

A Monograph of the Genus Polymorphina. By HENRY B. BRADY, *F.L.S.*,
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(Plates XXXIX.—XLII.)

INTRODUCTORY.

PERHAPS no genus of the Foraminifera, embracing individuals so widely different in conspicuous characters, presents at the same time so unbroken a series in the differentiation of its successive links as the group brought together by D'Orbigny under the name POLYMORPHINA.

Whilst its interest is heightened rather than diminished by this fact, the difficulties in the way of satisfactory systematic arrangement and subdivision are considerably augmented; and as successive observers have pursued independent paths, with but little reference to what has gone before, the nomenclature of the genus has lapsed into almost inextricable confusion. This condition is obvious enough to any one who has attempted to name even a small collection of *Polymorphinæ*; but in recent investigations for our "Monograph of the Foraminifera of the Crag," it was found to be a cause of constant embarrassment. The extraordinary predominance of specimens belonging to the genus in the later Tertiary beds of our Eastern Counties, and their wide range of variation, rendered it desirable, under these circumstances, to make a critical examination of all the "species" previously described, before attempting to assign trivial names to the forms which presented themselves from this particular source. The exhaustive survey of the group thus commenced has been a more considerable undertaking than was at first anticipated; and its results appear to be of sufficient importance for embodiment in a separate memoir; and this it is that we now lay before the Society. An attempt has been made to arrange the various members of the genus in something like a natural sequence; whether it has been successful in any thing more than in the reduction of a disorderly mass of ill-defined and chiefly needless "species" into manageable compass by the adoption of larger subdivisions than those previously recognized, it is for others to judge.

The question of the importance to be attached to minute and very variable external characters is so much one of opinion, that the acceptance of any series of conclusions in respect to it cannot be urged on quite the same basis as that which may properly be claimed for results admitting of more direct proof. Observations on a very large number of specimens, drawn from a wide range of distribution both geographical and geological, and a comparison of their morphological characters with analogous variations in allied genera, form the groundwork of the views now advanced; and we may at least claim for them whatever consideration is due to careful study within these limits.

It may be well to state at the outset the principles which have been held in view

in resetting the nomenclature of the group, inasmuch as some previous endeavours in the direction of simplification have been misunderstood by Continental Rhizopodists, and conclusions which appear to us quite inconsequent have been adduced from them*.

To most naturalists the question, whether, *if two specimens have the same zoological characters, they should be regarded as belonging to the same species, without reference to their age*, appears open to but one answer, namely that, unless proof of a positive nature be forthcoming of distinct and separate origin, specific determination must rest on zoological characters. Such proof is, in the very nature of things, impossible, and we are compelled to mould our views of the past on what we know of the present.

There are many well-marked species of Foraminifera now living in our seas, which are to be found in every marine microzoic deposit of Posttertiary and Tertiary date formed at corresponding depths. A published table of the distribution of living and fossil Foraminifera in the Mediterranean area† will afford us several illustrations of this fact. Many of the columns in the table referred to are by no means complete, having been compiled from limited supplies of material, and they represent sea-bottoms, present or past, widely differing in depth. Notwithstanding some discrepancies attributable to these causes, the twenty-five lists contained in the table, embracing the results of the examination of *eleven* Mediterranean soundings, and Tertiary deposits of various ages from *fourteen* localities in Italy (including Sicily), Spain, Malta, and the neighbourhood of Vienna, yield the following facts respecting some of the commoner species of Foraminifera.

<i>Globigerina bulloides</i> , D'Orb.	occurs in 11 recent soundings and 10 Tertiary deposits.
<i>Discorbina globularis</i> , D'Orb.	6 " " 5 " "
— <i>rosacea</i> , D'Orb.	5 " " 7 " "
— <i>elegans</i> , D'Orb.	8 " " 5 " "
<i>Planorbulina Haidingerii</i> , D'Orb.	4 " " 6 " "
<i>Truncatulina lobatula</i> , W. & J.	8 " " 11 " "
<i>Rotalia Beccarii</i> , Linn.	3 " " 11 " "
— <i>orbicularis</i> , D'Orb.	7 " " 5 " "
<i>Polystomella crispa</i> , Linn.	8 " " 11 " "

* This is scarcely the place to reply to a critique by our valued friend Dr. A. E. Reuss, of Vienna (see *Verhandlungen der k. k. geologischen Reichsanstalt*, No. 7, 1868), which, though based upon a short paper by one of us, is chiefly directed against the views held by British naturalists in respect to the subdivision of this group of Protozoa. We in no way undervalue the long and persevering labours of the learned German professor in the wide field of fossil Foraminifera; and though we cannot accept the principle which has led him to the use of a multitude of names for even the simplest types, we are equally far from expecting that he should now be inclined to adopt views which many others hold to be more consistent with natural laws, and more in accordance with the results of modern inquiry. It is unfortunately much easier to establish new "species" to accommodate each little set of specimens having trifling morphological peculiarities, or derived from a different geological horizon, than to trace their connexion with better-defined forms already described; and this is precisely true of the Liassic specimens on the descriptions of which he animadverts. Nor can we agree with him that a few "species" too many are less troublesome and mischievous than the bringing together of closely allied forms into one specific group which it may be found desirable subsequently for the convenience of classification to subdivide.

† See a paper "On the Rhizopodal Fauna of the Mediterranean, compared with that of the Italian and other Tertiary deposits, by T. Rupert Jones and W. K. Parker," *Quart. Journ. Geol. Soc.* vol. xvi. p. 292: 1860.

Considering that there is abundant evidence to show that the fossiliferous beds were generally deposited at a less considerable depth than that represented by the only series of Mediterranean soundings available for comparison, these figures require much stronger evidence than any that has yet been adduced against the theory of "continuity" to warrant the *specific separation* of recent and fossil specimens merely on the ground of age. The fauna of the Mediterranean area happens to be convenient for reference, because the data are already published; but the same conclusions are arrived at on a comparison of Recent and Tertiary Foraminifera, whatever the source. In the lapse of time, owing to causes partly well understood, partly only conjectured, some forms have died out or have gradually lost their importance, some have been replaced by others, and relative size and frequency have varied with altered climatal conditions; but with these exceptions the fossil Rhizopod fauna of the Tertiary and Quaternary epochs is the living Rhizopod fauna of similar depths of the present sea-bottom.

If these conclusions be accepted, the same must be held true of preceding geological times; for we find also in the microzoic rocks of the Secondary period a considerable proportion of the same "species" (*i. e.* forms having the same zoological characters); indeed, judging from recent researches on the deep-sea bed, it seems clear that we have at the present moment a Chalk area, with characteristic Rhizopoda, in process of formation in some parts of the North Atlantic.

In the comparison of the Mesozoic with the Recent, or even with the Tertiary fauna, a larger margin must be granted for different external conditions; and this allowance must be still further increased if the same question be discussed in respect to the animal life of the Palæozoic era. We may trace back even in the strata of those very early times, certain types of Foraminifera that are living at the present day in our seas. Thus, notably, the *Nodosariæ* and *Textulariæ* abound in certain parts of the Permian Limestone of Germany and England. A *Textularia*, undistinguishable from *T. sagittula*, is found in the Carboniferous Limestone; and a very similar form, possibly a variety of the type, is not rare in some parts of the same formation; and these occur together with the Planorbulina-like shell known as *Endothyra*, which is often seen in sections of compact Mountain limestone. Indications of a still higher Foraminifer, possibly *Nummulina*, have been noticed in both English and Russian limestone of Carboniferous age.

It is true that other forms are lost to us, so far as researches have yet extended; but even these tend rather to augment than diminish the cogency of our argument. Thus *Fusulina*, a genus which Dr. Carpenter has shown to be closely related to *Nummulina*, is a characteristic fossil of certain Palæozoic limestones of Russia and North America; and in the Devonian and Silurian rocks the massive *Stromatopora* appears with simple Foraminiferal structure. Other forms of Protozoa existed in these or even earlier ages, if we accept Professor Ehrenberg's conclusion that the green kernel-like grains occurring in the green Lower Silurian sand of St. Petersburg are casts of the chambers of Foraminifera. Lastly, structures essentially Foraminiferal (*Eozoon*) are traceable in the Lower Laurentian limestones, the lowest and oldest of the known geological series.

These few extinct types, the representatives probably of many, stand in the closest

relationship with surviving genera, and, so far from breaking the zoological continuity of the series, do but serve to fill up some of the links previously wanting to complete the chain.

It is quite true that, for some reasons, of which we know nothing, certain "genera" and "species" have become prominent at one period, and lapsed into insignificance at another; but the number of types which, so far as our present knowledge goes, are absolutely lost is comparatively trifling. Nor is this surprising; for it is seldom that we have evidence of sudden upheavals of the sea-bed extending over large areas; and even in such cases the displaced water would carry with it sufficient of its microzoa to stock a new area, should the fresh conditions be favourable to their development and increase; but in the far commoner process of gradual deposit the Rhizopoda would naturally follow, as it receded, the area of depth most favourable to their habits.

These considerations are merely brought forward to show that we have no evidence of want of "continuity" in respect to the forms of marine Microzoa recurring in successive strata, and that there is no valid reason for regarding morphological characters, wherever shown, in any other than a zoological light. It need not be assumed that there is absolute and direct descent in the trifling peculiarities which have been made the bases for so many "specific" subdivisions; indeed it is almost certain that the largest number of such modifications are brought about, gradually perhaps and within certain limits for each type, by external conditions.

The arguments employed to uphold the renaming of the same varietal form on its reappearance in successive beds would be as applicable, if well grounded, to geographical as to geological range, and must be held to be also true in case of the recurrence of the same variety in areas widely separated. It would be easy, for instance, to give a list of Foraminifera common on our own coast and equally at home at similar depths on the shores of North America; to trace direct relationship would be impossible; for we have the strongest negative evidence that the same varieties, or even the same types, do not occur in the abyssal depths that separate Europe from America; yet no naturalist would suggest the "specific" separation of specimens found in the eastern from those found in the western habitat, or would hesitate to accept zoological characters *alone* as sufficient basis for identification.

In one word, the following history of the genus is as purely zoological as we have been able to make it; and the subdivisions adopted are based solely on external physical characters. We can see no consistency in any other course; and the present aspect of the nomenclature of this little section of the animal kingdom shows sufficiently the practical contradictions which accrue from the admission of *time* as a primary element in systematic zoology.

We have no hesitation in saying that, read in the light of the older definitions, the whole of the widely differing shells referable to the Polymorphine type must be regarded as a single species. From end to end of the long series it embraces there is no single break; the successive modifications of the typical form, however well defined when judged by central and characteristic specimens, are seen, as the number of examples is multiplied,

to glide into each other by absolutely imperceptible gradations. This does not diminish the necessity for subdivision, but it alters the zoological significance of the constituent groups, which have no claim to rank as true species, although necessarily distinguished by trivial names. The headings under which the various modifications of the type have been arranged in the present memoir are based upon what we regard as the best representative specimens; and under one or other of these we have been able without much difficulty to place nearly all the forms described by the authors referred to. But when the most closely related individuals may differ in so many small particulars affecting their general appearance, and the successive links in the chain are so close, considerable latitude in minor points of variation may be properly allowed to each subgroup. Under such circumstances it is impossible entirely to avoid artificial distinctions; and the best that can be done is to accept only those that are really serviceable and do not interfere with natural sequence in general characters. Those who prefer an extended nomenclature based upon evervarying minute peculiarities, have ample field amongst the *Polymorphinæ* for the exercise of their ingenuity; indeed, if the subdivision be carried much further than the limits we have adopted, it can hardly stop short of naming every specimen. There would be no difficulty in splitting up each of the groups which, with us, stand in the place of "species" into half a dozen smaller sets; but if this were done, just as great necessity would appear again to subdivide, and so forth: and even such a process of multiplication of groups has found favour with some authors.

The plan which we have adopted in reducing the nomenclature has been to go carefully over the whole of the published descriptions and figures to which we have had access, taking them as nearly as possible in the order of precedence, selecting in the process the varieties which afforded the best-defined characters, and only introducing new subtypes for specimens not referable to previously described forms. Upwards of a hundred memoirs, dating from 1780 to the present time, have been worked over in this way; and no pains have been spared to place successive writers on a proper footing in respect to the forms they have described. In some instances scant justice may appear to have been done to the labours of an author in the non-adoption of trivial names founded on laboriously worked-out diagnoses. Such omissions, alluded to more at length at a subsequent page, do not result from any lack of disposition to accept already published material; and where names previously employed do not appear, it is due to the fact that we have failed to see any advantage likely to be gained by their retention.

In almost every case we have adopted the name *first* given to a variety as its proper designation, on the simple ground of priority, making no distinction whether its original application was to a recent or to a fossil specimen; but in one or two instances the description and figures appended to the first mention of a "species" are ill defined or obscure, or in some way do not fairly represent the subgroup to which it belongs, whilst a later name given to a better representative may have been in general use and be already well understood. In these rare cases we have chosen the better type, or have merged the question of priority in that of practical convenience.

The drawings of the different "species" have, as far as possible, been made from specimens; when copied, they have been carefully redrawn from the originally pub-

lished figures; and we wish to acknowledge the great attention and labour bestowed upon them by Mr. George West.

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The following synopsis contains the titles of few memoirs beyond those which are, in one way or other, made use of in the present monograph. There are, doubtless, other papers with casual notices of the occurrence of *Polymorphinæ* which have eluded our search; but we believe the list represents almost exhaustively what has been written on the genus. In some few instances we have made use of the references in Professor Williamson's 'Recent Foraminifera of Great Britain.'

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Genus POLYMORPHINA, D'Orbigny.

Synonyms:—

- Polymorphium*, Soldani, 1780.
- Serpula*, Walker and Jacob, 1784; Kanmacher, 1798.
- Vermiculum*, Montagu, 1803; Fleming, 1823; Macgillivray, 1843.
- Arethusa*, Montfort, 1808; Bowditch, 1822; Fleming, 1828; Thorpe, 1844.
- Misilus*, Montfort, 1808.
- Cantharus*, Montfort, 1808.
- Polymorphina*, D'Orbigny, 1826; Sander-Rang, 1829; Menke, 1830; Ehrenberg, 1838; Roemer, 1838; Macgillivray, 1843; Morris & Searles Wood, 1843; Philippi, 1844; Reuss, 1845; Strickland, 1846; Alth, 1850; Jones, 1852; Morris, 1854; Parker & Jones, 1857; Egger, 1857; Williamson, 1857; Terquem, 1858; Karrer, 1861; Carpenter, 1862; Gümbel, 1862; Brady, 1864; Stache, 1864; Dittmar, 1864; Sars, 1865; Schwager, 1866; Alcock, 1867; Bunzel, 1869; Von Schlicht, 1869.
- Globulina*, D'Orbigny, 1826; Sander-Rang, 1829; Roemer, 1838; Reuss, 1845; Alth, 1850; Morris & Jones, 1854; Bornemann, 1855; Egger, 1857; Karrer, 1861; Schwager, 1864; Von Schlicht, 1869.
- Guttulina*, D'Orbigny, 1826; Sander-Rang, 1829; Roemer, 1838; Reuss, 1845; Alth, 1850; Morris & Jones, 1854; Bornemann, 1855; Egger, 1857; Karrer, 1861; Stache, 1864; Von Schlicht, 1869.
- Pyrulina*, D'Orbigny, 1826; Sander-Rang, 1829; Reuss, 1845; Morris & Jones, 1854; Ehrenberg, 1854; Von Schlicht, 1869.
- Renoidea* (in part), Brown, 1827.
- Raphulina* (in part), Zborzewski, 1834.
- Apiopterina* (in part), Zborzewski, 1834.
- Proroporus* (in part), Ehrenberg, 1844; Reuss, 1845.
- Aulostomella*, Alth, 1850.
- Grammostomum* (in part), Ehrenberg, 1854.
- Strophoconus* (in part), Ehrenberg, 1854.
- Bigenerina* (in part), Ehrenberg, 1854.
- Vaginulina* (in part), Ehrenberg, 1854.
- Pleurites* (in part), Ehrenberg, 1854.
- Sagrina* (in part), Ehrenberg, 1854.
- Sphæroidina* (in part), Ehrenberg, 1854.
- Rostrolina*, Von Schlicht, 1869.
- Atractolina* (in part), Von Schlicht, 1869.

General Characters.—Shell free, or (rarely) adherent; globular, ovate, oblong, cylindrical, compressed, or complanate. Visible segments variable in number—two or many. Segments even-margined or ventricose; arranged in an obscure spiral or (less frequently) in two opposed alternating series (as in *Textularia*), more or less embracing, and partially investing the previous segments. Shell inequilateral, from unequal overlapping of the segments. Septal lines often depressed, obscure in thick-shelled specimens, but in hyaline individuals marked by whitish milky lines. Pseudopodial orifice at the anterior extremity of the ultimate segment; nearly central, and generally situated in a mamilliform protuberance; circular, oval, slit-like, or porous, and (normally) surrounded by a coronal of strongly defined radiating grooves. In rare cases the direction of the aperture is reversed, as in the Entosolenian *Lagenæ*. Texture hyaline and delicate in young specimens, opaque and coarse in older ones; never arenaceous. Foramina conspicuous in hyaline shells, minute and tubular in those with thicker walls. Surface either smooth or presenting outgrowths in the form of setæ, spines, tubercles, granular lines, striæ, or riblets.

The natural position of the genus *Polymorphina* is in the suborder PERFORATA, Family LAGENIDA (Carpenter), between the genera *Nodosarina* and *Uvigerina*.

Whilst there is little difficulty in distinguishing well-grown specimens pertaining to this group in any of the numerous modifications of form they are liable to assume, it must be borne in mind that there is scarcely a genus in the whole family of *Lagenida* which has not its isomorph amongst the *Polymorphinæ*. The minute globular forms, either smooth, as in the smaller examples of *P. gibba*, or with ornamented shell like *P. myristiformis*, have a strong resemblance to corresponding varieties of *Lagena*, especially if the septation be obscured, as it often is by a thickened shell-wall; and in these cases the inequilateral contour of the shell supplies the best indication of zoological affinity. In *P. Soldanii* we find an acervuline packing of the chambers; and when this occurs in tolerably regular series a striking analogy to the smooth *Uvigerinæ* is the result. In the Dimorphine varieties, which are sufficiently distinct to be roughly separated into a subgenus, the mode of growth simulates *Nodosaria*, *Bigenerina*, or *Sagrina*; and in addition to these the genus presents isomorphs of at least two other types—namely, of *Textularia* in many of the biserial varieties, and of *Bulimina* in one or two irregular forms described by D'Orbigny. But the chief difficulty in diagnosis arises not out of well-developed specimens, however much they mimic collateral types, but in modifications arising, on the one hand, out of an exaggerated condition of otherwise normal characters, or, on the other, out of the want of distinctive character resulting from external influences unfavourable to vigorous growth. Better examples of this latter "starved" condition could not be found than in the assemblage of few-chambered, ill-grown, elongate varieties upon which M. Terquem has founded his "Fourth Memoir on the Foraminifera of the Lias." It is not necessary here to occupy space by criticism on a memoir so unsatisfactory; but we may in passing enter a protest against the establishment of a number of species on a set of poorly developed and sometimes even monstrous individuals. Some of M. Terquem's drawings do not represent *Polymorphinæ* at all, but specimens belonging to widely differing genera, as *Lituola*; others are just as likely to be weak and irregularly grown *Nodosarinæ*, whilst

the remainder would be sufficiently provided for by association with *Polymorphina Thovini*, *P. fusiformis*, and *P. compressa*.

Whilst speaking of the literature of the genus, we may advert to the difficulty of identifying the particular varieties figured by some of the earlier writers. The value of an otherwise excellent paper, like that by Herr Roemer on the North-German Tertiary Marine Sands, is much diminished, so far as the Foraminifera are concerned, by the minuteness and want of definition of the drawings; and the same fault appears in Prof. Reuss's earlier illustrations. The desire to express *relative* size, by observing a uniform scale for all the figures on a plate, has in the same way somewhat marred the usefulness of our own Monograph of the Crag Foraminifera; but in this case the deficiency is confined to the smaller species.

A treatise on any subject pertaining to fossil microzoa can hardly be regarded as complete without reference the 'MIKROGEOLOGIE' of Prof. Ehrenberg, although so far as the "*Polythalamia*" are concerned, the value of its magnificent plates is very small in proportion to the labour bestowed upon them. Their defects are chiefly due to the system adopted throughout the work of drawing from specimens mounted in Canada Balsam and viewed by transmitted light. The result is that only one aspect of the test is given, and in transparent individuals the external characters are confused beyond recognition by the prominence of the septal lines in the interior. The figures, almost without exception, represent the longitudinal or horizontal section of the shell, from which, alone, the shape of its transverse section or its general external aspect cannot be determined. Under these conditions the compressed and complanate forms are undistinguishable from the subglobular and pyriform varieties, and the only characters left for diagnosis are the comparative length and breadth of the specimens and the contour of their margins. Whilst therefore we have thought it necessary to examine minutely all the figures in the 'Mikrogeologie' showing any apparent connexion with this genus, and have, to the best of our judgment, distributed the references to them amongst the synonyms appended to the species to which they seem to belong, the result is offered with much hesitation, and the determination must be accepted with a certain amount of reservation. The difficulty attending this re-setting of Prof. Ehrenberg's subdivisions is further enhanced by his non-acceptance of previously established and well known specific and even generic terms. We find undoubted *Polymorphinæ* under no less than ten generic headings, intermixed with Foraminifera belonging to several widely differing types; indeed the nomenclature of the 'Mikrogeologie' leaves us no terms of distinction between such genera as *Polymorphina*, *Textularia*, *Uvigerina*, and *Bulimina*, whilst the subgeneric names *Guttulina*, *Bigenerina*, and *Dimorphina* are applied to specimens that have no divisional characters in common with those for which they are employed by other writers.

