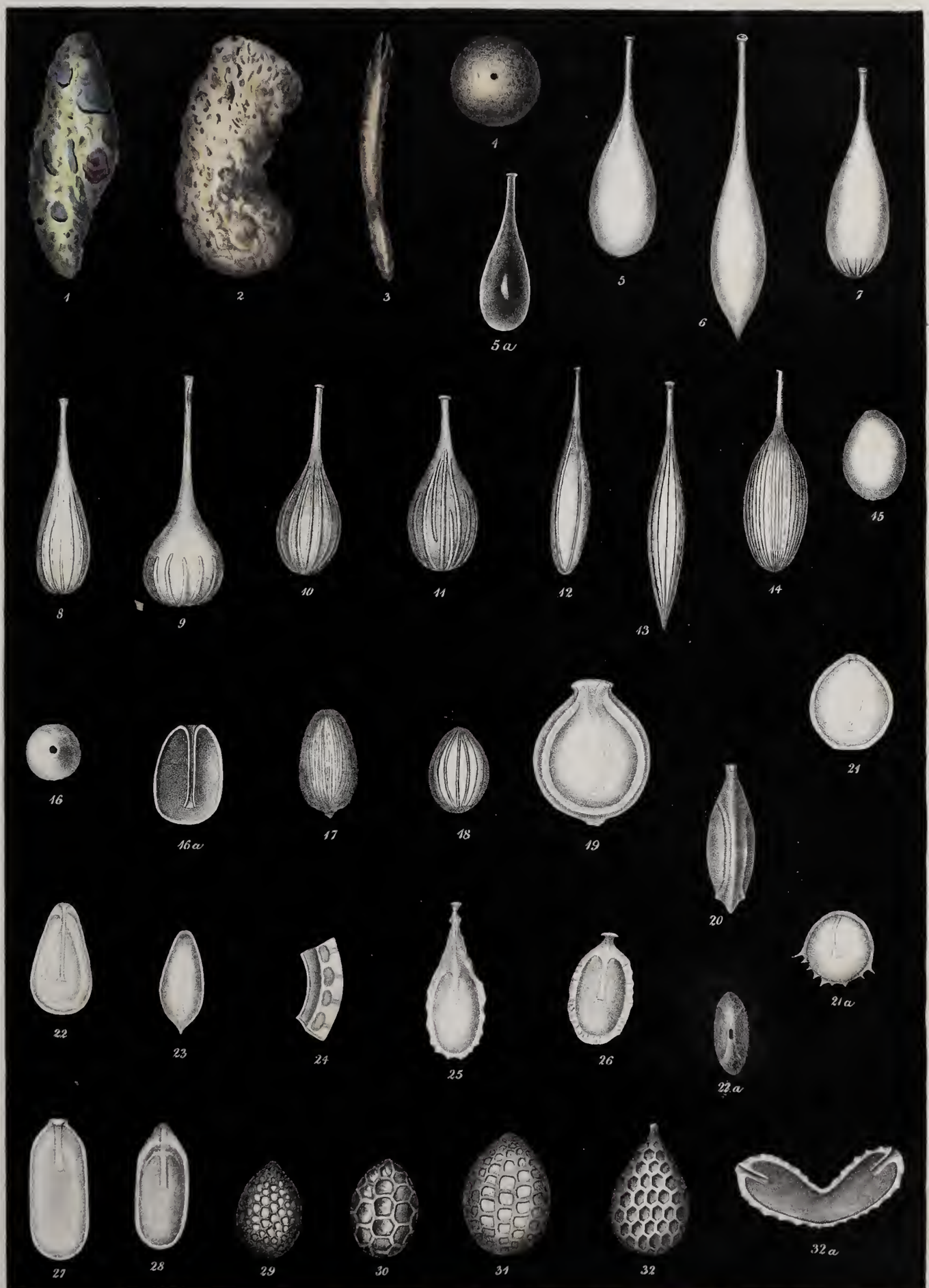
202. „ *perforata.* Lateral aspect, p. 92.
203. „ *arenacea.* Lateral aspect, p. 93.
204. „ *margaritifera.* Lateral aspect, p. 93.

PLATE I



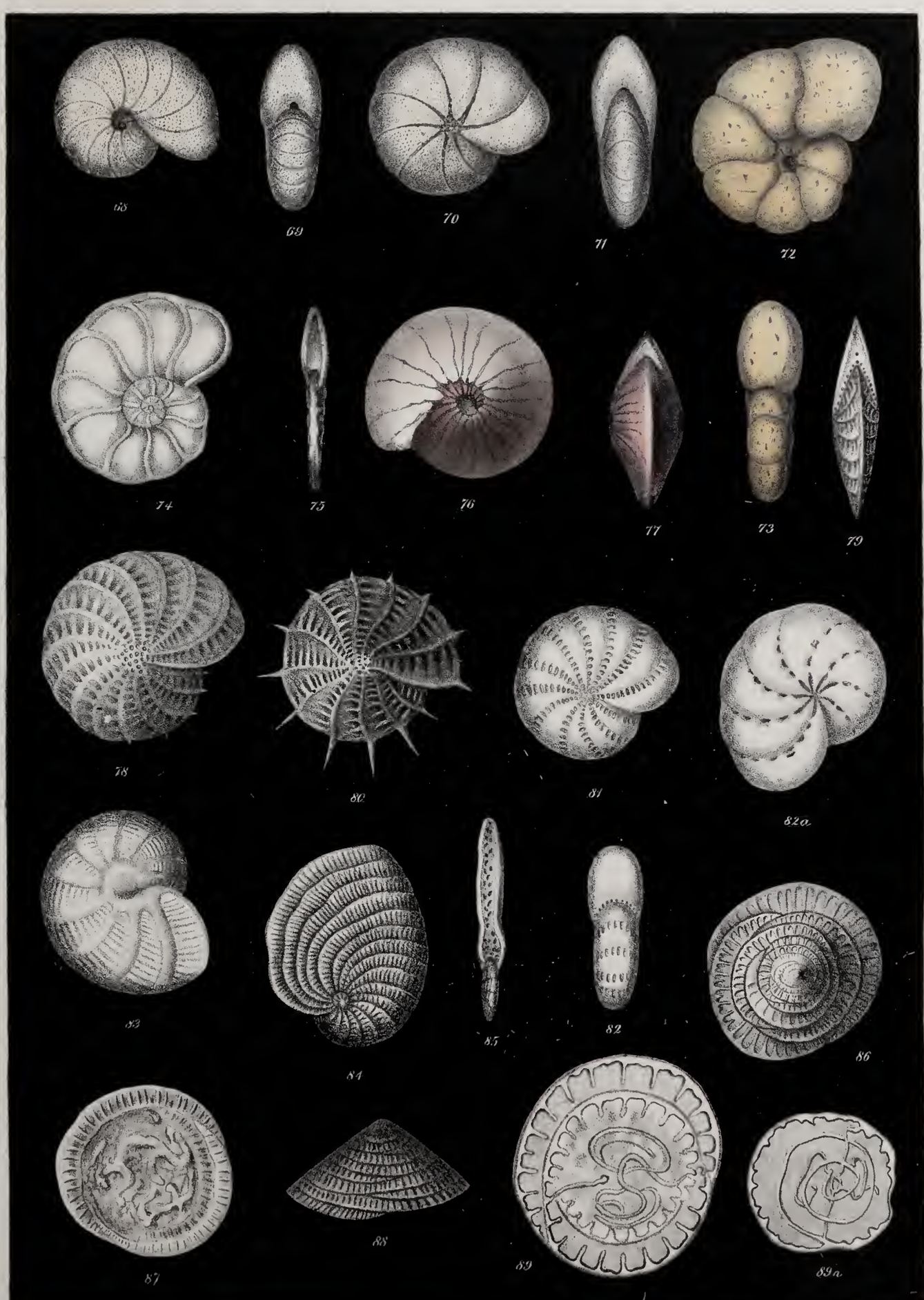
W. C. Williamson del. Tuffen West lith. W. West imp.

PROTELONINA. ORBULINA. LAGENA. ENTOSOLENIA.
1 — 3. 4. 5 — 14. 15 — 32.

PLATE II

W.C. Williamson del. Tuffen West lith. W. West Imp.