It seems necessary to make a passing allusion to the last memoir on our bibliographic list,—Herr von Schlicht's work on the 'Foraminifera of the Septaria-clay of Pietzpuhl,' which came into our hands whilst engaged in revising the present paper. The institution of two new genera (*Atractolina* and *Rostrolina*) for sets of specimens very slightly, if at all, divergent from previously well understood forms is a course which will scarcely

commend itself to a second observer. The first name is used for a mixed lot consisting partly of compact fusiform *Polymorphinæ*, the remainder of doubtful *Nodosarinæ*. His genus *Rostrolina*, on the other hand, consists entirely of *Polymorphinæ*; and its diagnosis is based upon the characters of the last chamber, especially its produced extremity and arcuate or slit-like terminal orifice. We have not pretended to sort the whole of the figures of the *Polymorphinæ* contained in Herr von Schlicht's work, but have inserted references to the least doubtful of them in their proper places.

In the subdivision of this truly polymorphic genus we are dependent on certain constantly varying characters, and the specific (or rather varietal) names we have adopted are those which have been given to forms which represent the best-defined lines of departure from a central type. We are well aware that many Continental observers, with their inclination towards minute and nominal distinctions, may regard some of the groups associated under a single varietal name as embracing too wide a range in minor characters; and we can only offer in defence the fact that we have in no case ignored a published trivial name that we could make of the slightest service in defining any particular assemblage of forms; and regarding the arrangement we have adopted as sufficient to embrace every modification of the type that has come under our notice, we could not have carried the process of subdivision further without naming almost every specimen.

The characters most available for purposes of systematic description are those depending on the shape, number, arrangement, and "setting on" of the chambers, and the condition of the surface of the shell in respect to ornamentation. In M. D'Orbigny's first scheme of classification of the Foraminifera*, whilst the type was still only known by its smooth varieties, the genus was divided into four subgenera, which are given with their characters as under:—

POLYMORPHINA (proper), having a large number of chambers visible, alternating upon two sides almost equally.

GUTTULINA, having but few of the chambers visible, alternating upon three faces; chambers embracing.

GLOBULINA, alternating on three faces, chambers embracing; three chambers only visible.

PYRULINA, alternation irregular, or somewhat obscurely spiral, formed of half-embracing chambers.

These subgeneric names have been accepted with more or less reservation by subsequent continental writers†. But when a subdivision of this sort has confessedly no natural basis, it is fair to judge it on the simple issue of convenience as an artificial arrangement; and it has been thought better to abandon the complication of terms it necessitates, as tending to confuse rather than to simplify a general scheme of the group.

* "Tableau méthodique de la classe des Céphalopodes."—*Annales des Sciences Naturelles, Tome 7^{ième}*, 1826.

† Quite recently Herr Karrer has abandoned the subdivision into subgenera, as Prof. Reuss also appears in some measure to have done.

There is, however, one set of forms, misunderstood by D'Orbigny, and correspondingly misplaced, which seems better entitled to the position of a subgenus or subtype, viz. those constituting his genus *Dimorphina*. All the biserial genera of Foraminifera have amongst their modifications some which show a tendency to a uniserial arrangement of a portion of their segments. In *Textularia*, for instance, there are a number of varieties, separated under the subgeneric name *Bigenerina*, differing in many of their characters, but alike in this—namely, that after the first few chambers have been formed on the normal alternating plan, the shell is completed by a uniserial line of segments. In the same way rare specimens of the Polymorphine type are found, in which the early segments are triserial, or obscurely spiral, and the later ones assume a uniserial arrangement. Thus *Dimorphina*, the subgenus embracing these varieties, bears precisely the same relation to *Polymorphina* that *Bigenerina* does to *Textularia*. These peculiar forms are interesting as supplying one of many evidences of the near relationship of the genus to the *Nodosarinæ*. In a large proportion of the specimens the later chambers are as completely Nodosarian in character as the earlier ones are Polymorphine; indeed it is an open question regarding such forms as the *Dimorphina obliqua* of D'Orbigny, which of the two genera they are best assigned to.

The genus *Uvigerina*, which is normally triserial, supplies another such instance in its subgenus *Sagrina*; and the resemblance its uniserial specimens often bear to those of *Dimorphina* is so close that the produced phial-shaped neck and lip is almost the only character which determines their Uvigerine affinity. Herr Schwager, in his contribution to the geological part of the 'Novara-Reise,' figures a beautiful variety of this kind as *Dimorphina striata*, which we have reluctantly omitted, regarding it as a striate *Sagrina*, on the ground of its neatly formed Uvigerine neck.

Accepting the shell first figured by Walker and Boys*, the smooth, hyaline, Globuline form named by them *Serpula lactea*, as the type of the genus, it is easy to divide the *Polymorphinæ* proper into two groups,—1st, those having smooth shells, and, 2ndly, those having tests more or less altered by outgrowths of shell-substance, constituting a sort of surface-ornamentation. But, broad and well defined as this division seems, it is by no means absolute; for perfectly smooth examples of *Polymorphina frondiformis* may frequently be met with, although it is necessarily placed amongst the "ornamented" forms on account of the subcostate surface of the majority of specimens.

1st. Of the smooth varieties little need be said in explanation of the order which has been adopted in the treatment of the species. Two somewhat anomalous forms, *P. concava*, Williamson, and *P. Humboldtii*, Bornemann, whose plano-convex shape appears to be due to a parasitic habit of growth†, are placed at the end of the series; and another interesting modification, *P. elegantissima*, Parker and Jones, is equally removed from the normal type by the reversed direction of its later segments. But beyond these excep-

* 'Testacea minuta rariora,' &c., p. 2, pl. 1. fig. 5.

† For *P. Humboldtii* this character is assumed from analogy, and we lay no stress upon it, never having seen specimens exactly similar to those figured by Dr. Bornemann; but whether our supposition be correct or not, the place assigned to it is probably nearly its natural one.

tional cases the varietal distinctions are derived chiefly from such characters as the form of the chambers, their number, the degree in which they overlap, the amount of depression at the sutures, and the general contour of the shell, as determined by their fitting together.

2nd. Amongst the "ornamented" varieties may be found almost every description of surface-marking known in the simple Foraminifera. The normal hyaline condition of the young shell is seldom preserved in the adult, but by degrees the delicate test is thickened and rendered opaque from the continued deposit of calcareous matter. This process usually takes place with uniformity over the whole surface; and as the pseudopodial perforations continue open, their length is necessarily increased, and from being mere minute circular apertures they become tubes traversing the shell-wall. A portion of a thickened shell exhibiting this tubular structure is shown at Plate XL. fig. 12, *f*.

But in another, large class of cases, the calcareous matter deposited by the sarcode issuing through the perforations of the originally thin and smooth chamber-wall, produces, by uneven deposition, a series of very different results. The characters depending on exogenous growths so formed are sufficiently marked to yield varietal distinctions, and we have employed the trivial names which previous authors have given in regard to the more salient of them; but it must be understood that in whatever guise the shelly outgrowths appear—whether as mere rugosities, as bristles, spines, tubercles, granular lines, striæ, or ribs—they all, physiologically speaking, originate in the same way, and, as might be expected, pass into each other by insensible degrees.

In so variable a genus there is perhaps less to be learnt from chance monstrous specimens than in those whose normal range of modification is narrower; indeed it becomes difficult, with such a group, to say what constitutes a monstrosity. The only really anomalous specimens we recollect, setting aside the fistulous or cervicorn varieties, here treated of separately, are a few rare examples which are partially double and present two principal orifices instead of one. An individual of this sort is represented at Plate XXXIX. fig. 1, *c*. It is of no special interest, except from the analogy it bears to the double-growing *Lagenæ* and *Cristellaris* that are occasionally met with.

Distribution.—The geographical area of the distribution of the genus *Polymorphina* is coextensive with a certain bathymetrical range throughout the world. Its "home" is in shallow seas, and it can scarcely be said to flourish at greater depth than 60 or 80 fathoms, though occasional specimens are still found at 90 fathoms, and under favourable conditions it may occur in still deeper water*. In littoral sands, or those dredged in the Laminarian, the Coralline, or the Coral zone, whatever the latitude, some variety of the type is sure to be found if Foraminifera are present at all.

Arctic dredgings off Hunde Island and off the coasts of Greenland and Norway have yielded fine specimens. Proceeding southwards, the genus is of common occurrence in

* At the time this paragraph was written we had not seen Dr. Sars's valuable paper, containing "Additional Observations on the Animal Life met with in the Depths of the Sea," which mentions the occurrence of three varieties of *Polymorphina*, viz. *P. lactea (typica)*, *P. compressa*, and *P. tubulosa (=P. Orbignii of the present memoir)*, in soundings from 300 fathoms; but as this fact does not affect the general accuracy of our statement, we have allowed it to remain as originally written.

the Shetland area, it is met with at every point on the shores of the British Islands, and again in the British Channel and the Bay of Biscay. Its occurrence in the Mediterranean strikingly follows the variations of depth: the table before alluded to, which embodies the results of a large series of observations*, shows its entire absence at 170, 250, 306, 500, 1100, 1620, and 1700 fathoms, whilst at 90 fathoms (off Syra) the attenuated variety is noted as "rare;" and the common forms by degrees come in, in the shallower water of the Gulf of Spezzia, off Leghorn, and off Crete; and, again, specimens of the genus have been noticed by many observers in the lesser depths of the Levant.

Polymorphinæ are found in the Red Sea, on the coast of China, amongst the Australian coral-reefs, in the sea-harbours of Tasmania, on the eastern shores of the American continent, in the West-Indian archipelago, and amongst the Canary Islands.

In all dredgings taken from mid-ocean the absence of the genus is conspicuous; in the deep Atlantic, whether in the northern, tropical, or southern portions, it is unknown; and there is no record of its occurrence at great depths in the Indian Ocean.

The distribution of the genus in *time*, geologically speaking, is similarly extensive.

If we accept the aggregations of green sand-grains figured by Prof. Ehrenberg under the names *Polymorphina avia* and *P. abavia* as glauconite casts of the chambers of Foraminifera (and, notwithstanding some doubt that has been thrown upon their organic origin, we must admit the extreme resemblance his two figures bear to some specimens of *Polymorphina compressa*), the first appearance of the genus must be placed back as far as the Lower Silurian sands of the neighbourhood of St. Petersburg. It has not, however, been noted in rocks of Palæozoic age by any other author.

In the Secondary period, specimens of *Polymorphina*, usually of the few-chambered, weaker forms, become gradually more frequent. In the Upper Trias of Derbyshire (Jones and Parker), the Raibl beds of southern Germany (Gümbel), and in the various Liassic marls of England and continental Europe examples of the genus are found, though rarely. It again makes its appearance in the Oxford and Kimmeridge clays (Middle and Upper Jurassic respectively), in the Portland beds, in the Gault, and the Chalk; and during the Tertiary period it occurs in abundance wherever conditions of depth and sea-bottom have been favourable. Though apparently wanting in the London Clay, specimens of the genus are to be found in some of the Lower Eocene beds of England; but in the Lower Tertiaries of the Paris district, in the Miocene strata of Bordeaux, of the Vienna Basin, and of Lower Bavaria, it exists in wonderful variety. In the later Tertiary beds of the Mediterranean area there is a curious discrepancy to be observed: the Italian Pliocene marls contain a fair representation of the genus, whilst beds of corresponding age on the Spanish coast (Malaga) yield no *Polymorphinæ* whatever: and the same absence is to be observed in a peculiar marl-bed of Miocene or late Eocene age at Baljik, on the Black Sea. In the Southern Hemisphere, such of the Tertiary clays as have been examined, *e. g.* those of New Zealand and South Australia, show a large number of specimens pertaining to the type. In one particular bed of the "Crag" of our own Eastern Counties (at Sutton, near Colchester) the size and abundance of the

* Quarterly Journal of the Geological Society, vol. xvi. p. 302.

Polymorphinæ constitute a remarkable and distinguishing feature, though elsewhere in that formation they are small and scattered. Lastly, in the Glacial beds of the west and north of Scotland, of Norway, and of Canada the type still abounds, and in the Posttertiary clays immediately underlying the peat in the fen districts of Lincolnshire and Northamptonshire numbers of minute specimens are found in a scarcely fossilized condition.

POLYMORPHINA LACTEA, Walker and Jacob, sp. (Pl. XXXIX. figs. 1, *a-c.*)

(Normal form; transverse section nearly circular.)

Serpula tenuis ovalis laevis, Walker and Jacob, 1784, Test. Min. p. 2, pl. 1. fig. 5.

S. lactea, W. and J., *vide* Kanmacher, 1798, Adams's Essays, 2nd ed. p. 634, pl. 24. fig. 4.

Vermiculum lacteum, Montagu, 1803, Test. Brit. p. 522.

Serpula lactea, Maton and Rackett, 1807, Trans. Linn. Soc. vol. viii. p. 246; Pennant, 1812, Brit. Zool. vol. iv. p. 363; Turton, 1819, Conch. Dict. p. 156.

Vermiculum lacteum, Fleming, 1822, Wern. Mem. vol. iv. p. 566, pl. 15. fig. 6.

?*Polymorphina (Globulina) ovata*, D'Orbigny, 1826, Ann. Sc. Nat. vol. vii. p. 266; Soldani, Testaceographia, vol. ii. pl. 112. figs. *g, g'*.

?*Arethusa lactea*, Fleming, 1828, Hist. Brit. Anim. p. 234.

?*Globulina Caribæa*, D'Orbigny, 1836, Foram. Cuba, p. 130, pl. 2. figs. 7, 8.

Guttulina Plancii, D'Orbigny, 1839, Voyage dans l'Amér. Mérid. p. 60, pl. 1. fig. 5.

Renoidea oblonga, Brown, 1839, Conch. Illust. p. 3, pl. 56. figs. 16, 17.

Vermiculum lacteum, Macgillivray, 1843, Moll. Aberd. p. 37.

Polymorphina lactea, *id.* 1843, *ibid.* p. 320.

Arethusa lactea, Thorpe, 1844, Brit. Mar. Conch. p. 233.

Globulina lachryma, Reuss, 1845, Verstein. böhm. Kreid. pt. 1, pp. 40, 110, pl. 13. fig. 83; Alth, 1849, Haidinger's Abhandl. vol. iii. p. 263, pl. 13. fig. 16; Reuss, 1850, *ibid.* vol. iv. p. 43, pl. 5. fig. 9.

Polymorphina lactea, Jones, 1854, in Morris's Cat. Br. Foss. 2nd edit. p. 40.

Pyrulina ovulum, Ehrenberg, 1854, Mikrogeologie, pl. 31. figs. 35, 36.

Strophoconus ovum (in part), *id.* *ibid.* pl. 20, § 2, fig. 3, and pl. 26. fig. 21.

S. spicula (in part), *id.* *ibid.* pl. 26. fig. 20.

S. laxum, *id.* *ibid.* pl. 25. fig. 15, and pl. 31. fig. 26.

Polymorphina Muensteri, Reuss, 1855, Sitzungsab. Akad. Wissen. Wien, vol. xviii. p. 249, pl. 8. fig. 80.

P. ovulum, *id.* *ibid.* p. 250, pl. 6. fig. 63.

P. Roemeri, *id.* *ibid.* p. 245, pl. 6. fig. 64.

P. deformata, *id.* *ibid.* p. 246, pl. 6. fig. 66.

P. turgida, *id.* *ibid.* p. 246, pl. 6. fig. 67.

P. lactea (typica), in part, Williamson, 1858, Rec. For. Gt. Br. p. 71, pl. 6. fig. 147.

P. lactea, var. *communis*, *id.* *ibid.* p. 72, pl. 6. figs. 153-155.

Guttulina diluta, Bornemann, 1860, Zeitschr. deutsch. geol. Gesellsch. vol. xii. p. 160, pl. 6. fig. 11.

Polymorphina lactea, Parker and Jones, 1859, Ann. N. H. Ser. 3, vol. iv. p. 336; 1860, Q. J. Geol. Soc. vol. xvi. p. 454, pl. 20. fig. 44; *id.* *ibid.* p. 302, table; *id.* 1862, in Carpenter's Introd. Appendix, p. 311; Brady, 1864 (in part), Trans. Linn. Soc. Lond. vol. xxiv. p. 473; Brady, 1865 (in part), Nat. Hist. Trans. Northumberland and Durham, vol. i. p. 99.

P. lactea (typica), Alcock, 1865, Proc. Lit. & Phil. Soc. Manchester, vol. iv. p. 206; Sars, 1865, Foss. Dyrelevn. fra Kvartærperiod. pp. 55, 62, 65, 68, 85, 91; Jones, Parker, and Brady, 1866, Monogr. Crag Foram. pl. 1. fig. 48; Brady, 1868, Trans. Geol. Soc. Glasgow, vol. iii. p. 125, &c.; Sars, 1868, Vidensk.-Selsk. Forhandling for 1868, p. 248.

?*Rostrolina*, sp., Von Schlicht, 1869, Foram. Septar. Pietzpuhl, no. 416, pl. 25. figs. 17, 18.
Guttulina, sp., id. ibid. No. 491, pl. 32. fig. 21.

Polymorphina lactea, var. *amygdaloides*, Reuss.

(Compressed varieties, Wood-cuts *a*, *b*, *c*, *d*.)

- Polymorphina* (*Globulina*) *minuta*, Roemer, 1838, Neues Jahrb. für Min., Jahrg. 1838, p. 386, pl. 3. fig. 35.
P. (*globulina*) *acuta*, id. ibid. p. 386, pl. 3. fig. 36.
Globulina minuta, Reuss, 1849, Denkschrift. d. mathem.-natur. Cl. k. Akad. Wissensch. vol. i. p. 377, pl. 48. fig. 8.
G. inæqualis, id. ibid. p. 377, pl. 48. fig. 9.
G. guttula, Reuss, 1851, Zeitsch. deutsch. geol. Gesell. vol. iii. p. 82, pl. 6. fig. 46.
G. amygdaloides, id. ibid. p. 82, pl. 6. fig. 47.
G. guttula, Bornemann, 1855, ibid. vol. vii. p. 344.
G. amygdaloides, id. ibid. p. 344.
Polymorphina deplanata, Reuss, 1855, Sitzungsab. k. Akad. Wissensch. Wien, vol. xviii. p. 246, pl. 6. fig. 67.
P. amygdaloides, id. ibid. p. 250, pl. fig. 84.
P. subdilata, Egger, 1857, Neues Jahrb. für Min., Jahrg. 1857, p. 286, pl. 13. figs. 30–33.
Guttulina elongata, Karrer, 1861, Sitzungsab. k. Akad. Wissensch. vol. xlv. p. 24, pl. 2. fig. 3.
Polymorphina (*Guttulina*) *sororia*, Reuss, 1862, Bulletin Acad. Roy. de Belgique, 2^{me} sér. vol. xv. p. 121, pl. 2. figs. 25–29.
P. sororia, Reuss, 1863, Sitzungsab. k. Akad. Wissensch. vol. xlv. p. 57, pl. 7. figs. 72–74; id. 1866, Denkschr. d. mathem.-naturw. Cl. k. Akad. Wissensch. vol. xxv. p. 152; id. 1867, Sitzungsab. k. Akad. Wissensch. vol. lv. p. 73.
P. inæqualis, id. ibid. p. 72.
P. depauperata, id. ibid. p. 73, pl. 3. fig. 9; Karrer, 1868, ibid. vol. lviii. p. 173.
Globulina guttula, Gümbel, 1868, Abhandl. d. ii. Cl. k. Akad. Wissensch. vol. x. p. 645.
? *G. subalpina*, id. ibid. p. 646, pl. 2. figs. 80, *a*, *b*.

Characters.—Shell (typical) ovate, gibbous, slightly unsymmetrical; anterior extremity acute; posterior obtuse, rounded. Chambers few, oblong, oblique, somewhat inflated. Sutures depressed. Surface smooth. Aperture simple, circular or oval, radiate. Length $\frac{1}{50}$ to $\frac{1}{20}$ inch.

The earliest figure of a specimen belonging to the genus *Polymorphina* happens to be a fair representation of the particular form that may be regarded as a type of the group. Walker's drawing, which we have reproduced on a somewhat larger scale than the original, Pl. XXXIX. fig. 1 *a*, though small and, in some respects, not very definite, has obviously been taken from a specimen very similar to that which has served as a basis for one of Prof. Williamson's figures, copied in fig. 1 *b*.

The shell of *P. lactea* has normally but four or five visible chambers, sufficiently ventricose to disturb the regularity of the general outline, the sutural lines being marked by depression or excavation. In its typical form the transverse section is nearly circular; but this is a character open to variation.