LINGULINA, NODOSARIA DENTALINA FRONDICULARIA CRISTELLARIA
33 — 35 36 — 39 40 — 49 50 — 51 52 — 67

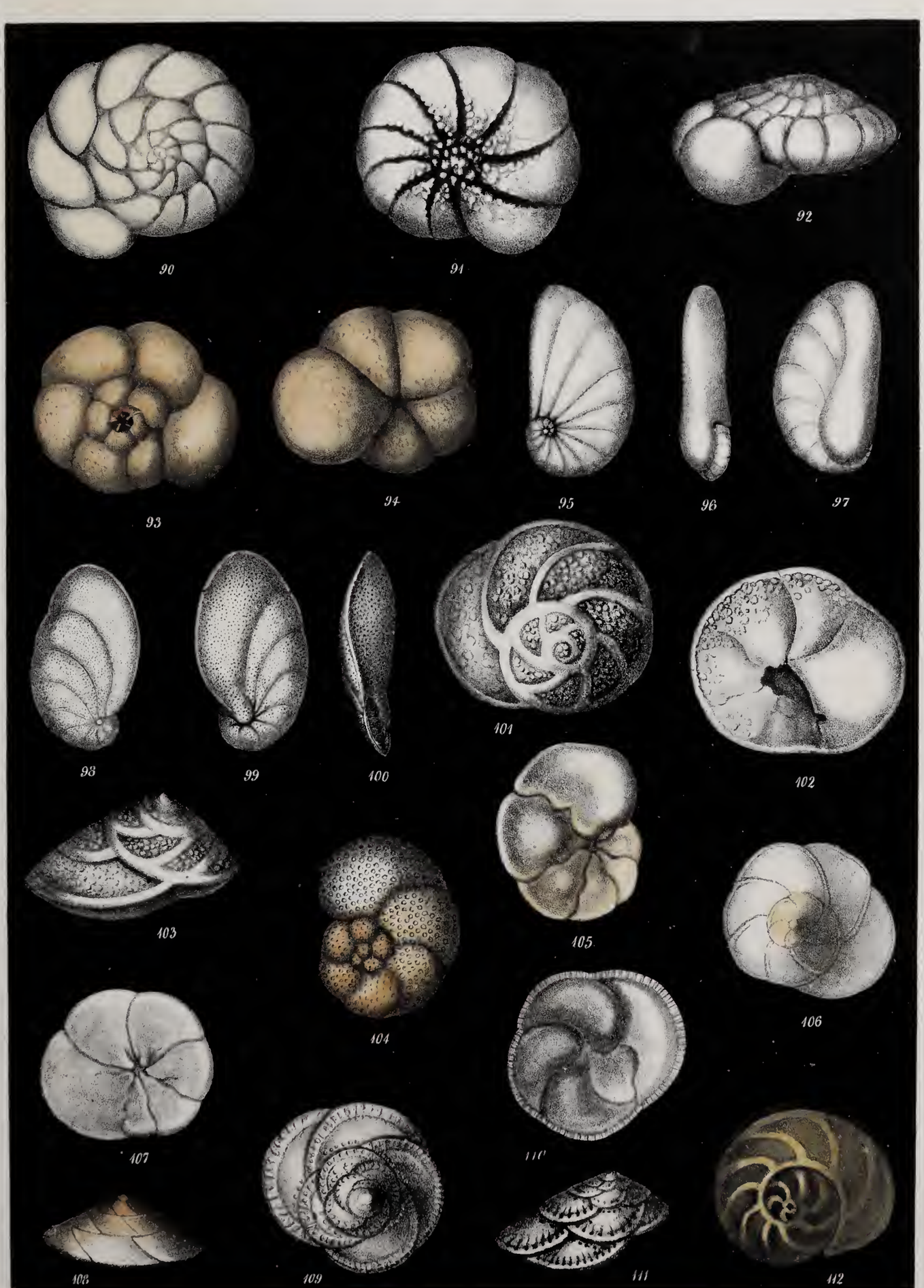


W C Williamson del Tuffen West lith

W West Imp

NONIONINA, NUMMULINA POLYSTOMELLA, PENEROPLIS, PATELLINA