These peculiarities are matters of degree only; and a "species" founded on them represents an indefinite portion of a series of which the successive sections cannot be absolutely distinguished by the existence or non-existence of any single character. Such a

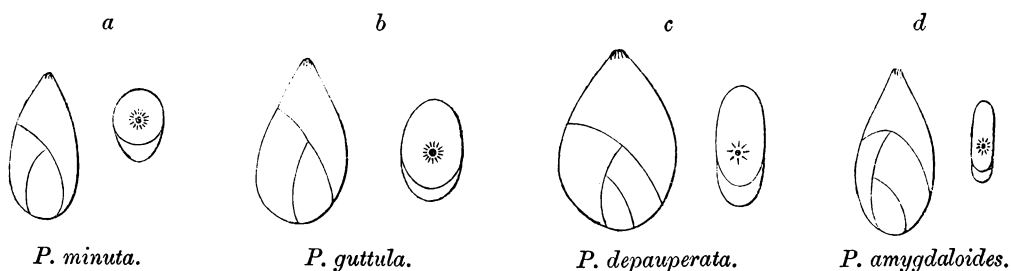
series may be said to commence with *P. gibba*, a subglobular shell, with three or four visible chambers, the sutures marked only by lines. By degrees these characters are modified in successive specimens, till in *P. lactea* the shell is rather longer proportionally, the external chambers number four or five, and the sutures are slightly excavated. Again, *P. communis*, with about the same number of chambers, has the sutures more deeply set, and the shell consequently somewhat irregular, but showing better evidence of its triserial arrangement. Lastly, in *P. problema* the number of chambers is increased to five, six, eight, or more, the convexity of each is heightened, and their order can sometimes scarcely be traced.

We have endeavoured to place the forms pertaining to this series, described by various writers, under one or other of these four subtypes, admitting the more or less compressed modifications of *P. lactea* and *P. gibba* to a sort of subvarietal distinction. Hence, under each, a considerable range of variation in minor and unimportant particulars is comprehended.

Globulina Caribæa of D'Orbigny has a slightly irregular shell, the lower portion of which is rugose: *P. Muensteri*, Reuss, is a porous or punctate variety; and *P. ovulum*, in the same memoir, is inequilateral; *P. Roemeri*, *P. deformata*, and *P. turgida* seem to represent heavier, less elegant forms, with the segments irregularly combined.

From the typical *Polymorphina lactea*, with its nearly circular transverse section, may be traced a series of modifications tending towards the complanate forms; and the references to the various authors who have alluded to these are placed together in the second division of the above synonymy. The subjoined outlines, taken from figures of four such subvarieties, about equidistant from each other in the chain of differentiation, will show how slight is the basis on which they have received distinctive names. Specimens intermediate again to these could, without difficulty, be found.

Polymorphina lactea, var. *amygdaloides*, Reuss.



P. sororia of Reuss is one of the most compact of the flattened varieties, elongate and almost pyruline in septation. *P. minuta* (a) scarcely differs from the type, except in its lateral compression. *P. guttula* (b) and *P. depauperata* (c) present the varietal peculiarity in increased degree. Lastly, in *P. amygdaloides* (d) we have a close approximation in contour to *P. oblonga* (Plate XXXIX. fig. 7); and it may even be a question whether this latter "species" might not with propriety have been brought into the same series.

P. inæqualis and *P. deplanata* are less regular and less symmetrical modifications of the type, the latter somewhat resembling *P. Burdigalensis*.

Distribution.—The range of *Polymorphina lactea* is very wide, whether regarded as a question of time or of geographical area. We have specimens from the Kimmeridge

Clay (Kimmeridge) and from the Upper Portland Limestone (Dorsetshire); and German observers figure the same form from the Cretaceous system of Bohemia. It is of frequent occurrence in the Lower and Middle Tertiaries of Northern and Central Germany and England, in the Subapennine Tertiaries (Pliocene) of Italy, in the Crag of our Eastern Counties and of Antwerp, and, lastly, in the Posttertiary (Glacial) clays of Scotland and Norway.

In the recent condition it is cosmopolitan, preferring shallow waters; indeed, except for the fact that it was one of the forms dredged by Prof. Sars in depths of 300 fathoms, it might have been set down as limited to an outside range of 80 or 90 fathoms. It is found on every portion of the shores of Great Britain, in the Arctic Sea, on the Norwegian coast, in the Mediterranean, in the West Indies, on the shores of Tasmania, and, indeed, in Foraminiferous sands from whatever latitude derived.

POLYMORPHINA GIBBA, D'Orbigny. (Plate XXXIX. figs. 2, *a-d*.)

(Typical form; subglobular, transverse section nearly circular, figs. 2, *a* and *b*.)

- Polymorphina (Globulina) gibba*, D'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 266, no. 20; Modèle no. 63; Menke, 1830, Synopsis Molluscorum, p. 5; Roemer, 1838, Neues Jahrb. für Min., Jahrg. 1838, p. 386, pl. 3. fig. 32; Morris, 1843, Cat. Brit. Foss. p. 62.
- Globulina gibba*, Reuss, 1845, in Geinitz's Grundriss der Verstein. p. 669, pl. 24. fig. 84; D'Orbigny, 1846, For. Fos. Vienne, p. 227, pl. 13. figs. 13, 14.
- G. punctata*, D'Orbigny, *ibid.* p. 229, pl. 13. figs. 17, 18.
- G. gibba*, Reuss, 1851, Zeitschr. deutsch. geol. Gesell. vol. iii. p. 80.
- G. amplexens*, *id. ibid.* p. 81, pl. 6. fig. 45; Bornemann, 1855, *ibid.* vol. vii. p. 344.
- G. gibba*, Bornemann, *ibid.* p. 344.
- Polymorphina communis* (in part), Parker and Jones, 1857, Ann. & Mag. Nat. Hist. 2nd ser. vol. xix. p. 283, pl. 11. fig. 32.
- Polymorphina (Globulina) gibba*, Egger, 1857, Neues Jahrb. für Min., Jahrg. 1857:—var. *a*, *vera*, p. 288, pl. 13. figs. 1–4; var. *β*, *ovoidea*, p. 289, pl. 13. figs. 5–7; var. *γ*, *subgibba*, p. 289, pl. 13. figs. 8–10; var. *δ*, *pyrula*, p. 290, pl. 13. figs. 11, 12.
- Globulina amplexens*, Bornemann, 1860, Zeitschr. deutsch. geol. Gesellsch. vol. xii. p. 160, pl. 6. fig. 12.
- Polymorphina lactea*, Parker and Jones, 1864, Phil. Trans. vol. clv. p. 359, pl. 13. figs. 45, 46.
- P. gibba*, Jones, Parker, and Brady, 1866, Monogr. Crag Foram. pl. 1. figs. 49–51; Reuss, 1867, Sitz. Akad. Wissensch. vol. lv. p. 72. no. 1; Karrer, 1868, Sitzungs. Akad. Wissensch. vol. lviii. p. 172.
- P. gibba*, var. *orbicularis*, Karrer, *ibid.* p. 54, pl. 4. fig. 8.
- P. punctata*, *id. ibid.* p. 53.
- Globulina subgibba*, Gümbel, 1868, Abhandl. d. ii. Cl. k. Akad. Wissensch. vol. x. p. 645, pl. 2. fig. 79.
- Rostrolina*, sp., Von Schlicht, 1869, Foram. Septar. von Pietzpuhl, no. 415, pl. 26. figs. 25–27.
- Globulina*, sp., *id. ibid.* no. 425, pl. 26. figs. 31–34, no. 427, pl. 27. figs. 1–3, no. 428, pl. 27. figs. 4–6, no. 429, pl. 27. figs. 7–9, no. 431, pl. 27. figs. 10, 12.

Polymorphina gibba, var. *æqualis*, D'Orbigny.

(More or less compressed varieties, Plate XXXIX. figs. 2, *c* and *d*.)

- Polymorphina (Globulina) globosa*, von Münster, 1838 (*vide* Roemer), Neues Jahrb. für Min., Jahrg. 1838, p. 386, pl. 3. fig. 33.
- Globulina globosa*, Reuss, 1845, Verst. böhm. Kreid. 1^{te} Abtheil. p. 40, pl. 3. fig. 82; Reuss, 1845, in Geinitz's Grundriss der Verstein. p. 669, pl. 24. fig. 85.

- Globulina aequalis*, D'Orbigny, 1846, For. Fos. Vien. p. 227, pl. 13. figs. 11, 12; Reuss, 1851, Zeitsch. deutsch. geol. Gesell. vol. iii. p. 81.
- G. inflata*, Reuss, *ibid.* p. 81, pl. 6. fig. 45; Bornemann, 1855, *ibid.* vol. vii. p. 344.
- G. aequalis*, Bornemann, *ibid.* p. 344.
- G. globosa*, Reuss, 1861, Sitzungs. Akad. Wissensch. vol. xlv. p. 318, pl. 3. fig 3.
- Polymorphina globosa*, Karrer, 1865, Sitzungs. Akad. Wissensch. vol. lii. p. 497, pl. 1. fig. 12.
- P. aequalis*, Reuss, 1867, *ibid.* vol. lv. p. 72, no. 2; Karrer, 1868, *ibid.* vol. lviii. p. 172; Bunzel, 1869, Jahrb. k. k. geol. Reichsanstalt für 1859, p. 203.

Characters.—Shell (typical) subspherical or oval, somewhat produced at the apex, broad and rounded at the base. Chambers few, compact, and overlapping. Sutures marked by lines only, neither excavated nor depressed externally. Surface smooth. Long diameter about $\frac{1}{50}$ inch.

Polymorphina gibba is, perhaps, as definite in its typical characters and as apt for technical description as any member of the group; still some latitude must be allowed in the terms employed for its diagnosis. D'Orbigny's "Modèle" represents a nearly globular shell, and may be taken as representing the normal form. Our first list of synonyms refers to specimens deviating in no striking particular from this standard.

Perhaps the commonest modification is to be found in the compressed varieties, of which the best-known and most generally recognized is the *Globulina aequalis* of the same author (Plate XXXIX. figs. 2, *c*, *d*); and the second portion of the above synonymy comprises (together with *Gl. aequalis*) a number of subvarieties differing from the type and from each other chiefly in the amount of lateral compression.

Dr. Karrer's *Polymorphina gibba*, var. *orbicularis*, on the other hand, instead of being compressed laterally, is shortened in the direction of its axis, and, whilst preserving a circular transverse section, is elliptical in its lateral aspect, the longer diameter being the horizontal one.

Specimens like Dr. Egger's subvarieties β , γ , and δ are often to be met with, and represent individuals in which the segments are unequally gibbous and not very regularly combined, rather than groups sufficiently stable in their characters for separation, even under varietal names, from the type.

Globulina punctata, D'Orb., we can regard only as representing a thin-walled condition in a shell of the common type. The extent to which the minute foramina in the chamber-walls are visible depends in great measure on the thickness and age of the shell. Old and opaque specimens seldom exhibit the perforations, which, notwithstanding, are still present, as may be seen under favourable circumstances, like the fractured edge shown at Plate XL. fig. 12 *f*. Just the same appearance may be observed in many other clear-shelled forms besides *P. gibba*.

The shape of the anterior portion of the shell differs a good deal in different individuals. In some it is acuminate, and the orifice is situate in a mamillate protuberance; in others it is truncate, and the general aperture is "flush" with the body of the shell. In rare examples the orifice is turned inwards, like that of an entosolenian *Lagena*.

Such trifling divergences from a normal type cannot be looked upon as safe ground

for the subdivision of an otherwise compact group. We are conscious that the principle we have adopted in endeavouring to simplify the nomenclature of the genus might be carried legitimately much further; and that the compromise arrived at has been in a measure influenced by motives of convenience; but the primary consideration of natural relationship has been steadily kept in view.

Distribution.—The range of *Polymorphina gibba*, geological and geographical, is very extended. It appears as a cretaceous fossil in Bohemia, and we have specimens from the Kimmeridge Clay of the South of England. It is found in the Septaria clays of Northern and Central Germany, in the Miocene of the Vienna Basin (Baden and Nussdorf beds) and Lower Bavaria, in Pliocene clays near Sienna (Coroncina), at Turin, and Palermo, in the Crag of our Eastern Counties, and in other Tertiary deposits.

It is equally common in the recent state. We have note of its occurrence off almost every portion of the shores of Europe, though never in very deep water.

POLYMORPHINA GUTTA, D'Orbigny. (Pl. XXXIX. figs. 3, *a*, *b*.)

Polymorphium pyriformium, Soldani, 1789, Testac. ac Zoophytograph. vol. ii. p. 117, pl. 122. fig. *gg*.

Polymorphina (Pyrulina) gutta, D'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 267, no. 28, pl. 12. figs. 5, 6; Modèle no. 30.

? *P. (Globulina) clavata*, Roemer, 1838, Neues Jahrb. für Min., Jahrg. 1838, p. 386, pl. 3. fig. 38.

Pyrulina obtusa, Reuss, 1862, Sitzungsab. d. k. Akad. Wissensch. vol. xlvi. p. 79, pl. 9. fig. 9.

Polymorphina gutta, Jones, Parker, and Brady, 1866, Monogr. Crag Foram. pl. 1. figs. 46, 47.

Rostrolina, sp., Von Schlicht, 1869, Foram. Septar. Pietzpuhl, p. 72, nos. 408, 409, and 411, pl. 26. figs. 1-6, 10-12.

Pyrulina, sp., id. *ibid.* nos. 423, 424, pl. 25. figs. 55, 56, pl. 27. figs. 13-15.

Characters.—Shell ovate-elongate, symmetrical, pyriform; anterior portion tapering, acuminate; posterior obtuse, rounded; margin entire, septal lines not depressed. Chambers elongate, closely embracing, arranged triserially. Surface smooth. Length $\frac{1}{50}$ inch.

As explained in the introduction (*vide ante*, p. 209), the earlier writers were accustomed to divide the *Polymorphinæ* into several genera or subgenera, and the present species was made the type of one of the groups, under the name of *Pyrulina gutta*. As this subdivision of the genus is being gradually abandoned, even by those who have been its upholders, it is unnecessary to make further allusion to it.

P. gutta, in good specimens, presents tolerably definite characters, its triserial arrangement, closely-embracing chambers, and circular transverse section being sufficient for ordinary diagnosis. Its long, tapering upper extremity and numerous chambers distinguish it from *P. gibba*, and the rounded base and compact spiral build from its nearly *P. acuminata*.

Pyrulina obtusa, Reuss, is more regularly elliptical than the generally accepted type, but may fairly be associated with it. The number of individuals that agree in every point with D'Orbigny's model is very limited, and we are obliged, as in every other group, to make some allowance for variation amongst the specimens associated under one specific name.

Distribution.—Although *Polymorphina gutta* has been noticed in the Hils Clay of Germany, a deposit of Neocomian age, it is best known as a Tertiary fossil. It is found in the various Tertiary clays of North Italy and Germany, in the Barton Beds (Isle of Wight), and is not uncommon in the Crag of Suffolk. We have no note of its occurrence except as a fossil.

POLYMORPHINA ACUMINATA, D'Orbigny, sp. (Plate XXXIX. figs. 4, *a*, *b*.)

Pyrulina acuminata, D'Orbigny, 1840, Mém. Soc. Géol. Fr. vol. iv. p. 43, pl. 4. figs. 18, 19; Reuss, 1845, in Geinitz's Grundriss der Verstein. p. 670, pl. 24, fig. 64; Jones, 1854, in Morris's Cat. Br. Fossils, 2nd ed. p. 40.

Strophoconus stiliger, Ehrenberg, 1854, Mikrogeologie, pl. 26. fig. 22.

S. acanthopus, id. ibid. pl. 26. fig. 23.

Atractolina, sp., Von Schlicht, 1869, Foram. Septar. Pietzpuhl, p. 70, no. 397, pl. 25. figs. 9, 10.

Pyrulina, sp., id. ibid. no. 422, pl. 25. fig. 53.

Characters.—Shell ovate-elongate, symmetrical, triserial; both anterior and posterior extremities acuminate; margin entire, septal lines not depressed, often indistinct. Earlier chambers small, and forming a short inverted cone; the two or three last-formed segments large, embracing, and erect. Surface smooth. Length $\frac{1}{80}$ inch.

The claims of this pretty little form to specific distinction are of similar value to those of *P. gutta*. Both have compact triserial shells, with no constriction along the septal lines; both are circular in transverse section; and in both the upper portion of the shell tapers gently to a point: but whilst *P. gutta* has an obtuse, rounded base, the earlier chambers of *P. acuminata* are arranged in a short spire, resembling an inverted cone, the point of which forms the lower extremity of the shell.

In some of its characters *P. acuminata* bears a resemblance to *P. fusiformis*; but the latter has fewer chambers, they are more even in size and scarcely overlap; it is also a much larger shell, and not so compactly built.

We have already stated our views on Herr von Schlicht's genus *Atractolina*, two of the figures of which seem to pertain to the present species. His *Pyrulina*, numbered 422, is not quite pointed, but may, from its general accordance with the characters above laid down, be looked upon as belonging to *P. acuminata*.

Distribution.—D'Orbigny's specimens were obtained from the Chalk of Meudon, in France; and a few examples have been found in the Chalk-marl of Kent (Charing). The Tertiary clays of Northern Germany have also afforded specimens; still, although it is probable that *P. acuminata* might be found wherever *P. gutta* occurs, it is, so far as our present knowledge goes, a rare species, and, like its close ally, unknown in a recent condition.

POLYMORPHINA FUSIFORMIS, Roemer. (Plate XXXIX. figs. 5, *a*, *b*, *c*; and Woodcut *e*.)

Polymorphina (Globulina) fusiformis, Roemer, 1838, Neues Jahrb. für Min., Jahrg. 1838, p. 386, pl. 3. fig. 37.

P. liassica, Strickland, 1845, Quart. Journ. Geol. Soc. vol. ii. p. 30, fig. *b*.

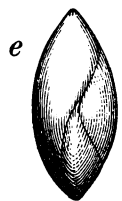
Globulina Leopoltana, Reuss, 1850, Haidinger's Abhandl. vol. iv. p. 44, pl. 5. fig. 11.

- Polymorphina lanceolata*, Reuss, 1851, Zeitschr. deutsch. geol. Gesel. vol. iii. p. 83, pl. 6. fig. 50.
Grammostomum turio, Ehrenberg, 1854, Mikrogeologie, pl. 26. fig. 19.
Globulina minima, Bornemann, 1855, Zeitschr. deutsch. geol. Gesel. vol. vii. p. 344, pl. 17. fig. 3.
Guttulina ovalis, id. ibid. p. 345, pl. 17. fig. 7.
G. vitrea, id. ibid. p. 346, pl. 17. fig. 8.
G. cylindrica, id. ibid. p. 347, pl. 18. figs. 4–6.
Polymorphina lanceolata, id. ibid. p. 347.
Globulina acuta, Reuss, 1855, Sitzungsber. k. Akad. Wissensch. vol. xviii. p. 51, pl. 6. fig. 62.
Polymorphina (Globulina) angusta, Egger, 1857, Neues Jahrb. für Min. 1857, p. 290, pl. 13. figs. 13–15.
? *Polymorphina praelonga*, id. ibid. p. 287, pl. 13. figs. 25–27.
Globulina porrecta, Reuss, 1859, Sitzungsber. k. Akad. Wissensch. vol. xl. p. 86, pl. 12. fig. 4.
Polymorphina subteres, Reuss, 1861, ibid. vol. xlii. p. 361, pl. 2. fig. 14; id. 1861, Bulletins de l'Acad. Roy. Belg. 2nd ser. vol. xv. p. 122, no. 41.
P. proteiformis (in part), id. ibid. p. 121, pl. 2. figs. 30–36; pl. 3. figs. 37–40.
Guttulina jurassica, Gümbel, 1861, Württemb. naturwiss. Jahreshfte, Jahrg. xviii. p. 228, pl. 4. figs. 15, a, b.
Polymorphina rudis, Reuss, 1861, Sitzungsber. k. Akad. Wissensch. vol. xlv. p. 319, pl. 3. figs. 5–8.
Globulina prisca, Reuss, 1862, ibid. vol. xlvi. p. 79, pl. 9. fig. 8.
Polymorphina (Guttulina) lanceolata, Reuss, 1863, ibid. vol. xlviii. p. 58, pl. 7. figs. 75–84.
P. cylindrica, id. ibid. p. 58.
Globulina nuda, Schwager, 1864, in Dittmar's "Contorta-Zone," p. 201, pl. 3. fig. 14.
Polymorphina bilocularis (in part), Terquem, 1864, 4^{me} Mém. For. Lias, p. 293, pl. 11. figs. 10, 11, 12, &c.
P. ovula (in part), id. ibid. p. 294, pl. 11. fig. 33, &c.
P. Breoni (in part) id. ibid. p. 295, pl. 12. fig. 4, &c.
P. triloba (in part), id. ibid. p. 300, pl. 13. fig. 19, &c.
? *P. avena* (in part), id. ibid. p. 304, pl. 13. fig. 45, &c.
? *P. metensis* (in part), id. ibid. p. 301, pl. 13. fig. 38, &c.
P. lactea, Brady, 1867, Proc. Somersetshire Archæol. Soc. vol. viii. p. 114, pl. 3. fig. 49.
Guttulina, sp., Von Schlicht, 1869, For. Septar. Pietzpuhl. no. 485, pl. 32. figs. 13–16, no. 487, pl. 32. figs. 5–8.

Characters.—Shell elongate, subcylindrical, tapering at both extremities. Chambers few (often only three), oblique, somewhat convex. Septal lines but little depressed. Surface smooth. Length $\frac{1}{30}$ to $\frac{1}{5}$ inch.

Roemer's name appears to be the earliest for the feeble, few-chambered, fusiform members of the genus, forming a long series downwards (if we may be allowed the expression) from *P. lactea (typica)*. The shell originally figured as *Globulina fusiformis* differs from *Polymorphina lactea* only in being slightly narrower and having its base somewhat drawn out to a point; and from this form we are led by imperceptible gradations to specimens with the elongate fusiform contour of *Globulina porrecta*, Reuss, or, it may be, to some of even slenderer proportions.

Roemer's figure, as nearly as can be made out, coincides in general features with *P. liassica*, Strickland (Woodcut *e*), *Globulina minima*, *Guttulina ovalis*, and *G. vitrea*, Bornemann, *Gl. prisca*, Reuss, and *Gl. nuda*, Schwager,—an interesting series, as it comprehends some of the earliest examples of the genus, geologically speaking.



Polymorphina liassica,
Strickland.

In his figures of *Gutt. lanceolata* Prof. Reuss gives a series of forms extending not only from the longer to the shorter extremes above described, but embracing a number of irregular specimens which connect the series with such varieties as *Gl. Leopolitana* and *P. rudis*.

Polymorphina lanceolata and *P. subteres* have tests more compactly built, and tend towards Bornemann's *Gutt. cylindrica* (vide Plate XXXIX. fig. 5, *b*). Two of Dr. Egger's "species," *Globulina angusta* and *Polymorphina praelonga*, seem to be transition-forms between the present group and *P. compressa*: both of them are proportionally very long; but they are rounded at the ends, and otherwise depart somewhat from the characters set down to *P. fusiformis*. Dr. Gümbel's *Guttulina jurassica* is possibly an immature shell: the figure given is small and too indefinite for positive diagnosis; but we should for many reasons be inclined to place it in company with the kindred early forms of Strickland and Schwager, above named. M. Terquem's figures and our references to them must be taken for what they are worth.

Plate XXXIX. fig. 5, *a*, represents the elongate few-chambered form of *P. fusiformis*, copied from Prof. Reuss's figure of *Gl. porrecta*; figs. 5, *b* and *c*, show the more compact and regular variety copied from the best of Dr. Bornemann's many figures of *Guttulina cylindrica*; the woodcut *e* represents the stouter section of the group, and is reproduced from the late Mr. Strickland's drawing of *P. liassica*.

In one of his recent papers, Dr. Reuss has placed *Gutt. cylindrica* as a synonym of *G. rotundata*; and there is much to be said for such an arrangement; but a review of the entire series of figures given by Dr. Bornemann leads to the conviction that they find their closest allies amongst the feebler specimens constituting the present group, and the figures show much the same sort of range of variation in general form as that just alluded to.

Distribution.—The references already made indicate what is known of the geological distribution of *Polymorphina fusiformis*. It is found in the Lower Lias of England, France, and Germany; in the Chalk; in the Hils Clay of Hanover; in the Septaria-clay of Hermsdorf, Offenbach, Pietzpuhl, &c., and in various other Tertiary beds of Germany. It has also been recognized among the Tertiary Foraminifera of New Zealand. It does not appear to exist as a living species; at any rate we find no figures of recent specimens that conform precisely to the characters laid down.

POLYMORPHINA CYLINDROIDES, Roemer. (Plate XXXIX. figs. 6, *a*, *b*, *c*.)

Polymorphina cylindroides, Roemer 1838, Neues Jahrb. für Min., Jahrg. 1838, p. 385, pl. 3. fig. 26;

Philippi, 1844, Beiträge zur Kenntniss d. Tertiärverst. d. nord-west. Deutsch. p. 41.

Proroporus cylindroides, Reuss, 1845, in Geinitz's Grundriss d. Verstein. p. 678, pl. 24. fig. 80.

Polymorphina cylindroides, Karsten, 1849, Verzeichn. d. Rostock. Verst. a. d. Sternberger Gestein, p. 8;

Reuss, 1855, Sitzungsber. k. Akad. Wissensch. vol. xviii. p. 249, pl. 8. fig. 78.

Polymorphina lactea, var. *acuminata*, Williamson, 1858, Rec. For. Gt. Br. p. 71, pl. 6. fig. 148.

P. compressa (in part), Parker & Jones, 1864, Phil. Trans. vol. clv. p. 361, pl. 13. figs. 48 *a*, *b*.

Guttulina, sp., Von Schlicht, 1869, Foram. Septar. Pietzpuhl, no. 471, pl. 31. figs. 5, 6.

Characters.—Shell elongate, fusiform, more or less compressed. Anterior extremity

acuminate, posterior acuminate or slightly rounded. Chambers elongate, arranged in two parallel series. Margins entire, scarcely depressed at the sutures. Aperture large, radiate. Surface smooth. Length $\frac{1}{30}$ to $\frac{1}{15}$ inch.

As we have elsewhere observed, the figures given with Herr Roemer's paper on the North-German Tertiary Sands are often obscure, owing to their small size and poor execution. We have endeavoured (Plate XXXIX. figs. 6, *a*, *b*) to reproduce his drawing of *P. cylindroides* on a larger scale, as it seems to represent a useful subtype and is referred to constantly by German authors. Professor Williamson's *P. lactea*, var. *acuminata* (Plate XXXIX. fig. 6, *c*) manifestly belongs to the same species. Reference to the two figures, placed side by side, will show that in all main features they are identical, the acuminate lower extremity of the latter being the only appreciable difference. Prof. Reuss, in his paper on the Tertiary Foraminifera of Northern and Central Germany, figures the shell with *both* ends somewhat rounded and a nearly circular transverse section, but other authorities agree in the more or less compressed contour indicated in Plate XXXIX. fig. 6, *b*. Dr. Gümbel describes, under the name of *Guttulina strumosa*, a shell somewhat akin to this species from the Streitberger sponge-bed (Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg, p. 227, pl. iv. figs. 13 *a*–14 *b*), but too ill-defined for absolute diagnosis. Its age (Jurassic) would, in the absence of distinctive characters, suggest relationship with the poorly grown Liassic forms, of which *P. fusiformis* is the best example.

Distribution.—Fossil, in the North-German Tertiary sands and Septaria-clay. Recent, in Mr. Barlee's dredgings from Skye and some other more northern localities.

POLYMORPHINA OBLONGA, Williamson. (Plate XXXIX. figs. 7, *a*, *b*.)

Polymorphina lactea, var. *oblonga*, Williamson, 1858, Rec. For. Gr. Br. p. 71, pl. 6. figs. 149, 149 *a* ; Alcock, 1865, Proc. Lit. & Phil. Soc. Manchester, vol. iv. p. 206.

Characters.—Shell oblong, ovate, symmetrical, tapering but little, rounded at both extremities, compressed; consisting of numerous, erect, narrow, oblong segments extending nearly to the upper extremity of the shell, and scarcely overlapping at all laterally, so that the earlier segments are left partly uncovered. Septal plane narrow, oblong, convex. Septal lines scarcely depressed, but distinct. Orifice surrounded by a conspicuous corona of radiating grooves. Surface smooth. Length $\frac{1}{35}$ inch.

The present species must not be confounded with the *Polymorphina oblonga* of D'Orbigny ('Vienna Basin,' pl. xii. figs. 29–31), which is an elongate many-chambered Uvigerine form, closely related to, if not identical with, *P. Soldanii*. Again, the *Polymorphina* (*Globulina*) *oblonga* of Roemer (Neues Jahrbuch, 1838, pl. iii. fig. 34) belongs rather to the well-known *P. communis*. Neither of these varieties has been recognized as a leading form by subsequent rhizopodists; hence there will be no inconvenience in retaining Prof. Williamson's name for the well-marked variety to which it was applied by him.

We have little to add to the description above given, which is quoted, in the main, from Professor Williamson's notes. It represents one of the most symmetrical varieties of the genus; and its long erect chambers, strongly marked terminal orifice, and generally very translucent shell are sufficiently distinctive characters for its recognition.

Distribution.—The geographical range of *P. oblonga* seems to be limited; it is most abundant on the Devonshire and Cornwall coast, and may be found sparingly distributed at intervals all round the British Islands. We are not aware of its occurrence in the seas of warmer latitudes or in a fossil condition.

POLYMORPHINA ANCEPS, Philippi. (Plate XXXIX. figs. 8, *a-c*.)

Polymorphina anceps, Philippi, 1844, Beiträge zur Kenntniss d. Tertiärverstein. d. nordwest. Deutsch. pp. 41, 70, pl. 1. fig. 34.

P. compressa, id. *ibid.* p. 69, pl. 1. fig. 35.

Guttulina dilatata, Reuss, 1849, Denkschr. mathem.-natur. Cl. k. Akad. Wissensch. vol. i. p. 378, pl. 48. fig. 11.

Polymorphina dilatata, Reuss, 1851, Zeitschr. deutsch. geol. Gesell. vol. iii. p. 83, pl. 6. figs. 49, *a, b*.

? *Strophoconus Hemprichii*, Ehrenberg, 1854, Mikrogeologie, pl. 24. fig. 32.

Polymorphina dilatata, Bornemann, 1855, Zeitschr. deutsch. geol. Gesell. vol. vii. p. 347.

P. anceps, Reuss, 1855, Sitzungs. k. Akad. Wissensch. vol. xviii. p. 246, pl. 6. fig. 68, pl. 7. fig. 69; id. 1864, *ibid.* vol. i. p. 38, pl. 4. figs. 2, 3; id. 1866, Denkschr. math.-natur. Cl. Akad. Wiss. vol. xxv. p. 155, pl. 4. figs. 9–11.

P. pernaeformis, Stache, 1865, Novara-Reise, vol. i. 2^{te} Abtheil. Paläont. von Neu-Seeland, p. 256, pl. 24. fig. 2.

? *P. cognata*, id. *ibid.* p. 257, pl. 24. fig. 3.

? *P. contorta*, id. *ibid.* p. 257, pl. 24. fig. 4.

Characters.—Shell oblong, ovate, compressed, symmetrical, broad and rounded at the base, tapering towards the apex; periphery usually sharp-edged, sometimes slightly rounded. Chambers long, oblique, regular, springing from the base of the shell or near it. Septa marked externally by lines, or by slight depressions over the sutures. Surface smooth. Length $\frac{1}{10}$ inch.

The large biconvex or sometimes complanate *Polymorphinae*, with broad, rounded base and oblique or nearly erect segments, constitute an assemblage which arrange themselves conveniently around the *P. anceps* of Philippi. As even the limited number of subdivisions which we have recognized for the purposes of nomenclature have no claim to be regarded in the light of true species, in the older acceptation of the word, the fact that such a series inosculates with kindred groups is of little consequence. It has therefore been thought preferable to retain both *P. anceps* and *P. regularis* as types of subdivisions, although they have recently been stated by Prof. Reuss to represent only extreme examples of the same species.

Polymorphina dilatata, Reuss, represents an outspread variety with inflated chambers, rather than the regular biconvex form; and Ehrenberg's *Strophoconus Hemprichii* shows similar divergence from the type. Dr. Stache's three species (*P. pernaeformis*, *P. cognata*, and *P. contorta*) are intermediates that tend to establish the connexion alluded to between *P. anceps* and *P. regularis*.

Distribution.—This is an essentially Tertiary Foraminifer; and, except Dr. Stache's somewhat doubtful forms, which were derived from the New-Zealand beds, notices of its occurrence are almost entirely confined to the Tertiaries of Germany.

POLYMORPHINA BURDIGALENSIS, D'Orbigny. (Plate XXXIX. figs. 9, *a*, *b*.)

Polymorphina Burdigalensis, D'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 265, no. 2; Modèle no. 29.

Characters.—Shell oblong, unsymmetrical; flattened, or even slightly concave on one side, irregularly convex on the other; anterior extremity acute, posterior rounded. Septal lines slightly excavated. Aperture excentric, situate near the flattened side of the terminal segment. Surface smooth.

The mere name of a species in a synopsis, with reference to a plaster model, is far from being a satisfactory basis on which to lay down its normal peculiarities; yet this is all we have as authority for *Polymorphina Burdigalensis*. D'Orbigny's "Modèle," which we assume to be a fair representation (Ann. N. H. 1865, ser. 3, vol. xvi. p. 181, pl. 2. fig. 48), exhibits a compact shell, somewhat resembling *P. Humboldtii* in its septation, flattened on one side and having rounded edges. The chambers are numerous and obscurely tri-serial in their arrangement, and the septa are marked by lines rather than depressions.

We may just remark that the *Guttulina semiplana* of Reuss (Zeitschr. deutsch. geol. Gesell. vol. iii. p. 82, pl. vi. figs. 48, *a-c*) resembles *P. Burdigalensis* in the contour of its transverse section; but as its general characters are much more those of *P. communis*, we have preferred to associate it with the latter.

Distribution.—The only habitat appended to the species in the 'Tableau Méthodique' is, "Fossil, near Bordeaux," from which we suppose it to be a Middle-Tertiary form.

POLYMORPHINA COMMUNIS, D'Orbigny. (Plate XXXIX. figs. 10, *a*, *b*.)

Polymorphina (Guttulina) communis, D'Orbigny, 1826, Ann. Sc. Nat. vol. vii. p. 226, no. 15, pl. 12. figs. 1-4; Modèle no. 62.

? *Guttulina vitrea*, D'Orbigny, 1836, Foram. Cuba, p. 128, pl. 2. figs. 1-3.

Polymorphina (Guttulina) communis, Roemer, 1838, Neues Jahrb. für Min., Jahrg. 1838, p. 385, pl. 3. fig. 29.

P. (Globulina) oblonga, id. ibid. p. 386, pl. 3. fig. 34.

? *P. glomerata*, Roemer, 1841, Verstein. nordeutsch. Kreid. pt. 2, p. 19, pl. 15. fig. 19.

P. communis, Morris, 1843, Cat. Br. Foss. 1st ed. p. 62.

? *P. glomerata*, Reuss, 1845, Verstein. böhm. Kreid. pt. 1, p. 40, pl. 12. fig. 32; Reuss, 1845, in Geinitz's Grundriss der Verstein. p. 668, pl. 25. fig. 19.

Guttulina communis, Reuss, ibid. p. 669, pl. 24. fig. 82; D'Orbigny, 1846, For. Foss. Vien., p. 224, pl. 13. figs. 6-8.

G. irregularis, D'Orb. ibid. p. 226, pl. 10. figs. 9, 10.

Globulina discreta, Reuss, 1849, Denkschr. mathem.-natur. Cl. k. Akad. Wissensch. vol. i. p. 378, pl. 48. fig. 10.

Guttulina cretacea, Alth, 1849, Haidinger's Abhandl. vol. iii. p. 262, pl. 13. fig. 14; Reuss, 1850, ib. vol. iv. p. 44, pl. 5. fig. 10.

G. semiplana, Reuss, 1851, Zeitschr. deutsch. geol. Gesell. vol. iii. p. 82, pl. 6. fig. 48.

Polymorphina communis, Jones, 1854, in Morris's Cat. Br. Foss. 2nd ed. p. 40.

Sphæroidina Parisiensis, Ehrenberg, 1854, pl. 27. figs. 23, 24.

Guttulina robusta, Reuss, 1855, Sitzungsab. k. Akad. Wissensch. vol. xviii. p. 246, pl. 6. fig. 65.

G. semiplana, Bornemann, 1855, Zeitschr. deutsch. geol. Gesellsch. vol. vii. p. 344.

Polymorphina (Guttulina) communis, Egger, 1857, Neues Jahrb. für Min., Jahrg. 1857, p. 288, pl. 13. figs. 16-18.

Polymorphina (Guttulina) lata, Egger, *ibid.* p. 288, pl. 13. figs. 22–24.

P. communis, Morris & Quekett, 1860, *Cat. Hunt. Mus. Coll. Surg. Eng.* p. 88, a 5.

? *Globulina bulloides*, Reuss, 1861, *Sitzungsab. k. Akad. Wissensch.* vol. xlv. p. 318, pl. 3. fig. 4.

Guttulina communis, Karrer, 1863, *Sitzungsab. k. Akad. Wissensch.* vol. xlvi. (Table).

G. fissurata, Stache, 1865, *Novara-Reise*, vol. i. 2^{te} Abtheil. *Paläont. Neu-Seeland*, p. 263, pl. 24. fig. 10.

G. obliquata, *id. ibid.* p. 264, pl. 24. fig. 11.

Polymorphina problema, var. *deltoidea*, Reuss, 1866, *Denkschr. d. mathem.-natur. Classe d. k. Akad. Wissen.* vol. xxv. p. 154, pl. 4. fig. 8.

P. communis, Brady, 1868, in Crosskey and Robertson, *Trans. Geol. Soc. Glasgow*, vol. iii. p. 118.

P. irregularis, Karrer, 1868, *Sitzungsab. k. Akad. Wissensch.* vol. lviii. p. 172.

Guttulina, sp., Von Schlicht, 1869, *Foram. Septar.* Pietzpuhl, no. 435, pl. 27. figs. 22–25.

Polymorphina, sp., *id. ibid.* no. 493, pl. 32. figs. 17–20.

Characters.—Shell ovate, gibbous, more or less compressed at three sides; anterior extremity acute; posterior obtuse and rounded. Chambers few, oblique, inflated. Sutures depressed. Surface smooth. Aperture circular, coronate. Length $\frac{1}{30}$ to $\frac{1}{15}$ inch.

In the section referring to *Polymorphina lactea* (page 215) the relations of *P. communis* with that species on the one hand and *P. problema* on the other are described; and but little need be added to what is there stated. A glance at the figures of the three forms (Plate XXXIX. figs. 1, 10, & 11) will explain better than words whatever may have been left obscure. Prof. Reuss, in his memoir on the Fossil Fauna of Wieliczka, has placed *P. communis* and *P. Austriaca* in the same group as *P. problema*,—a course to which we only object on the ground of convenience, as may be gathered from our previous remarks.

Some difficulty has been experienced in determining the place of *P. glomerata* of Roemer and Reuss. The figures given by both authors are too small to be of much service; but they appear to represent a short, wide, few-chambered variety, such as would find its nearest allies amongst specimens of *P. communis*; and possibly *Gl. bulloides* may also be included in the group for similar reasons. D'Orbigny's *Gutt. irregularis* is a thinner, outspread form, partaking of the same characters; and Egger's *Gutt. lata* is almost circular in its lateral aspect, notwithstanding a somewhat irregular septation. *Gutt. semiplana* has a plano-convex transverse section, and may be a transition variety between the present species and *P. Burdigalensis*. The remaining references in our list answer to the characters of the subtype as laid down above.

Distribution.—In distribution *P. communis* has much the same range as *P. lactea*. It appears in the Chalk of Northern Germany and Bohemia and in the Lower Tertiaries of Central Europe, in the Miocene of the Vienna Basin and Lower Bavaria, and in the Crag of Suffolk. The New-Zealand Tertiary formations also yield specimens referable to this species. It occurs too in the Glacial (Posttertiary) clays of Scotland and Norway.

Recent specimens are found in sea-sands from the littoral, laminarian, coralline, and coral zones in every latitude.

POLYMORPHINA PROBLEMA, D'Orbigny. (Plate XXXIX. figs. 11. *a*, *b*.)

Polymorphina (Guttulina) problema, d'Orbigny, 1826, *Ann. Sc. Nat.* vol. vii. p. 266, No. 14; *Modèle* no. 61.

- Polymorphina (Guttulina) crassatina*, Von Münster, 1838 (*Fide* Roemer), Neues Jahrb. für Min., Jahrg. 1838, p. 385, pl. 3. fig. 30.
- P. (G.) spicæformis*, Roemer, 1838, *ibid.* p. 386, pl. 3. fig. 31.
- Guttulina problema*, Reuss, 1845. In Geinitz's Grundriss der Verstein. p. 669, pl. 24. fig. 83.
- G. austriaca*, D'Orbigny, 1846, For. Foss. Vien. p. 223, pl. 12. figs. 23-25.
- G. problema*, *id. ibid.* p. 224, pl. 12. figs. 26-28.
- Polymorphina uvula*, Ehrenberg, 1854, Mikrogeologie, pl. 26. fig. 28.
- Strophoconus polymorphus* (in part), *id. ibid.* pl. 27. figs. 23-28.
- S. auricula*, *id. ibid.* pl. 20. § 2. fig. 2.
- S. africanus*, *id. ibid.* pl. 21. fig. 88.
- Polymorphina problema*, Egger, 1857, Neues Jahrb. für Min., Jahrg. 1857, p. 287, pl. 10. figs. 23-25.
- P. uvula*, *id. ibid.* p. 293, pl. 10. figs. 26-29.
- Guttulina rotundata*, Reuss, 1864, Sitzungsab. Akad. Wissensch. vol. 1. p. 469, pl. 3. fig. 4.
- G. problema*, *id. ibid.* p. 470, pl. 5. fig. 4.
- G. pusilla*, Stache, 1865, Novara-Reise, vol. i. 2^{te} Abtheil., Paläont. von Neu-Seeland, p. 265, pl. 24. fig. 12.
- Polymorphina problema*, Parker, Jones, & Brady, 1865, Ann. Nat. Hist. Ser. 3, vol. xvi. p. 187, pl. 2. fig. 50; *id.* 1866, Monogr. Crag Foram. pl. 1. fig. 64; Reuss, 1867, Sitzungsab. Akad. Wissensch. vol. lv. p. 73; Karrer, 1868, Sitzungsab. Akad. Wissensch. vol. lviii. p. 172.