68 — 75 76 — 77 78 — 82 83 — 85 86 — 89



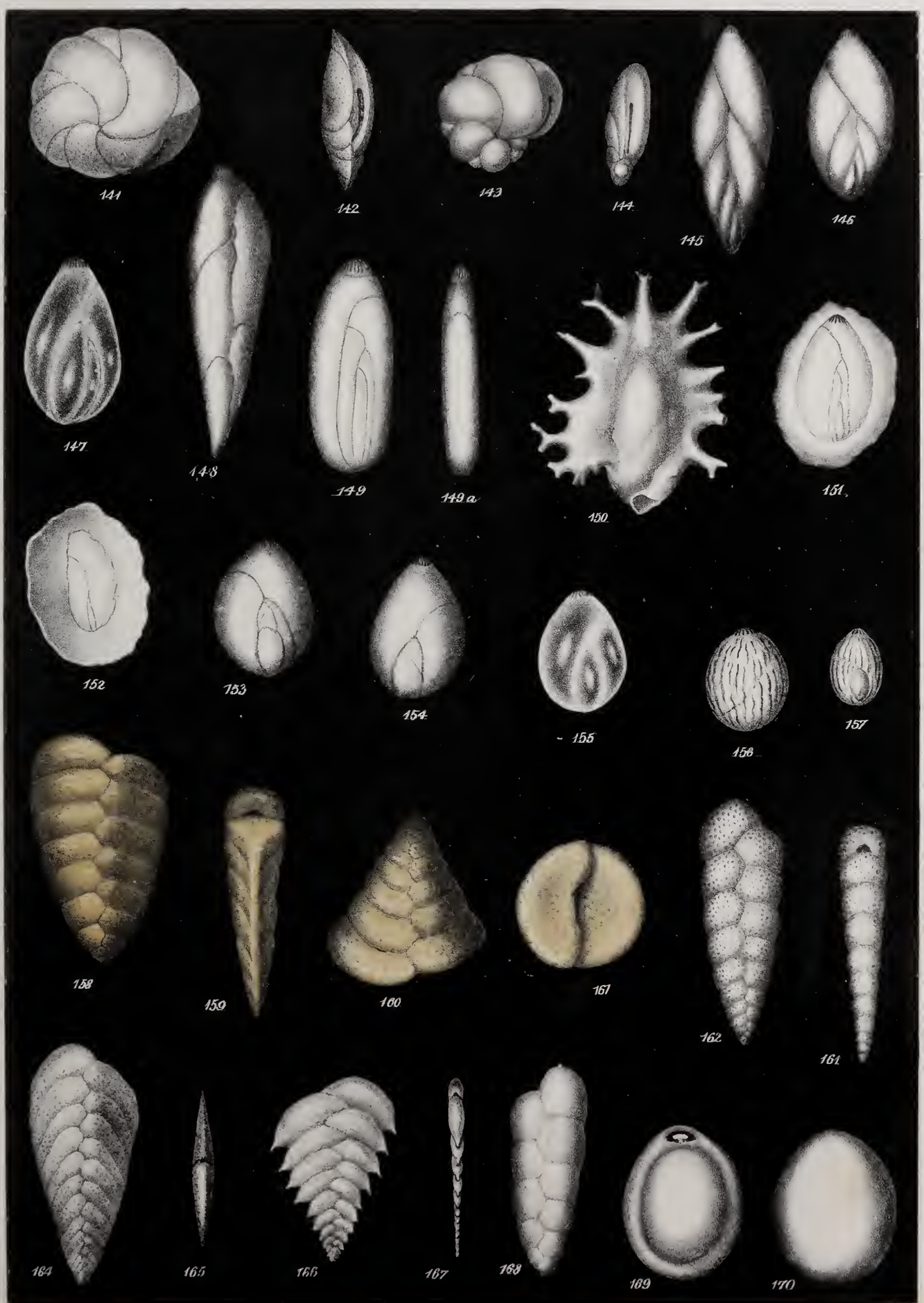
W. C. Williamson del. Tuffen West lith

W West Imp

ROTALINA

ROTALINA, GLOBIGERINA, PLANORBULINA, TRUNCATULINA, BULIMINA, UVIGERINA.