Characters.—Shell oblong, ovate, irregular. Chambers numerous, much inflated, and separated by deep sutures; sometimes arranged triserially, but more frequently crowded together irregularly; orifice round, radiate; surface smooth. Length $\frac{1}{75}$ to $\frac{1}{10}$ inch.

D'Orbigny's Model, represented in fig. 11, *a*, is a convenient subtype embracing a large group of *Polymorphinæ* having in common a somewhat acervuline mode of growth and but little adhesion or overlap amongst the segments. His later figures of the same species are by no means so characteristic, and are scarcely separable from *P. communis*. This circumstance has led Prof. Reuss in a recent memoir to place together *P. problema*, *P. communis*, and *P. Austriaca*—a conclusion in which we should entirely agree were the figures in the "Vienna Basin" monograph our only guide. That the typical *P. lactea* inosculates with *P. communis*, and this again with *P. problema*, does not admit of doubt; but they none the less represent types round which a large number and variety of individuals may be conveniently arranged; and this is all that can be said for any single "species" of the genus. We have therefore preferred to accept the Modèles no. 61 and no. 62 as a basis of subdivision; and our synonymy has been arranged accordingly.

The specimen described by Egger under the name *P. uvula* may be regarded as an irregularly grown example of this species; and Prof. Reuss's *Guttulina rotundata*, figured in his memoir "Zur Fauna des deutschen Oberoligocäns," appears to be more nearly related to *P. problema* than to Bornemann's form.

Guttulina Austriaca is somewhat longer proportionally than the type; and in *Polymorphina oblonga*, D'Orb., and *P. uvæformis*, Reuss, we have varieties apparently intermediate to *P. problema* and *P. Soldanii* (more nearly approaching the latter)—that is to say, somewhat Uvigerine in their general contour.

Distribution.—It is as a Tertiary fossil that *Polymorphina problema* is best known; indeed our notes of its occurrence in a living condition are not sufficient to enable us to

lay down its geographical range. In the earlier Tertiaries of North Germany, in the Miocene of the Vienna Basin, of Lower Bavaria, and of Kostej in the Banat, in the Pliocene clays of Northern Italy, and the Crag formation of the east of England it is constantly found; and the presence of a similar, if not identical, variety in the Tertiaries of New Zealand is recorded by Herr Stache.

POLYMORPHINA COMPRESSA, D'Orbigny. (Plate XL. figs. 12, *a-f*.)

Polymorphina tuberosa, D'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 265; *Polymorphium*, Soldani, Testaceographia, vol. ii. p. 99, pl. 107. fig. *kk*.

Guttulina elliptica, Reuss, 1845, Verst. norddeutsch. Kreid. 2^{te} Abtheil. p. 110, pl. 24. fig. 55; Alth, 1850, Haidinger's Abhand. vol. iii. p. 75, pl. 13. fig. 15.

Polymorphina compressa, D'Orbigny, 1846, For. Foss. Vien. p. 243, pl. 12. figs. 32-34.

P. acuta, D'Orbigny, 1846, For. Foss. Vien. p. 244, pl. 14. figs. 5-7, and pl. 13. figs. 4, 5.

P. ovata, id. *ibid.* p. 233, pl. 13. figs. 1-3.

P. acanthophora, Ehrenberg, 1854, Mikrogeologie, pl. 31. fig. 30.

P. obtusa, id. *ibid.* pl. 31. fig. 31.

? *P. Gizensis*, id. *ibid.* pl. 23. fig. 26.

P. prisca, id. *ibid.* pl. 24. fig. 34.

Grammostomum lingua, id. *ibid.* pl. 27. fig. 15.

G. myoglossum, id. *ibid.* pl. 27. fig. 18.

G. gracile, id. *ibid.* pl. 27. fig. 25.

G. polytrema, id. *ibid.* pl. 28. figs. 15, 16.

G. thebaicum, id. *ibid.* pl. 23. fig. 19, & pl. 31. fig. 25.

? *G. attenuatum*, id. *ibid.* pl. 23. fig. 20.

Strophoconus leptoderma, id. *ibid.* pl. 24. figs. 28, 30.

S. ovum, id. *ibid.* (in part), pl. 22. fig. 81, pl. 24. fig. 29, & pl. 27. fig. 27.

S. spicula, id. *ibid.* (in part), pl. 24. fig. 31, pl. 27. fig. 24.

S. gibbus, id. *ibid.* pl. 20. § ii. fig. 4.

S. teretiusculus, id. *ibid.* pl. 23. fig. 24.

S. efflorescens, id. *ibid.* pl. 26. fig. 24.

Bigenerina apiculata, id. *ibid.* pl. 28. fig. 23.

B. libnotica, id. *ibid.* pl. 25. figs. 25, 26, pl. 26. fig. 25.

Pleurites calciparus, id. *ibid.* pl. 30. fig. 19.

Pl. turgens, id. *ibid.* pl. 31. fig. 37.

Pl. obtusus, id. *ibid.* pl. 32. fig. 24.

Pl. americanus, id. *ibid.* pl. 33. fig. 20.

Polymorphina insignis, Reuss, 1855, Sitzungs. k. Akad. Wissensch. vol. xviii. p. 248, pl. 7. figs. 74, 75.

P. communis, Parker & Jones (in part), 1857, Ann. & Mag. Nat. Hist. 2nd ser. vol. xix. p. 283, pl. 11. fig. 32.

P. incerta, Egger, 1857, Neues Jahrb. für Min., Jahrg. 1857, p. 286, pl. 13. figs. 19-21.

P. media, *ibid.* p. 287, pl. 13. figs. 28, 29.

P. lactea, Williamson (in part), 1858, Rec. For. Gt. Br. p. 70, pl. 6. fig. 145.

? *P. abavia*, Ehrenberg, 1858, Monatsb. d. Akad. Wissensch. June, 1858, p. 337, pl. 1. fig. 4.

? *P. avia*, id. *ibid.* pl. 1. fig. 5.

Globulina discreta, Reuss, 1864, Sitzungs. k. Akad. Wissensch. vol. l. p. 468, pl. 3. fig. 3.

Guttulina robusta, id. *ibid.* p. 470, pl. 3. figs. 5-7.

Polymorphina lactea, var. *compressa*, Parker & Jones, 1862, in Carpenter's Introd., Appendix., p. 311; *ibid.* (in part), 1864, Phil. Trans. vol. clv. p. 361, pl. 13. figs. 47, 49, 57.

- ? *Polymorphina ovula*, Terquem (in part), 1864, 4^me Mém. Foram. Lias, p. 294, pl. 11. figs. 35 &c.
P. angustata, id. ibid. p. 296, pl. 12. figs. 33, 34.
P. sinuata, id. ibid. p. 298, pl. 12. fig. 48.
P. compressa, Brady, 1864, Trans. Linn. Soc. Lond. vol. xxiv. p. 473; Brady, 1865, Nat. Hist. Trans. Northumberland & Durham, vol. i. p. 99.
P. sacculus, Stache, 1865, Novara-Reise, vol. i. 2^{te} Abtheil., Paläont. Neu-Seeland, p. 259, pl. 24. fig. 6.
P. incavata, id. ibid. p. 260, pl. 24. fig. 7.
P. compressa, Jones, Parker, and Brady, 1866, Monog. Crag Foram. pl. 1. figs. 54, 65, 77-80.
P. Zeuchneri, Reuss, 1867, Sitzungs. k. Akad. Wissensch. vol. lv. p. 74, pl. 4. fig. 1.
P. ovata, id. ibid. p. 75.
P. compressa, Brady, 1867, Proc. Somerset. Arch. Soc. vol. viii. p. 114, pl. 3. fig. 50; Sars, 1868, Vidensk.-Selsk. Forhandling for 1868, p. 248; Karrer, 1868, Sitzungs. k. Akad. Wissensch. vol. lviii. p. 174.
P. acuta, Karrer. ibid. p. 174.
P. compressa, Brady, 1868, in Crosskey & Robertson's Memoir, Trans. Geol. Soc. Glasgow; vol. iii. p. 118.
Polymorphina, sp., Von Schlicht, 1869, Foram. Septar. Pietzpuhl, nos. 495 & 496, pl. 32. figs. 29-32 & 35-38.

Characters.—Shell oblong, inequilateral, compressed, more or less fusiform. Chambers numerous, arranged in two unequal series, somewhat inflated. Septal lines depressed. Surface smooth. Aperture variable, usually simple, circular, and coronate, sometimes labyrinthic or porous. Length $\frac{1}{20}$ to $\frac{1}{10}$ inch.

The three figures of the exterior aspect of *Polymorphina compressa* (Plate XL. figs. 12, *a*, *b*, *c*), although they indicate a considerable range of variation, from the wide outspread examples like those found in the Crag to the tapering specimens separated by D'Orbigny under the name *P. acuta*, fall far within what may fairly be regarded as the limits of the present group; for, on the one hand, its modifications may be said to lose themselves amongst the less regular examples of *P. complanata*, whilst, on the other, they are scarcely separable from the feebler forms typified by *P. fusiformis* and *P. cylindroides*.

A somewhat indefinite biserial arrangement, in which the segments appear irregularly opposed to each other rather than in alternation, together with the rounded margins and constricted septa, are characters sufficient for general diagnosis. The difficulty in distinguishing attenuated specimens from those of *P. cylindroides* is confessedly great; but the less compressed contour of the latter, its few chambers, and their erect position will usually serve the purposes of the systematist.

So far as it is in our power to determine, from the information supplied by the respective authors, the representatives of all the reputed species comprised in the foregoing extended synonymy answer to the characters assigned to this subtype. We reserve our judgment in respect to those taken from the works of Prof. Ehrenberg and M. Terquem, for reasons already given.

Distribution.—In *Polymorphina compressa* we have one of the commonest and one of the most widely spread members of the genus. Setting aside the Silurian casts figured by Prof. Ehrenberg as somewhat doubtfully pertaining to this subtypical form, we may regard as the earliest specimens those of the Lower and Middle Lias of the north-east of France and of the Middle and Upper Lias of Somersetshire. It appears

again in the Lower Oolite of Somerset, in the Upper Oxford Clay (Oxford), in the Kimmeridge Clay (Kimmeridge), and in the Cretaceous system of North Germany. Since the Secondary period it has been even more generally distributed, being common in the Septaria-clays and Miocene deposits of Central Europe, and occurring in the Tertiary beds of New Zealand. It is present in the Lower Crag of Suffolk, in the Upper Crag of Norfolk, and in the Postpliocene (Glacial) clays of Norway and the west of Scotland.

In the living state it is cosmopolitan, especially common in the seas of temperate latitudes, but extending even into the Arctic regions. Although affecting shallow water, it is one of the three species of *Polymorphina* dredged by Prof. Sars in 300 fathoms; but this depth must be regarded as an exceptional range.

POLYMORPHINA REGULARIS, von Münster. (Plate XL. figs. 13, *a-c.*)

Polymorphina regularis, von Münster, 1838, *fide* Roemer, Neues Jahrb. für Min., Jahrg. 1838, p. 385, pl. 3. fig. 21; Philippi, 1844, Beiträge zur Kenntniss d. Tertiärverst. nord-west. Deutsch. pp. 41, 70; Karsten, 1849, Verzeichn. d. Rostock. Verst. a. d. Sternberger Gestein, p. 8; Reuss, 1855, Sitzungsber. k. Akad. Wissensch. vol. xviii. p. 247, pl. 7. figs. 70-73; id. *ibid.* vol. 1. p. 38, pl. 3. figs. 11, 12, pl. 4. fig. 1.

P. regularis, var. *Nysti*, Reuss, 1863, Bullet. de l'Acad. roy. de Belgique, vol. xv. p. 162, pl. 3. fig. 42.

P. lingulata, Stache, 1865, Novara-Reise, vol. i. 2^{te} Abtheil., Paläont. von Neu-Seeland, p. 255, pl. 24. fig. 1.

? *P. marsupium*, id. *ibid.* p. 258, pl. 24. fig. 5.

P. dispar, id. *ibid.* p. 261, pl. 24. fig. 8.

P. gigantea, id. *ibid.* p. 262, pl. 24. fig. 9.

Characters.—Shell oblong, irregularly biconvex, broadest in the upper half, tapering towards both base and apex; periphery thin and produced but not carinate. Septal lines marked by slight constriction. Chambers numerous, long, oblique. Surface smooth. Length $\frac{1}{10}$ inch.

Notwithstanding certain differences that at first sight appear formidable, there can be little doubt that *Polymorphina regularis* is very closely allied to *P. anceps*. Prof. Reuss, in his later papers, has placed the two under the same heading, giving *P. anceps* precedence, and describing them as the extreme modifications of the same series. The relationship is not very manifest; but the careful study of such a set of figures as that given by Dr. Stache (*op. cit.* pl. xxiv. figs. 1-5, 8, 9) is sufficient to show that there is no real boundary-line between the two, and, further, that, on the side of *P. regularis*, there are still more aberrant specimens, like *P. marsupium*, Stache, which must be taken into the same group. It is, however, consistent with the plan adopted in the present paper, and it is certainly more convenient, to recognize *both* as subtypes for separate congeries of specimens having average characters very distinct from each other. The same reasons that have led Prof. Reuss to merge these two varieties must, if uniformly pursued, result in the entire disuse of subdivisions in most of the generic or typical groups of Foraminifera. In the case of the genus *Polymorphina* there is, as we have already stated, no single reputed "species" that does not inosculate with one or more other groups of similar zoological value; but whilst this fact must be borne in mind, it does not affect the necessity for recognizing the more important and characteristic modi-

fications as they occur. Many of them may be associated with external conditions, such as climate, depth of water, and the like; and some of the peculiar forms, the result of gradual alteration, afford evidence of a certain value in respect to geological age.

Distribution.—The range of *Polymorphina regularis* is nearly identical with that of *P. anceps*. The Middle and Lower Tertiaries of Germany, and the Crag of Antwerp, are the only localities in which its occurrence is noted.

POLYMORPHINA COMPLANATA, D'Orbigny. (Plate XL. figs. 14, *a*, *b*; Woodcuts *f*–*j*.)

? *Polymorphina lingua*, Roemer, 1838, Neues Jahrb. für Min., Jahrg. 1838, p. 385, pl. 3. fig. 25.

? *P. obscura*, id. ibid. p. 385, pl. 3. fig. 23.

? *P. campanulata*, id. ibid. p. 385, pl. 3. fig. 22.

? *P. teretiuscula*, id. ibid. p. 385, pl. 3. fig. 24.

P. lingua, Philippi, 1844, Beiträge zur Kenntniss d. Tertiärverstein. nord-west. Deutsch. pp. 41, 69; Reuss, 1855, Sitzungsab. k. Akad. Wissensch. vol. xviii. p. 248, pl. 7. fig. 77.

P. complanata, D'Orbigny, 1846, For. Foss. Vien. p. 234, pl. 13. figs. 25–30.

P. Philippii, Reuss, Sitzs. Ak. Wissen. vol. xviii. p. 248, pl. 7. fig. 76.

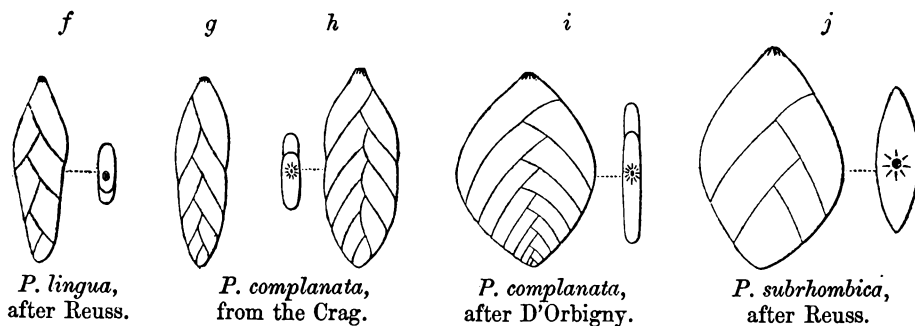
P. subrhombica, Reuss, 1861, ibid. vol. xlv. p. 239, pl. 7. fig. 3.

P. obscura, Reuss, 1864, ibid. vol. l. p. 471, pl. 7. figs. 8–10.

P. complanata, Karrer, 1864, Sitzungsab. k. Akad. Wissensch. vol. l. p. 716 (table); Jones, Parker, and Brady, 1866, Monogr. Crag For. pl. 1. figs. 52, 53, 60.

Characters.—Shell much compressed, elongate or subrhomboidal. Chambers elongate, oblique, arranged in two regularly alternating series. Septal lines but slightly excavated. Surface smooth. Aperture radiate. Length $\frac{1}{50}$ inch or more.

The figures given by M. D'Orbigny in the "Vienna-Basin" monograph, to represent his *Polymorphina complanata*, indicate very wide and thin specimens, with an almost angular or rhomboidal lateral aspect. Such specimens may be regarded as the extreme examples of a considerable series which have as a common character the regular alternating or Textularian arrangement of their chambers. They vary amongst themselves in certain particulars—to a certain extent in the degree of compression of the shell, but far more in its relative length and width. The following outlines are copied from some of the figures included in the list of synonyms.



We see no reason why the *Proroporus Schultzzi* of Prof. Reuss should not be regarded as the extreme form of the series, at the opposite end to the short outspread variety which originally received the name now adopted for the whole. Its shell is thin and flat, and the arrangement of its segments distinctly Textularian; its anomalous length alone dis-

tinguishes it from the commoner modifications. Setting this aside, we have in the *Polymorphina lingua* (Woodcut *f*) and *P. obscura* of Roemer * two of the lanceolate varieties, having a transverse diameter equal to about one-third of the length, and showing the characteristic arrangement of the chambers. Our own specimens from the Crag yield many intermediates, two of which are represented in Woodcuts *g* and *h*, whilst D'Orbigny's figure (*i*) exhibits the extreme form. *P. subrhombica* (*j*) appears to be only a few-chambered and somewhat stouter modification, possessing otherwise the same general features.

Polymorphina complanata is very closely connected with *P. compressa* and *P. regularis*; but the thickened centre and obscure septation of the one, and the unequal and irregular disposition of the segments of the other, and its depressed sutures, will in general prevent their being confused with the more regularly built specimens of the form under consideration.

Distribution.—Well-marked Textularian *Polymorphinæ* seem only to be known as Tertiary fossils. The Miocene beds of the Vienna Basin were the source of D'Orbigny's specimens; and the various Tertiary formations of North and North-western Germany, and the Crag of the east of England, have supplied those of later observers.

POLYMORPHINA ELEGANTISSIMA, Parker and Jones. (Plate XL. figs. 15, *a-c*.)

Polymorphina elegantissima, Parker and Jones, 1864, Phil. Trans. vol. clv. Table x. p. 438.

Characters.—Shell oblong or oval, thin, complanate, composed of a number of long, arcuate, erect chambers, arranged in two unequal series. The final segment of each series large, and embracing those previously formed, the arrangement being reversed on the two sides of the shell. Chambers but slightly convex, occasionally having an ill-defined border or blunt carina. Surface smooth. Length $\frac{1}{10}$ inch.

This beautiful variety received bare mention in the Appendix to the Memoir on North-Atlantic and Arctic Foraminifera above referred to, and is now first described and figured.

It differs from other modifications of the type in the peculiar obliquity of its segments, which are arranged in two alternating series, but in such a way that on each face of the shell one of the series is completely invested by the overlap of its large terminal chamber. The series of segments which is exposed on one face of the shell is covered on the other, and *vice versâ*. Thus from whichever side it is viewed, it presents four or five arcuate or semicircular chambers, with their ends embraced by the outspread terminal segment of the opposite series.

Distribution.—We have specimens of *Polymorphina elegantissima* from shell-sand collected near Melbourne, Australia, and from soundings in Storm Bay, Tasmania, the latter forwarded to us by the late Dr. Greville, of Edinburgh. Though it has not been met with

* Herr Roemer's drawings are, unfortunately, too small and indistinct to be of much service—a circumstance the more to be regretted as they were amongst the earliest illustrations of Tertiary Foraminifera. In many cases the want of definite character in the figures has precluded the adoption of names that might otherwise have taken precedence of those in use. Prof. Reuss, in subsequent papers relating to geological formations of similar age, has reproduced some of the drawings on a larger scale, thereby restoring their value. Our remarks on *P. lingua* and *P. obscura* are founded on the later figures rather than on those of the original plate.

in any other locality, we can scarcely suppose that its distribution is confined to the Australasian seas.

POLYMORPHINA TRIGONULA, Reuss, sp. (Plate XL. figs. 16, *a*, *b*.)

Guttulina trigonula, Reuss, 1845, Verstein. böhm. Kreid. 1^{re} Abtheil. pp. 40, 110, pl. 13. fig. 84.

Characters.—Shell oblong transversely, truncate at the base. Anterior extremity obtuse, pointed. Chambers numerous, turgid. Orifice radiate. Surface smooth. Long diameter (at the base) $\frac{1}{40}$ inch.

Professor Reuss, in his work on the Cretaceous System of Bohemia, describes and figures a curious and somewhat anomalous *Polymorphina* under the name *Guttulina trigonula*. We are unable to associate any specimens, recent or fossil, that have come under our notice with his description of the species, and are therefore content to copy his figure on a somewhat larger scale than the original, and adapt our description to it. It appears to represent a variety allied to *P. communis*, and differing chiefly in its truncate, somewhat three-sided base. Were a good specimen of this latter species cut across in its widest part, we should have a near approach to the characters indicated in the drawing. Another squat variety mentioned in the same work, *P. glomerata*, may possibly pertain to the same subtypical division; but the insufficiency of the figures has left us in so much doubt, that we have preferred to place it provisionally under *P. communis*, p. 224.

Distribution.—The geological stage and locality given by Reuss are the Plänermergel of Lusnitz in Bohemia.

POLYMORPHINA THOUINI, D'Orbigny. (Plate XL. fig. 17.)

Polymorphina Thouini, D'Orbigny, 1826, Ann. Sc. Nat. vol. vii. p. 265, no. 8; Modèle no. 23.

P. asparagus, Ehrenberg, 1854, Mikrogeologie, pl. 27. fig. 14.

P. turio, id. ibid. pl. 28. fig. 27.

Bigenerina Cretæ, id. ibid. pl. 28. fig. 21.

B. acanthopora, id. ibid. pl. 28. fig. 22.

Proroporus Cretæ, id. ibid. pl. 27. fig. 29, and pl. 28. fig. 20.

P. Siculus, id. ibid. pl. 26. fig. 18.

Sagrina longirostris, id. ibid. pl. 32. fig. 23.

Vaginulina obscura, id. ibid. pl. 26. fig. 27.

Polymorphina Thouini, Parker and Jones, 1860, Quart. Journ. Geol. Soc. vol. xvi. p. 302 (Table).

P. pupiformis (in part), Terquem, 1864, 4^{me} Mém. sur les Foram. du Lias, p. 524, pl. 13. figs. 23, 26, 29, &c.

P. Thouini, Parker, Jones, and Brady, 1865, Ann. & Mag. Nat. Hist. 3rd Ser. vol. xvi. p. 22, pl. 2. fig. 49; Jones, Parker, and Brady, 1866, Monogr. Crag Foram. pl. 1. fig. 59.

Guttulina, sp., von Schlicht, 1869, Foram. Septar. Pietzpuhl, p. 467, pl. 25. figs. 14, 15.

Characters.—Shell attenuate, subcylindrical, slightly constricted at the septal lines. Anterior extremity acute; posterior rounded. Chambers elongate, oblique, erect, slightly ventricose. Orifice round, central. Surface smooth. Length $\frac{1}{50}$ to $\frac{1}{12}$ inch.

Of the very long, many-chambered *Polymorphinæ*, perhaps *P. Thouini* is the best-defined variety; yet it does not appear to have been generally adopted. It represents a

longer, more cylindrical subtype than *P. fusiformis*, with a larger number of chambers and less oblique setting on; indeed it resembles more a much outdrawn specimen of *P. problema* than any other variety.

We have given references to a number of Ehrenberg's figures, which may, we think, properly be placed under this species. *Proroporus Cretæ* and *Pr. Siculus* are somewhat shorter than our figure; and *Bigenerina acanthopora* is armed with a terminal mucro; but we cannot regard these as variations of sufficient importance to merit specific separation. Some of M. Terquem's Liassic *Polymorphinæ* seem also to belong to *P. Thowini*. His *P. pupiformis* represents a very mixed set of specimens, mostly ranging between *P. Thowini* and *P. nodosaria*, with some others that we should hesitate to place in the same genus.

Distribution.—Accepting M. Terquem's figures representing Liassic specimens as belonging, in part at least, to this species, it is one of the earliest in its appearance. We have notes of its occurrence in the Eocene beds of the Paris Basin, in various Pliocene clays of North Italy, and in the Crag of our Eastern Counties.

In the living state it is a rare shell. A sample of Levant dredgings, obtained by Capt. Spratt at a depth of 90 fathoms, off Syra, contained a few specimens, the only recent ones on record.

POLYMORPHINA NODOSARIA, Reuss. (Plate XL. figs. 18, *a*, *b*.)

? *Vaginulina paradoxa*, Ehrenberg, 1854, Mikrogeologie, pl. 26. fig. 26.

Polymorphina subnodosa, Reuss, 1860, Sitzungs. Akad. Wissensch. vol. xlii. p. 362, pl. 2. fig. 15.

P. nodosaria, Reuss, 1863, Sitzungs. Akad. Wissensch. vol. xlvi. p. 58, pl. 7. fig. 85.

P. quadrata (in part), Terquem, 1864, 4^me Mém. Foram. Lias, p. 296, pl. 12. figs. 27 &c.

Dimorphina nodosaria, Jones, Parker, and Brady, 1866, Monogr. Crag Foram. pl. 1. figs. 55–58.

Polymorphina nodosaria, Reuss, 1866, Denkschr. mathem.-natur. Cl. k. Akad. Wissensch. vol. xxv. p. 155.

Characters.—Shell elongate, cylindrical, somewhat tapering, irregular, composed of from 4 to 8 chambers. Chambers oblique, inflated, alternating. Sutures constricted. Orifice central, radiate. Surface smooth. Length $\frac{1}{30}$ to $\frac{1}{15}$ inch.

It may be questioned whether the uniserial *Polymorphinæ* typified by *P. nodosaria* belong more properly to the principal division of the group or to the subgenus *Dimorphina*. On the whole, it seems most convenient to confine the term *Dimorphina* to those varieties which begin growth on a biserial or triserial plan, and, after a certain number of segments have been formed, lapse into a single rank. In the present species, the mode of growth is uniserial from the commencement, or very nearly so; and its chief departure from the characters of the simpler type it otherwise resembles is in the alternating obliquity of the septal lines. Thus, while the genus *Nodosaria* has horizontal sutures connecting the chambers, and *Dentalina* has oblique septa, all slanting in one direction, *Polymorphina nodosaria* has oblique septa the direction of which is reversed with each succeeding segment. The general outline of the shell is somewhat irregular, from the different convexity of the segments; but its central axis is straight.

The *Polymorphina subnodosa* of Prof. Reuss does not represent so good a type as that more recently described under the name which we have adopted; and Ehrenberg's figure is unreliable, for reasons already explained.

Dr. Karrer, in his paper on the Miocene Foraminifera of Kosteĵ, figures an anomalous shell as *Cristellaria pleurostomelloides*. There is, doubtless, some good reason for placing it under the genus *Cristellaria*; but, judging from the figures, we should have inclined to regard it as much more closely related to the group under consideration.

Distribution.—Setting aside the references to Ehrenberg and Terquem as unsatisfactory in the highest degree, we have no record of *Polymorphina nodosaria* except as a Tertiary fossil. The Middle Tertiaries of Central Germany, the Crag of Antwerp, and the Crag of the East of England are the only localities for the species, so far as our present knowledge extends.

POLYMORPHINA ROTUNDATA, Bornemann, sp. (Plate XL. figs. 19, *a-e*. Woodcuts *k, l, m*.)

? *Polymorphina Rochefortiana*, D'Orbigny, 1840, Foram. Cuba, p. 131, pl. 2. figs. 9-11.

? *Polymorphina nucleus*, Ehrenberg, 1854, Mikrogeologie, pl. 30. fig. 18.

Guttulina rotundata, Bornemann, 1855, Zeitschr. deutsch. geol. Gesell. vol. vii. p. 346, pl. 18. fig. 3.

G. incurva, id. ibid. p. 345, pl. 17. fig. 6.

G. fracta, id. ibid. p. 344, pl. 17. fig. 4.

G. dimorpha, id. ibid. p. 345, pl. 17. fig. 5.

G. globosa, id. ibid. p. 346, pl. 18. fig. 1.

G. obtusa, id. ibid. p. 346, pl. 18. fig. 2.

P. rotundata, Reuss, 1866, Denkschr. mathem.-naturw. Cl. k. Akad. Wissensch. vol. xxv. p. 153.

P. obtusa, id. ibid. p. 153.

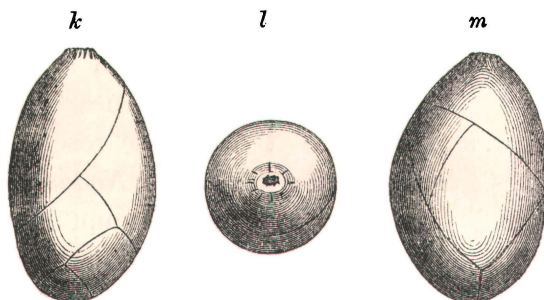
P. tenera, Karrer, 1868, Sitzungsber. Akad. Wissensch. vol. lviii. p. 174, pl. 4. fig. 9.

Rostrolina, sp., Von Schlicht, 1869, Foram. Septar. Pietzpuhl, no. 412, pl. 26. figs. 13-15.

Guttulina, sp., id. ibid. no. 442, pl. 28. figs. 6-25.

Characters.—Shell oblong, ovoid, subcylindrical, gibbous, rounded at the base, more or less produced at the apex. Chambers numerous, broad. Septa marked by lines only, neither constricted nor excavated. Orifice simple, round, oval, or radiate. Surface smooth. Length $\frac{1}{30}$ to $\frac{1}{20}$ inch.

Out of a large number of figures of compact, oval, Guttuline *Polymorphinæ* accompanying Dr. Bornemann's paper on the Microzoa of the Septaria-clay of Hermsdorf, those of *Guttulina rotundata*, from which the subjoined Woodcuts are copied, appear to represent



Guttulina rotundata, after Bornemann.

the best-developed specimens; and as the range of variation in the whole series is not more than is often found within the limits of a single variety, we have placed a number of them together under this head.

Guttulina incurva (Plate XL. figs. 19, *a, b*) has the same general characters, but is somewhat longer in proportion and less symmetrical, one side being straight or even slightly concave, the other convex. In *G. fracta* (Pl. XL. figs. 19, *c, d, e*) this peculiarity is present to an exaggerated extent, whilst in *G. globosa* and *G. obtusa* the whole setting-on of the segments is anomalous and irregular. *Guttulina dimorpha*, but for its obvious connexion with the others of the group, might have been placed amongst the *Dimorphinæ*; but it is probably only a feeble example of *P. rotundata*, with two of its chambers uniserial. Karrer's *Polymorphina tenera* closely resembles the figures of the "incurved" varieties. The curious recent specimen figured in D'Orbigny's "Cuba" monograph, under the name *P. Rochefortiana*, is possibly as nearly related to the present group as any; but no form exactly similar to it has been observed by subsequent writers. Of Herr von Schlicht's *Rostrolinæ* we have already spoken.

Distribution.—We are dependent on the German authors above quoted for our knowledge of the distribution of *Polymorphina rotundata*. It appears to be a predominant form in the Septaria-clays both of Hermsdorf, near Berlin, and Pietzpuhl, near Magdeburg. The locality of Herr Karrer's specimens alluded to is the Miocene clay of Kostež in the Banat.

POLYMORPHINA SOLDANII, D'Orbigny. (Plate XL. fig. 20.)

? *Arethusa corymbosa*, De Montfort, 1808, Conchyl. Systém. vol. i. p. 302, 76° genre.

Polymorphina Soldanii, D'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 265. no. 12; Soldani, 1789, Testaceographia, vol. ii. p. 99, pl. 107. fig. *nn*.

Polymorphina oblonga, D'Orbigny, 1846, For. Foss. Vien. p. 233, pl. 12. figs. 29–31.

P. wæformis, Reuss, 1855, Zeitschr. deutsch. geol. Gesell. vol. vii. p. 289, pl. 11. fig. 5.

Characters.—Shell elongate, subcylindrical. Chambers numerous, convex, arranged in a compact indefinite spire, the visible portions of the external segments somewhat triangular. Orifice circular, or radiate. Surface smooth. Length $\frac{1}{20}$ inch or more.

The drawing in the 'Testaceographia,' to which D'Orbigny gave the name *Polymorphina Soldanii*, seems to represent a tolerably distinct varietal form—a compact, subcylindrical, spirally arranged shell, which might be mistaken for one of the smooth *Uvigerinæ*. De Montfort's figure is so rough and ill-drawn that it is recognized with difficulty as belonging to the same, notwithstanding evidence of its having been copied from Soldani's plate.

Polymorphina oblonga, D'Orbigny, and *P. wæformis*, Reuss, are almost identical in general characters with *P. Soldanii*; but both of them are figured with a central, erect aperture, whilst that of the original drawing is somewhat eccentric and oblique—a difference of slight importance; both have also slightly longer and more fusiform chambers.

Distribution.—The Chalk of Mecklenburg and the Nussdorf beds of the Vienna Basin (Miocene) are the localities given by Reuss and D'Orbigny respectively for the specimens above alluded to. Soldani's figure is from a recent specimen found in the rich shore-sand of the Adriatic, near Rimini.

POLYMORPHINA HUMBOLDTII, Bornemann. (Plate XL. figs. 21, *a*, *b*.)

Polymorphina Humboldtii, Bornemann, 1855, Zeitschr. deutsch. geol. Gesell. vol. vii. p. 347, pl. 18. figs. 7, 8; Reuss, 1866, Denkschr. d. math.-natur. Cl. k. Akad. Wissensch. vol. xxv. p. 155; Gümbel, 1868, Abhandl. d. ii. Cl. k. Akad. Wissensch. vol. x. p. 647.

Characters.—Shell oval or oblong, inequilateral, compressed; one side flat, or sometimes slightly concave, the other surface convex. Anterior extremity acute; posterior rounded. Margins thin, often spreading into an obtuse carina. Chambers long, narrow, oblique, curved, slightly inflated; arranged with some regularity in two unequal series. Orifice pouting, radiate. Surface smooth. Length $\frac{1}{40}$ to $\frac{1}{18}$ inch.

In the absence of specimens from which to form an independent judgment, we are quite ready to accept *Polymorphina Humboldtii*, represented in Dr. Bornemann's figures, as a good subtype. The drawings indicate a compressed, carinate, Textulariform test, bearing near relationship in the arrangement of its chambers to *P. complanata*, but rounder and more elegant in its lines and unequal in its two sides.

Distribution.—*P. Humboldtii* was first described from specimens obtained in the Septaria-clay (Lower Tertiary) of Hermsdorf, near Berlin; and though this formation has been thoroughly examined in many localities widely separated, it has not been noticed at any other portion of it. Dr. Gümbel's note refers to specimens of somewhat earlier age, the Eocene of the Northern Alps.

POLYMORPHINA CONCAVA, Williamson. (Plate XL. figs. 22, *a*, *b*.)

Polymorphina lactea, var. *concaua*, Williamson, 1858, Rec. For. Gt. Br. p. 72, pl. 6. figs. 151, 152.

Characters.—Shell irregular, oval or oblong, concavo-convex; at some period of its growth parasitic. Central portion consisting of a small hyaline shell of the typical form, round which the last segment is extended as a thin, arched, marginal expansion. On the under or concave surface the earlier segments are scarcely visible. Margin very thin, rounded, sinuous. Surface smooth.

Professor Williamson's figures, from which our own are copied, are the only previous record we find of unmistakably parasitic *Polymorphinæ*, and they agree with specimens which have come under our own notice. In the present memoir we describe a second attached variety (see p. 246), in which cervicorn shelly growths serve to root the animal to a foreign body. We propose, notwithstanding certain points of similarity between the two, to limit Prof. Williamson's name to the more regularly formed variety which he describes.

It is not easy to read the physiological significance of the outspread ultimate segment which characterizes *Polymorphina concaua*. It has no visible orifice, and is, in fact, only a wide inequilateral ring round the long periphery of the shell; and in well-preserved specimens the orifice of the penultimate chamber remains large and conspicuous. It may be that the supplementary closed-in segment bears a direct analogy to the closed tubular expansions often observable in *P. Orbignii*.

Distribution.—*P. concaua* is extremely rare, and probably has not been noticed except

on our own coast. Prof. Williamson gives Brixham as the locality whence his specimens were obtained.

POLYMORPHINA RUGOSA, D'Orbigny. (Plate XL. figs. 23, *a-d*.)

? *Polymorphina rugosa*, D'Orbigny, 1840, Foram. Cuba, p. 132, pl. 2. figs. 14, 15.

Globulina rugosa, id. *ibid.* 1846, For. Foss. Vien. p. 229, pl. 13. figs. 23, 24.

P. leprosa, Reuss, 1867, Sitzungsber. Akad. Wissensch. vol. lv. p. 73, pl. 4. fig. 3.

P. foveolata, id. *ibid.* p. 74, pl. 4. fig. 2.

P. leprosa, Karrer, 1868, *ibid.* vol. lviii. p. 173.

P. foveolata, id. *ibid.* p. 173.

Globulina asperula, Gümbel, 1868, Abhandl. d. ii. Cl. k. Akad. Wissensch. vol. x. p. 646, pl. 2. fig. 81, *a, b*.

Characters.—Shell subglobular, oval, or oblong. Chambers few, variously combined. Surface rough, either from minute granular outgrowths, or slight elongate pitted depressions, or both. Length $\frac{1}{5}$ inch.

As has been stated in the Introduction, almost every variety of "surface" within certain limits may be found amongst the *Polymorphinæ*. When fully developed exostoses (like spines, bristles, or tubercles) occur, they are easily understood, and it only remains to the observer to determine the amount of importance to be assigned to them; but when the altered condition of the shell amounts to little more than mere rugosity of the exterior, the questions arising from it are more difficult to answer.

D'Orbigny's *Globulina rugosa* owes its roughness chiefly to minute elongate pitted depressions, whilst his *Polymorphina rugosa* has in addition granular outgrowths of shell-substance. *P. foveolata*, Reuss, appears to resemble the former, and *P. leprosa*, Reuss, follows the latter variety in these particulars. Such modifications of the typically smooth shell commence in *Globulina punctata*, D'Orb., which shows a somewhat irregular surface from abnormally developed foramina. In *P. rugosa* specimens are to be found porous or pitted or granular, sometimes both pitted and granular; and it is scarcely needful to attempt to separate into two or three subspecies so interwoven a series.

The figure given in the "Vienna Basin," copied in Plate XL. fig. 23, *a, b*, is excellently supplemented by those of Prof. Reuss above referred to. D'Orbigny's Cuban specimen (Plate XL. fig. 23, *c, d*) represents an altogether anomalous shell, with an irregular, embracing, terminal chamber, monstrously developed, which almost obscures its Polymorphine characters. He admits that such specimens are very rare; and much importance can hardly be assigned to an exceptional example of this sort.

Distribution.—Fossil in various Tertiary deposits. Recent in littoral sand from Cuba and Martinique.

POLYMORPHINA VARIATA, Jones, Parker, and Brady. (Plate XL. fig. 24.)

Polymorphina variata, Jones, Parker, and Brady, Monogr. Crag Foram., App. I. & II. (foot-notes), pl. 1. figs. 67, 68.

Characters.—Shell oblong, compressed, unsymmetrical, few-chambered. Margin rounded, somewhat constricted over the septal lines. Chambers slightly inflated. Surface uneven, studded with irregular angular depressions imparting a mottled appearance to the whole exterior. Orifice variable, simple or labyrinthic. Length $\frac{1}{2}$ inch.

Some of the fine large *Polymorphinæ* from the Crag show a peculiar form of surface-ornamentation that has not hitherto been described; nor have we observed any thing precisely similar in specimens from other localities. It consists of unequal and irregular depressions of angular shape, sometimes bordered by a slightly raised line. In these specimens the shell-wall is coarse and thick, and the terminal orifice sometimes differs from the normal circular aperture and becomes labyrinthic, or even divided into two or three distinct perforations.

Distribution.—We have only found *P. variata* in Mr. Searles Wood's gatherings from the Crag of Sutton, near Colchester; and even in these it is by no means of common occurrence.

POLYMORPHINA DIGITALIS, D'Orbigny. (Plate XLI. figs. 25, *a*, *b*.)

Polymorphina digitalis, D'Orbigny, 1846, For. Foss. Vien. p. 235, pl. 14. figs. 1–4.

Grammostomum costulatum, Ehrenberg, 1854, Mikrogeologie, pl. 25. fig. 21.

Polymorphina digitalis, Karrer, 1868, Sitzungs. Akad. Wissen. Wien, vol. lviii. p. 174; Bunzel, 1869, Jahrb. k. k. geol. Reichsanstalt, vol. for 1869, p. 203.

Characters.—Shell elongate, subequilateral, compressed, composed of many segments. Chambers oblique, narrow, convex. Aperture oval. Surface rugose, the rugosities distributed in longitudinal lines. Length $\frac{1}{5}$ inch.

The shell figured by M. D'Orbigny, *loc. cit.* is a good representative of a section of the *Polymorphinæ* which, in the arrangement of their chambers, simulate the *Textulariæ*; indeed, in this particular instance, the general resemblance is so strong that the true affinity of the species is only betrayed by the central terminal orifice and its radiate corona. Closely allied in form to the elongate modifications of *P. complanata*, it differs from them in its peculiar surface-ornamentation, consisting of granular lines.

Distribution.—We have never met with specimens corresponding exactly with the figures given by D'Orbigny, and can add nothing in respect to distribution to the localities noted by the observers quoted above, viz. the Nussdorf beds of the Vienna Basin, and a Tertiary deposit at Kostež in the Banat, both of Miocene age.

POLYMORPHINA GRANULOSA, Egger. (Plate XLI. figs. 26, *a*, *b*.)

Polymorphina (Globulina) granulosa, Egger, 1857, Neues Jahrb. für Min., Jahrg. 1857, p. 290, pl. 14. figs. 1, 2.

Characters.—Shell oblong or oval, regular, subcompressed, rounded at the anterior and posterior extremities. Surface marked by closely set, delicate, parallel, longitudinal striæ. Septal lines scarcely perceptible. Length $\frac{1}{3}$ inch.