113 — 115 116 — 118 119 — 120 121 — 123 124 — 137 138 — 140



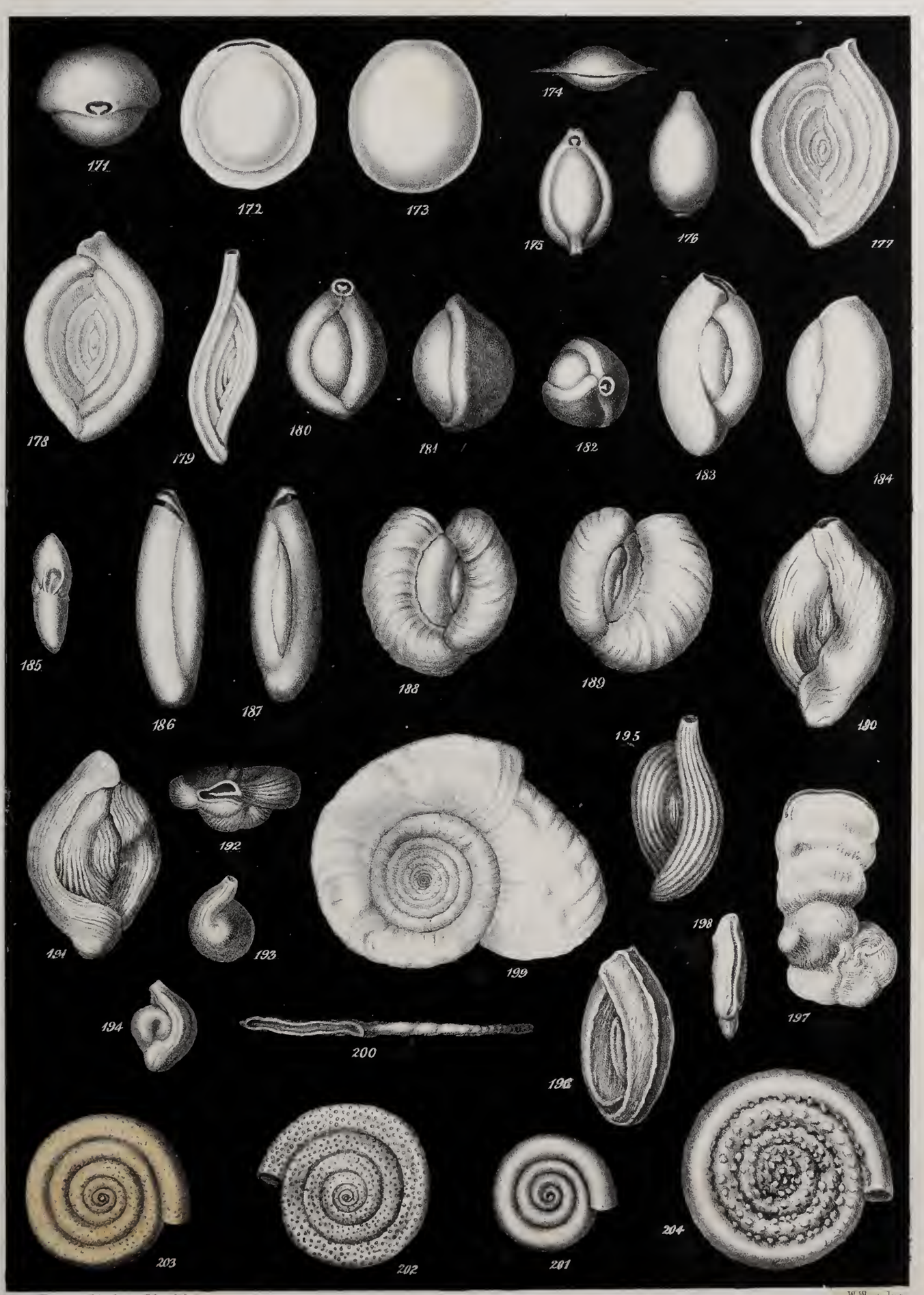
W C Williamson del Taffen West lith

W West imp.

CASSIDULINA. POLYMORPHINA. TEXTULARIA. BILOCULINA.

141 ___ 144 145 _____ 157 158 ___ 168 169 ___ 176

PLATE VII



W.C. Williamson del. Tuffen West lith. W. West Imp.

BILOCULINA SPIROLOCULINA MILIOLINA, VERTEBRALINA, SPIRILLINA

171 — 176 177 — 179 180 196 196 a, b 197 — 202

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The greater part of the preceding list was prepared for my own use some time before the appearance of a similar one in Schultze's volume; but I have been indebted to the latter for a number of additional references, especially to German publications treating of fossil Foraminifera. I have not felt it necessary to include in my list every work on general geology which happened to refer to a Nummulite, otherwise an already lengthy catalogue must have been still further extended.