It would probably be impossible to draw a rigid line between the varieties of *Polymorphina granulosa* and those of some other striate or substriate forms, such as for example *P. myristiformis*, but for the compact ellipsoidal contour of the shell and the granular texture of the striæ; these are distinctive characters, and cannot readily be mistaken in fully grown or average specimens.

Distribution.—Found by Dr. Egger in the Miocene beds of Stansbach, Bavaria.

POLYMORPHINA AUSTRALIS, D'Orbigny, sp. (Plate XLI. figs. 27, *a*, *b*.)

Globulina australis, D'Orbigny, 1839, Voyage dans l'Amér. Mérid. p. 60, pl. 1. figs. 1-4.

Characters.—Shell ovate, inequilateral, somewhat compressed, slightly constricted at the septal lines. Anterior portion acuminate, smooth; posterior rounded, striate longitudinally. Orifice circular, radiate. Length $\frac{1}{75}$ inch.

Judging from D'Orbigny's description and drawings, the minute, feebly developed, partially striate shell to which he has given the name *Polymorphina australis* may without inconsistency be admitted under a distinct name. The surface-ornamentation is similar to that of *P. pulchella* and *P. irregularis*, but is confined to the earlier chambers. In the form and arrangement of the segments it differs considerably from either of the last-named varieties.

Distribution.—We have never met with *P. australis*, and can only note the locality appended to the original description, viz. "littoral sand from the Bay of San Blas, Patagonia."

POLYMORPHINA PULCHELLA, D'Orbigny, sp. (Pl. XLI. figs. 28, *a*, *b*.)

Guttulina pulchella, D'Orbigny, 1840, Foram. Cuba, p. 129, pl. 2. figs. 4-6.

Characters.—Shell elongate, fusiform, somewhat compressed. Anterior end acute; posterior obtuse. Margin even; septal lines slightly excavated. Surface having an ornamentation of numerous, regular, well defined, longitudinal striæ. Chambers few, much elongated, erect, thin, and overlapping. Length $\frac{1}{75}$ inch.

D'Orbigny's figures, from which our own are copied, represent a modification of the Polymorphine type exceedingly interesting in connexion with the morphology of the group. In general form *Polymorphina pulchella* most resembles *P. Thouini*; that is to say, it has long chambers, combined so as to form a narrow, fusiform, subcylindrical test, but possesses a distinctive mark in the parallel longitudinal striæ which cover the shell. Both this species and the next in order, *P. irregularis*, owing to the peculiar setting-on of the chambers have a strong resemblance at first sight to some forms of the genus *Bulimina*.

Distribution.—The specimens described by D'Orbigny were found in shore-sand from the islands of Cuba and Martinique. As we have never met with the species, we can add nothing in respect to its distribution.

POLYMORPHINA IRREGULARIS, D'Orbigny. (Plate XLI. figs. 29 *a*, *b*.)

Polymorphina irregularis, D'Orbigny, 1840, Foram. Cuba, p. 131, pl. 2. figs. 12, 13.

Characters.—Shell oblong, inequilateral, compressed, excavated at the septal lines. Anterior portion subacuminate; posterior obtuse and rounded. Surface traversed longitudinally by well marked parallel furrows. Chambers unequal, irregular, inflated. Aperture round, pouting. Length $\frac{1}{50}$ inch.

The irregular, almost uniserial, setting-on of the chambers, and the sulcate surface of

the whole test, may be regarded as the principal distinctive characters of this pretty West-Indian species.

Such specimens as those figured remind us of the close affinity of the *Polymorphina* to the *Nodosariæ*. A very slight inequality in the development of the chambers of *Nodosaria scalaris*, for instance, might produce a shell undistinguishable from these, especially in the absence of a radiate aperture. Nevertheless they probably find their right place amongst the *Polymorphinæ*, and they sort well with some other anomalous varieties, like *P. australis* and *P. pulchella*.

Distribution.—Our knowledge of the distribution of the variety is confined to the information supplied by M. D'Orbigny, who gives "the shores of Cuba, Jamaica, and Martinique" as the localities whence his specimens were derived,—in each case from littoral sand.

POLYMORPHINA MYRISTIFORMIS, Williamson. (Plate XLI. figs. 30, *a-c*.)

Polymorphina myristiformis, Williamson, 1858, Rec. For. Gt. Br. p. 73, pl. 6. figs. 156, 157; Brady, 1864, Trans. Linn. Soc. vol. xxiv. p. 473; Alcock, 1865, Proc. Lit. & Phil. Soc. Manchester, vol. iv. p. 206.

Characters.—Shell subspherical, consisting of few (two to four) visible segments. Septal lines obscure, scarcely depressed. Surface marked by numerous longitudinal, interrupted, translucent costæ. Orifice surrounded by a corona of raised ridges. Shell finely foraminated. Length $\frac{1}{10}$ inch.

Polymorphina myristiformis is a well-known recent species, being found at all points on our own coast where the water is deep enough. It is very rare in shallow water, but in forty fathoms or upwards becomes comparatively common. It is a pretty, bright little shell, not to be mistaken for any of its natural allies, but liable, at first sight, to be confused with the fine large specimens of *Lagena sulcata* found at similar depths. When the septation is obscured, as it often is by the thickening of the shell, the best diagnosis is afforded by the slightly gibbous and unsymmetrical contour of the test, and the radiate orifice. Our figure (Plate XLI, fig. 30, *a*), copied from Prof. Williamson's, fairly represents the species as usually found. Mr. Robertson, of Glasgow, has forwarded to us specimens, from deep water off Eddystone, in which the costæ are much more strongly developed (figs. 30, *b, c*), but not otherwise differing from the normal form. Although the costæ are usually interrupted, as shown in the figures, examples are occasionally met with in which they are nearly continuous and regular.

Distribution.—*P. myristiformis* has probably a very wide distribution as a recent Foraminifer. It is much more limited in its range as a fossil; our only fossil specimens are from the Barton beds (Lower Tertiary), Isle of Wight.

POLYMORPHINA COSTATA, Egger. (Plate XLI. figs. 31, *a, b*.)

Polymorphina (Globulina) costata, Egger, 1857, Neues Jahrb. für Min., Jahrg. 1857, p. 291, pl. 14. figs. 5, 6.

P. (Globulina) striata, Id. ibid. p. 292, pl. 14. figs. 3, 4.

P. costata, Karrer, 1868, Sitzungs. Akad. Wissen. Wien, vol. lviii. p. 173; Bunzel, 1869, Jahrb. k. k. geol. Reichsanstalt, vol. for 1869, p. 203.

Characters.—Shell ovate, globuline, more or less unsymmetrical. Septa obscure. Surface-ornamentation consisting of parallel longitudinal costæ, often irregular and varying in thickness, but always strong and conspicuous. Orifice circular, coronate, sometimes stellate and jagged. Length $\frac{1}{50}$ to $\frac{1}{30}$ inch.

We have placed under one name the two costate varieties of *Polymorphina* figured by Dr. Egger, as we do not see how any distinction sufficient for separate definition can be drawn between them. We can only speak from analogy based on the information supplied in Dr. Egger's memoir; but, judging from the habit of allied forms, we cannot think that it would be difficult, if a sufficient number of specimens were obtained, to find examples in every degree intermediate to the two which he has figured, in such variable characters as the contour of the shell and the thickness of the ribs.

Distribution.—*Polymorphina costata* is only known as a Miocene fossil. In the memoir referred to, the localities given are Mairhof, Buchleiten, Hausbach, and Habühl, all in Lower Bavaria. Herr Karrer more recently has noted its occurrence in beds of similar age at Kostej, in the Banat (Austria).

POLYMORPHINA REGINA, spec. nov. (Plate XLI. figs. 32, *a, b*.)

Characters.—Shell ovate, irregular, obscurely triserial. Anterior extremity acuminate, posterior obtuse and rounded. Chambers erect, distinct, inflated, separated by deep depressions at the sutures. Orifice circular, pouting. Surface marked by equidistant, longitudinal costæ. Length $\frac{1}{30}$ inch.

There is but little danger of confounding *Polymorphina regina* with any other member of the genus. It may be regarded morphologically as *P. problema* with an ornamentation of longitudinal ribs. It differs from *P. costata* chiefly in general contour, the latter having its smooth-shelled analogue in *P. gibba*, but also to some extent in its more regular and definite external markings.

Distribution.—We have but three or four specimens of this striking and beautiful form. They were picked out of soundings from Storm Bay, Tasmania, forwarded to us by the late Dr. Greville, of Edinburgh.

POLYMORPHINA FRONDIFORMIS, Searles Wood. (Plate XLI. figs. 33, *a-c*.)

Polymorphina frondiformis, Searles Wood, 1843, in Morris's Catalogue of British Fossils, p. 62; Jones, Parker, and Brady, 1866, Monogr. Crag Foram., App. I. & II. (foot-notes), pl. 1. figs. 62, 63, & 69; pl. 4. figs. 11-14.

Characters.—Shell elongate, compressed or complanate, unsymmetrical. Chambers long, fusiform, irregular. Surface depressed over portions of the septal lines; sometimes smooth, but more frequently marked by exogenous shelly growths, either in the form of circular beads or short, interrupted costæ. Length $\frac{1}{20}$ to $\frac{1}{8}$ inch.

Polymorphina frondiformis has perhaps the largest dimensions of any variety of the genus hitherto described. It was discovered by Mr. Searles Wood in the Polyzoan débris of some of the Suffolk Crag-beds; and a detailed account of it, with figures of several

of the more striking specimens will be found in our 'Monograph of the Crag Foraminifera.'

Both the form and arrangement of the chambers are very variable; and from this circumstance it is difficult to assign characters to the species with any amount of precision. The shell is sometimes flat and Textularian; and then the chambers are regular and biserial, as in Plate XLI. fig. 33, *a*. A chance specimen of this sort, without surface-markings, could scarcely be distinguished from *P. complanata*, except on the ground of difference in size. But more frequently the chambers are irregular both in form and combination, and the lines of septation are only marked by slight unequal depressions on the surface of the test. Examples in this condition often resemble *P. compressa*; but the superficial ornament, usually present to a greater or less extent, will generally serve as a means of diagnosis.

Distribution.—Mr. Searles Wood's gatherings from the Crag at Sutton, near Colchester, represent all we know of either the geological or geographical range of the species.

POLYMORPHINA ORNATA, Karrer. (Plate XLI. figs. 34, *a*, *b*.)

Polymorphina ornata, Karrer, 1868, Sitzungsber. k. Akad. Wissensch. vol. lvii. p. 175, pl. 4. fig. 10.

Characters.—Shell oval or subspherical, having about five visible chambers; septal lines slightly depressed. Surface having an ornamentation consisting of slightly raised warts or tubercles in more or less regular lines parallel to the long axis of the shell. Orifice stellate. Length $\frac{1}{34}$ inch.

We adopt this pretty little variety from our friend Herr Karrer's recently published memoir on the "Miocene Foraminifera of Kostež in the Banat." The nature of the ornamentation (elongated clear beads of exogenous shell-substance) is obviously similar to that of some of our specimens of *P. frondiformis*, though more regular in point of arrangement. The shell, too, is much smaller than our Crag form and is Globuline in its general contour. It bears also many points of resemblance to the fine subcostate specimens of *P. myristiformis* obtained by Mr. Robertson on the Devonshire coast, as will be seen by a comparison of the figures. The "beads" in the one case might be regarded as costæ broken up at regular intervals, whilst in the other the interruption is irregular and less frequent.

Distribution.—The author gives no particulars as to its distribution; we infer, however, that it occurs in the Miocene beds of Kostež, in the Banat, Austria.

POLYMORPHINA TUBERCULATA, D'Orbigny, sp. (Plate XLI. fig. 35, *a-d*.)

Globulina tuberculata, D'Orbigny, 1846, For. Foss. Vien. p. 230, pl. 13, figs. 21, 22.

Polymorphina (Globulina) tuberculata, Egger, 1857, Neues Jahrb. für Min., Jahrg. 1857, p. 292, pl. xiv. figs. 7, 8.

Globulina tuberculata, Reuss, 1862, Sitz. Akad. Wiss. Wien, vol. xlvi. p. 79.

Polymorphina tuberculata, Karrer, 1868, *ibid.* vol. lviii, p. 173.

Characters.—Shell ovate or subspherical. Anterior extremity more or less acute, posterior rounded. Surface beset with tubercles of unequal size and irregularly placed. Septation obscure. Aperture radiate. Length $\frac{1}{80}$ to $\frac{1}{30}$ inch.

Notwithstanding the great difference that appears at first sight between Dr. Egger's specimens of *Polymorphina tuberculata* and those originally figured by D'Orbigny under the same name, there need be little difficulty in accepting them as representing the same species. A slight doubt may exist as to whether the former may not be as nearly related to *P. spinosa*; but the two varieties probably inosculate in their extreme specimens, so that this is a circumstance of minor importance. In Pl. XLI. figs. 35, *a-d*, we have copied the drawings of both authors: *a* and *b* are from D'Orbigny; *c* and *d* are after Egger. We have remarked that in some other *Polymorphinæ* the Bavarian specimens are larger and more stoutly grown, as a rule, than those of similar geological age from the Vienna Basin; and in the case of the "ornamented" forms (*e.g.* *P. spinosa*) the former show a stronger development of the distinctive markings. The term "*tuberculata*" would scarcely suggest itself as applicable to the external condition of figs. *c* and *d*, viewed by itself; but if we suppose the exostoses to originate in tubercular shelly growths, increased in size until their margins have become merged into irregular ridges, it no longer conveys an anomaly. Intermediate specimens would probably demonstrate the correctness of this view; but we are altogether dependent on the authors above quoted for our knowledge of the species.

Distribution.—Baden beds, Vienna Basin (D'Orbigny); Mairhof and Hausbach, Ortenburg, Lower Bavaria (Egger), and Kostej in the Banat (Karrer), all these being of Miocene age. Dr. Reuss notes its occurrence in the "Minimus-Thon" (Gault) of North Germany and in the Crag of Antwerp.

POLYMORPHINA SPINOSA, D'Orbigny, sp. (Plate XLII. figs. 36, *a, b*.)

Globulina spinosa, D'Orbigny, 1846, For. Foss. Vien. p. 203, pl. 13. figs. 23, 24.

Polymorphina (Globulina) spinosa, Egger, 1857, Neues Jahrb. für Min., Jahrg. 1857, p. 292, pl. 14. figs. 9, 10.

P. spinosa, Karrer, 1868, Sitz. Akad. Wissensch. vol. lviii. p. 173.

Characters.—Shell oblong, ovate, or subspherical. Anterior extremity acute or rounded; posterior obtuse. Surface studded with more or less closely set, stout, pointed spines. Aperture radiate. Length $\frac{1}{5}$ to $\frac{1}{2}$ inch.

The Bavarian specimens of this species, figured by Dr. Egger, although of nearly the same geological age, are larger than those originally described by D'Orbigny, and have the characteristic superficial spiny processes developed to a much more striking extent. Our figures are copied from Dr. Egger's illustrations of Bavarian Foraminifera.

Polymorphina spinosa may be easily distinguished from allied forms, except in the rare cases in which the spines simulate the shorter outgrowths of *P. tuberculata*.

Distribution.—It is only known as a Miocene fossil—D'Orbigny's locality being the Nussdorf beds of the Vienna Basin; Egger's, Hausbach in Lower Bavaria; and Karrer's, Kostej in the Banat.

POLYMORPHINA HIRSUTA, spec. nov. (Plate XLII. fig. 37.)

Characters.—Shell subspherical, gibbous, oval, or slightly compressed. Septa obscure. Surface beset with short, stout bristles. Length $\frac{1}{4}$ inch.

Amongst the simpler Foraminifera, the tendency to form superficial outgrowths of shell-

substance shows itself under many different phases; and in several genera it is not uncommon to meet with varieties having the test beset with needle-shaped points instead of the stouter exostoses such as the tubercles and spines more frequently seen. Thus there are aculeate varieties of *Lagena*, *Nodosaria*, and *Dentalina*; and even in *Uvigerina* and *Bulimina* a disposition is manifested to assume the prickly condition, though in the latter genera it affects only certain portions of the test. From the close connexion of these types with *Polymorphina*, it is a matter of some surprise that no specimens of the genus (in a normal form) have hitherto been described with this peculiarity of surface, a circumstance probably due in part to the delicacy and perishable nature of the aculei and their liability to be worn down or otherwise obscured.

Herr E. von Schlicht, in his work on the Foraminifera of the Septaria-clay of Pietzpuhl (pl. xxxiv. figs. 1–3), has figured a single specimen of this acerose variety, but it is in the cervicorn or tubulose condition.

Distribution.—The figure last alluded to seems to warrant the assumption that *Polymorphina hirsuta* dates as far back as the early Tertiary period. Our fossil specimens were obtained from the Crag of Sutton, near Colchester; and we have a single recent example, which was found adhering to a clam-shell from the West Indies.

POLYMORPHINA ORBIGNII, Zborzewski, sp. (Plate XLII. figs. 38, *a-o*.)

Polymorpha corcula spinosa, Soldani, 1791, Testaceographia ac Zoophytographia, vol. i. part 2, pls. 109–111.

? *Misilus aquatifer*, de Montfort, 1808, Conchyl. Systématique, vol. i. p. 294, 74^e genre.

Raphinulina Humboldtii, Zborzewski, 1834, Nouv. Mém. Soc. Imp. Nat. Moscou, vol. iii. p. 311, pl. 28.

fig. 1, *a*.

Apiopterina D'Orbigni, id. ibid. p. 311, pl. 28. fig. 2, *b*.

Guttulina damæcornis, Reuss, 1845, Verst. böhm. Kreid. 1^{te} Abtheil. p. 40, pl. 13. fig. 85.

Globulina horrida, Reuss, 1846, ibid. 2^{te} Abtheil. p. 110, pl. 43. fig. 14.

Gl. tubulosa, D'Orbigny, 1846, For. Foss. Vien. p. 228, pl. 13. figs. 15, 16.

Aulostomella pediculus, Alth, 1849, Haidinger's Naturw. Abhandl. vol. iii. p. 264, pl. 13. fig. 17.

A. horrida, id. ibid. p. 264.

Globulina horrida, Reuss, 1850, Haidinger's Naturw. Abhandl. vol. iv. p. 43, pl. iv. fig. 8.

Polymorphina communis (in part), Parker and Jones, 1857, Ann. & Mag. Nat. Hist. 2 ser. vol. xix. p. 283, pl. 11. fig. 34.

P. fistulosa, Williamson, 1858, Rec. For. Gt. Br. p. 72, pl. 6. fig. 150.

? *Globulina tubulifera*, Bornemann, 1860, Zeitschr. deutsch. geol. Gesellsch. vol. xii. p. 16, pl. 6. fig. 10.

Polymorphina lactea, var. *tubulosa*, Parker and Jones, 1860, Q. J. Geol. Soc. vol. xvi. p. 302 (table); Parker and Jones, 1862, in Carpenter's Introd., Appendix, p. 311.

P. tubulosa, Brady, 1864, Trans. Linn. Soc. Lond. vol. xxiv. p. 473; Brady, 1865, Nat. Hist. Trans. Northumberland and Durham, vol. i. p. 99.

P. lactea, var. *tubulosa*, Parker and Jones, 1865, Phil. Trans. Roy. Soc. vol. clv. p. 362, pl. 13. fig. 52, *a-d*; M Sars, 1865, Forekommende fossile Dyreleminger, Quartærperioden, p. 62.

P. tubulosa, Alcock, 1867, Proc. Manchester Phil. Soc. vol. vi. p. 85; M. Sars, 1868, Vidensk.-Selsk. Forhandling for 1868, p. 248; Jones, Parker, and Brady, 1866, Monogr. Crag Forum. pl. 1. figs. 70–76.

Characters.—Shell free or adherent. General form variable; oval, oblong, or com-

pressed. Terminal segments developing numerous irregular expansions and tubular outgrowths.

No variety of *Polymorphina* has been made the subject of so much discussion as that comprising the fistulose modifications of the type; and to none pertains the same amount of zoological interest. As early as 1791 cervicorn specimens had attracted the attention of the Abbé Soldani, and three entire folio plates of the "Testaceographia" are devoted to their elucidation. De Montfort, in 1808, gave what we suppose to be a rough copy of one of Soldani's figures; but if it be so, it must have been drawn in entire ignorance of the characters of the genus to which it belonged, and therefore much importance cannot be attached to either his figure or description. The first figures we find serviceable for purposes of nomenclature are those appended to Zborzewski's "*Observations Microscopiques sur quelques fossiles rares de Podolie et de Volhynie*," drawn from two specimens found in the Tertiary beds of the districts indicated. Although the author has so far misunderstood the nature of their peculiarities as to constitute two new genera for them, there seems no reason why one of his specific names should not take the precedence which, in point of time, is due to it. Of the two we prefer "*D'Orbigni*"*—the other, "*Humboldtii*," having been since used for a distinct variety of *Polymorphina*.

Somewhat later other modifications were discovered by Professor Reuss in the Chalk formation of Bohemia; and M. D'Orbigny followed with specimens from the Miocene of the Vienna Basin, representing the simplest type of the genus (*Polymorphina gibba*), with four or five radiating tubular projections at the anterior extremity of the shell, surrounding or overgrowing the orifice. Shortly afterwards Dr. Alois Alth †, continuing Prof. Reuss's observations on specimens from the same geological habitat, came to the conclusion that the physiological differences indicated by the irregular shelly outgrowths were of generic importance; and he accordingly separated the tubulose forms from the rest of the *Polymorphinæ*, under the new generic term *Aulostomella*. No subsequent writer has participated in this view; and more recent investigation has shown clearly that the wild-growing forms possess no character sufficiently uniform or constant to render even specific definition desirable, except on the plea of convenience.

It is quite open to question whether, after all, the association of examples, having as their only common character the production of a terminal chamber of a certain sort, is the best method of recognizing a physiological peculiarity. Every separate variety of the genus has, or may have, its "fistulose" condition, and Continental Rhizopodists have been satisfied to give a new name to each of these as it was discovered,—a system open to great objection. One alternative is to place them together under a single head; another, to distribute them as subvarieties under the names of the symmetrical types in which they have their origin ‡. The former of these two courses has certain advantages for

* "*Orbignii*" is manifestly more correct, and we have taken this amount of liberty with the original spelling in adopting the specific term; we do not say "*Von Humboldtii*."

† Haidinger's Naturw. Abhandl. vol. iii. p. 263.

‡ Prof. Reuss appears recently to have adopted the latter of these alternatives. In his "*Wieliczka*" memoir, p. 72, he places *Globulina tubulosa*, D'Orb., under *Polymorphina gibba*, with the note "*Monströse Aulostomellenform*," a diagnosis which agrees with the table at page 246.

purposes of description; and, in conformity with the views already expressed as to the scope and limitation of subdivision in a group constituted like the genus *Polymorphina*, there need be no hesitation in its adoption. It is also more in conformity with our treatment of the varieties in which surface-ornamentation is accepted as a ground for binomial distinction.

A few examples from the list of synonyms will show the relationship between the simple and their corresponding fistulose forms. Thus, the typical

<i>Polymorphina lactea</i>	becomes in its cervicorn condition	<i>P. horrida</i> , Reuss, sp.
<i>P. gibba</i>	„ „ „	<i>P. tubulosa</i> , D'Orb., sp.
<i>P. trigonula</i>	„ „ „	<i>P. damæcornis</i> , Reuss, sp.
<i>P. compressa</i>	„ „ „	<i>P. fistulosa</i> , Williamson.
<i>P. regina</i>	„ „ „	like the Crag variety figured Pl. XLII. fig. 38, <i>m</i> .
<i>P. fusiformis</i>	„ „ „	the long tubulose variety found in the Chalk.
<i>P. hirsuta</i>	„ „ „	the prickly fistulose form fi- gured by Herr von Schlicht, <i>op. cit.</i> , pl. xxiv. figs. 1-3.

and so forth. Reference to the plates will confirm and extend this analogy.

The lobed and tubular extensions of the shell, which constitute the common character of the series, are never alike in two specimens, but vary in extent and shape, from minute excrescences resembling papillæ on the terminal chamber, to irregular expansions completely investing the test. The condition most commonly found in free-growing recent specimens is that of tubular passages commencing at the orifice and running in the direction of the base of the shell. These passages are at intervals prolonged outwards, and form smaller tubes, which again branch and constitute what have been described as "stag's-horn processes" or "cauliflower excrescences." The ends of the smaller tubuli are usually found open; and it is likely that they take the place, in part at least, of the normal terminal orifice, which is often overgrown to such an extent as to preclude the passage of pseudopodia. We can scarcely coincide with Dr. Carpenter's view, that "such wild-growing specimens are probably always parasitic." In our experience, adherent examples are very rare; almost the only instances we recollect are those represented in the two figures, Pl. XLII. figs. 38 *i, j*, one recent, the other from the Crag. On the other hand, the most abundant gathering of fistulose specimens we have met with was from sand recently dredged in Berwick Bay, from which hundreds of examples might have been selected, not one of which bore any trace of attachment to a foreign body; indeed the soft, granular nature of the material in which they lived, would of itself indicate no ground for this supposition. Again, those found in the Chalk appear to have been quite independent in their manner of growth. At the same time the specimens cited are sufficient evidence that the animal has the power, under favourable circumstances, of fixing or rooting itself by the tubular prolongations of the shell-wall.

The ends of the tubuli are by no means invariably open, but are often found sealed in

by the continuation of the shelly investment; and the question has been raised, whether this may not be their normal condition. Further observations on living specimens are much needed; without them it can scarcely be admitted that the open ends are due to the breakage or erosion of the calcareous investment. It is not uncommon to meet with *Polymorphinæ* having irregular perforations of considerable size in the shell-wall. The same peculiarity may be and is observed from time to time in other genera; but in none does it exist to the same extent as a habit of growth, and in the particular varieties at present under notice it is a distinguishing feature. Soldani, as early as 1791, makes those frequent, large, irregular or rounded orifices very prominent in some of his figures, and appears to have suspected that they were indications of importance; and they have not been passed over by subsequent writers. Dr. Alcock, however, in some interesting observations on *Polymorphina tubulosa**, draws from them an ingenious argument in favour of the view that Foraminifera have the power of absorbing and re-precipitating portions of the carbonate of lime of which the shell-wall is formed, and supports the theory by collateral evidence. Thus, in specimens having the supplementary fistulose chamber, we find that the primary shell has the thickened homogeneous wall usual amongst fully grown Foraminifera of the same class, whilst the wild-growing portion of the test is of much more delicate texture. Individuals in which the irregular growths have been broken away (Pl. XLII. figs. 38, *g*, *k*, *l*) commonly exhibit a number of the perforations alluded to, in the region of the primary shell which formed the floor of the fistulose chamber. It might be supposed that the irregular segment was the result of the covering in of a lobe of sarcodæ issuing from those large perforations—in other words, that the perforations were the cause rather than the effect of the aberrant chamber; but this supposition is inconsistent with the well-observed fact, that the shell-wall is uniformly diminished in thickness over those portions which are so covered in. In old and worn specimens in which the fistulose chamber, from the tenuity of its wall, has been quite lost, its exact extent may commonly be traced by observing the outline of the area on the primary shell so thinned away. It would scarcely be necessary to insist on this, were it not that the Protozoa are seldom accredited with the power of performing any but the most simple vital processes. In some of the Mollusca the habit of thinning the interior portions of the calcareous spire as its growth advances is well ascertained; and a section of one of these shells presents some curious resemblances to our drawing, Pl. XL. fig. 12, *e*, taken from an accidentally broken specimen of a common thick-walled variety. It has been noticed, also, that, not unfrequently, the stolon-passages between the older chambers of large individuals are very free and patulous, whilst the terminal orifice of the last segment consists only of constricted radiate slits. It is fair to assume that this difference is due to resorption of calcareous material.

The shelly investment of the cervicorn chamber differs much in appearance and texture

* Proc. Lit. and Phil. Soc. Manchester, vol. vi. p. 85. See also note on *Polymorphina lactea* in a memoir by W. K. Parker and T. R. Jones, on "Some Foraminifera from the North Atlantic and Arctic Oceans," Phil. Trans. vol. clv. p. 361, in which the opening of foraminal communication by absorption had previously been suggested as a possible explanation of the rows of orifices sometimes met with on the side of the antepenultimate, and even of the earlier chambers in these free-growing varieties.

from that of the earlier and regular segments. The latter are usually smooth, solid, and almost structureless; the former are delicately thin, and beset with minute, pointed rugosities, which have a glassy, subcrystalline appearance under a high magnifying-power. The difference is probably due to increased or diminished rapidity of deposition under the altered relations of the terminal sarcode lobe.

The nature of the irregular chambers is best explained by its analogy to conditions occasionally presented by other types. In luxuriant specimens of many genera, *Textularia* for instance, it is not uncommon to find a chamber abnormally large and unsegmented completing the shell—that is to say, sarcode enough for two or three segments of the normal size closed in, in bulk as it were, without subdivision. This is no evidence of enfeebled vital power as has been suggested*, probably the contrary; for in the localities where the tubulose varieties most abound, the *Polymorphinæ*, in common with other Foraminifera, are remarkable for their fine proportions and apparently vigorous growth.

Distribution.—*Polymorphina Orbignii* is widely distributed both geologically and geographically. In one or other of its various modifications it has been noticed in the Chalk of Bohemia and the South of England, and the Chalk-marl of Kent and Central Europe, in the Tertiaries of the South-west of Russia, the Septaria-clays of Northern and Central Germany, the Miocene deposits of the Vienna Basin, the Pliocene clays of North Italy, and the Crag of our Eastern Counties. In the living state it is found wherever other members of the genus are abundant. We have record of its occurrence in the English Channel (55–60 fathoms), in the Mediterranean, on the shores of Norway, in the Arctic Sea, and at almost every part of our own coast. It is one of the three *Polymorphinæ* which were obtained by Dr. Sars from a depth of 300 fathoms in the North Atlantic.

Subgenus DIMORPHINA, D'Orbigny.

Orthoceratium (in part), Soldani, 1780.

Dimorphina, D'Orbigny, 1826; Sander-Rang, 1829; Menke, 1830; Reuss, 1845; Parker, Jones, and Brady, 1865; Schwager, 1866; Karrer, 1868; Von Schlicht, 1869.

General Characters.—Shell free, inequilateral; commencing growth in alternating (obscurely triserial) segments, as in the typical *Polymorphinæ*, but becoming uniserial after a certain number of chambers are formed. Orifice, at the summit of the terminal chamber.

In the subgenus *Dimorphina* have been included those few members of the group which commence growth regularly on the Polymorphine plan, but subsequently take on a Nodosarian arrangement of the chambers. As previously set forth, their separation cannot be regarded as absolute or very well-defined, but still sufficiently so to serve a practically useful purpose. We have, however, retained in the typical division of the group those specimens (like *Polymorphina nodosaria*, Reuss) whose chambers are oblique and alternating, and whose uniserial condition depends on an attenuated habit of growth, diminishing or entirely precluding the usual overlap of the segments. These we regard

* Dr. Alcock, *op. cit.*

as extreme examples of the normal arrangement, inasmuch as they do not exhibit any real difference of plan between the earlier- and later-formed portions of the shell.

The phenomenon of change in the typical plan of growth is by no means uncommon amongst the Foraminifera. A triserial genus may have biserial varieties; for instance, *Bulimina*, which in all its more perfect forms has three or more segments to each turn of its spire, presents in the feebler varieties which constitute the subgenus *Bolivina*, an alternation of but two sets of chambers, and in this condition is scarcely distinguishable from *Textularia*; whilst *Textularia* itself, though typically biserial, has a uniserial group (*Bigenerina*) precisely analogous to the Polymorphine subgenus *Dimorphina*. The closely allied genus *Uvigerina* has also a uniserial section, described by D'Orbigny under the generic name *Sagrina*; and it would be very difficult to assign any characters that would serve in every case to distinguish it from *Dimorphina*. The Uvigerine parentage generally, however, betrays itself either in a long phial-shaped neck or by an ornamentation of raised lines and minute spines at some portion of the surface of the test.

Distribution.—It is to its morphological peculiarities, and to the assistance they yield in elucidating the relationship of several parallel genera, that *Dimorphina* owes its interest and importance; for in point of distribution the subgenus yields little ground for comment. It is very rare both in a recent and fossil state, too rare to be of service in the estimation of any external physical conditions. Its occurrence seems to be limited to a few particular deposits of the Tertiary epoch and to occasional living specimens from the seas of warm latitudes.

DIMORPHINA TUBEROSA, D'Orbigny*. (Plate XLII. figs. 39, *a*, *b*.)

Orthoceratium tuberosum, Soldani, 1780, Testac. ac Zooph. vol. ii. p. 99, pl. 106. fig. *gg*.

Dimorphina tuberosa, D'Orbigny, 1826, Ann. Sci. Nat. vol. vii. p. 264, No. 1; "Modèle," No. 60.

D. nodosaria, D'Orbigny, 1846, For. Fos. Vien. p. 221, pl. 12. figs. 21, 22.

D. tuberosa, Parker, Jones, & Brady, 1865, Ann. & Mag. Nat. Hist. 3 ser. vol. xvi. p. 14, pl. 2. fig. 53.

D. nodosaria (in part), Iid. 1866, Monogr. Crag Foram., App. I. & II. pl. 1. fig. 61; Karrer, 1868, Sitzungs. k. Akad. Wissenschaft, vol. lviii. p. 177.

Characters.—Shell elongate, subcylindrical, straight, or nearly so. Anterior portion acuminate; posterior obtuse, and rounded. Early (alternating) chambers varying greatly in their proportion to the whole shell. Later (uniserial) chambers two to six in number, more or less inflated. Surface smooth. Length $\frac{1}{50}$ to $\frac{1}{25}$ inch.

The differences indicated by M. D'Orbigny between *Dimorphina tuberosa* and *D. nodosaria* are such as will scarcely bear examination; and we are compelled to regard them as the same variety, reserving the latter trivial name for a distinct form, belonging to the *Polymorphinæ* proper, described by Professor Reuss. M. D'Orbigny's figures of the

* It is the custom to ignore the names given by pre-Linnæan observers, and those who wrote before the Linnæan method of nomenclature was generally adopted, in quoting the authority for specific or generic terms; else to Soldani, rather than D'Orbigny, should the present species be attributed; the latter only adopted the designation previously given by the indefatigable Tuscan naturalist.

two forms he separates specifically, correspond very nearly; but *D. tuberosa* is said to be recent, and to have its alternating segments more largely developed than *D. nodosaria*, which he regarded as essentially a fossil species. The relative development of the two portions of the shell, in point of fact, varies with each individual specimen; and the mere question of time, we repeat, cannot rightly be admitted as an element affecting zoological characters.

Distribution.—*Dimorphina tuberosa* is rare. It occurs as a fossil in the Tertiary deposits of Italy and Spain, of the Vienna Basin, and the East of England. Mediterranean soundings from depths not exceeding one hundred fathoms occasionally bring to light living specimens.

DIMORPHINA OBLIQUA, D'Orbigny. (Plate XLII. figs. 40, a-c.)

Dimorphina obliqua, D'Orbigny, 1846, For. Foss. Vien. p. 220, pl. 12. figs. 18-20.

Characters.—Shell elongate, arcuate. Anterior and posterior extremities acuminate. Chambers oblique, convex. Aperture excentric. Surface smooth. Length $\frac{1}{2}\frac{1}{5}$ inch.

The uniserial chambers of *D. obliqua*, as described by D'Orbigny, are in a curved line, and oblique in their setting-on, simulating the characters of *Dentalina* rather than those of the straight *Nodosarinæ*. The primary alternating segments are few, small, and inconspicuous. We have never met with specimens having precisely the aspect shown in the "Vienna" plates, the nearest approach being the elongate *Polymorphinæ* with two, or sometimes even three, oblique chambers, succeeding each other in one line, occasionally to be met with in shallow-water dredgings; and in these examples the uniserial segments are not developed with the regularity which marks M. D'Orbigny's figures. Judging from analogy, the existence of such a form might be anticipated; and if the biserial (or spiral) chambers are habitually as small and inconspicuous as they are represented in the drawing, it is not surprising that they have been overlooked by other observers. It is more than possible that two specimens figured by M. Terquem as *Bigenerina dentaliniformis* (Sixième Mémoire sur les Foraminifères du Lias, pl. 22. figs. 29, 30) are *Dimorphinæ*; and if so, they differ from *D. obliqua* chiefly in their extreme length and tenuity; but the drawing is too obscure to permit exact diagnosis.

Our figures are copied from the original ones (For. Foss. Vien. pl. xii.), and somewhat enlarged for the sake of greater distinctness.

Distribution.—The sole habitat given by D'Orbigny is "Baden (near Vienna), not common," his specimens being, of course, Miocene fossils.

DIMORPHINA COMPACTA, spec. nov. (Plate XLII. fig. 41.)

Dimorphina tuberosa (in part), Jones, Parker, & Brady, 1866, Monogr. Crag Foram., App. I. & II. pl. 1. fig. 66.

Characters.—Shell elongate, subcylindrical, arcuate, compactly built; anterior extremity obtuse or truncate; posterior rounded. Margin even; septa marked only by faint lines. Later segments set on obliquely. Length $\frac{1}{10}$ inch.

This variety furnishes another instance of the close parallelism that exists between the

allied genera *Polymorphina* and *Nodosarina*. As amongst the *Nodosarinae* (whether curved or straight) varieties are found having the chambers so combined that no constriction marks the course of the septal lines, so in *Dimorphina compacta* we have an even margin and obscure septation arising from the same habit of growth. The peculiarity of contour depending upon the relation of the chambers has been deemed sufficient for "specific" definition in the case of such modifications of *Nodosaria*, *Dentalina*, and *Vaginulina*; and it is only consistent to distinguish similar *Dimorphinae* by a trivial name. For this reason, although the present variety was associated with some of its congeners in our partially finished "Monograph of the Foraminifera of the Crag," under the general term *Dimorphina tuberosa*, we have since regarded it as meeting better the exigencies of a scheme of subdivision to distinguish it from the more common form having ventricose chambers.

Distribution.—*Dimorphina compacta* is of rare occurrence. We know it only as a Tertiary fossil, from specimens obtained by Mr. Searles Wood in the rich Crag deposit at Sutton, which has furnished so many rarities.

DESCRIPTION OF THE PLATES.

General Note.—The great difference in the size of the various species has rendered it impracticable to make the drawings on a uniform scale. The idea of relative size is conveyed by the small vertical line placed near each figure, which represents *five times* the length of the longer diameter of the shell. The actual measurement of average specimens is given with the descriptions of species.

The *numbers*, 1 to 41, represent "species;" the *small letters* refer to different aspects of the same shell, or different specimens of the same "species."

PLATE XXXIX.

Fig. 1. *Polymorphina lactea*, Walker and Jacob, sp.: *a*, copy of Walker and Jacob's original figure slightly enlarged; *b*, typical form, after Williamson; *c*, monstrous double specimen.

[For sketches of the compressed variety, *P. lactea*, var. *amygdaloides*, Reuss, see Woodcuts *a* to *d*, p. 215.]

Fig. 2. *P. gibba*, D'Orbigny: *a* and *b*, typical form; *c* and *d*, compressed variety, *P. gibba*, var. *æqualis*, D'Orbigny.

Fig. 3. *P. gutta*, D'Orbigny. Copied from D'Orbigny's figures.

Fig. 4. *P. acuminata*, D'Orbigny. Copied from D'Orbigny's figure of a Chalk specimen.

Fig. 5. *P. fusiformis*, Roemer: *a*, after Reuss ("*Globulina porrecta*"); *b* and *c*, after Bornemann ("*Guttulina cylindrica*").

[A figure of the stouter fusiform variety ("*Polymorphina liassica*," Strickland) is given at p. 220, Woodcut *e*.]

- Fig. 6. *P. cylindroides*, Roemer: *a* and *b*, copied from Roemer's figures (Tertiary); *c*, after Williamson ("*P. lactea*, var. *acuminata*") recent.
- Fig. 7. *P. oblonga*, Williamson. From Williamson's figures of a recent specimen.
- Fig. 8. *P. anceps*, Philippi: *a* and *b*, exterior aspects of the shell; *c*, diagram showing septation. All after Reuss.
- Fig. 9. *P. Burdigalensis*, D'Orbigny: drawn from D'Orbigny's "Modèle no. 29."
- Fig. 10. *P. communis*, D'Orbigny. Copied from the original figures in the "Tableau Méthodique."
- Fig. 11. *P. problema*, D'Orbigny: *a*, drawn from D'Orbigny's "Modèle no. 61;" *b*, specimen from the Crag.

PLATE XL.

- Fig. 12. *Polymorphina compressa*, D'Orbigny: *a*, recent specimen, after Williamson ("*P. lactea*"); *b*, specimen from the Crag; *c* and *d*, Miocene specimens, after D'Orbigny; *e*, broken example from the Crag, showing the mode of septation and anomalous labyrinthic aperture; *f*, portion of thickened shell-wall, in which the pores have become lengthened into tubes; *g*, porous aperture of a specimen from the Crag.
- Fig. 13. *P. regularis*, Von Münster. Copied from Prof. Reuss's figures.
- Fig. 14. *P. complanata*, D'Orbigny. Copied from D'Orbigny's figures (Vienna Basin).
[Figures of a range of varietal forms are given at p. 230, Woodcuts *f* to *j*.]
- Fig. 15. *P. elegantissima*, Parker and Jones. Recent specimens: *a*, from Melbourne, Australia; *b* and *c* from Storm Bay, Tasmania.
- Fig. 16. *P. trigonula*, Reuss, sp.: enlarged from Prof. Reuss's figures.
- Fig. 17. *P. Thouini*, D'Orbigny: drawn from D'Orbigny's "Modèle no. 23."
- Fig. 18. *P. nodosaria*, Reuss: after Reuss.
- Fig. 19. *P. rotundata*, Bornemann, sp. (the typical form is shown at p. 234, Woodcuts *k*, *l*, *m*): *a* and *b*, variety figured by Bornemann as "*Guttulina incurva*;" *c*, *d*, and *e*, variety figured by Bornemann as "*Guttulina fracta*."
- Fig. 20. *P. Soldanii*, D'Orbigny. Copied from Soldani.
- Fig. 21. *P. Humboldtii*, Bornemann. After Bornemann.
- Fig. 22. *P. concava*, Williamson. After Williamson.
- Fig. 23. *P. rugosa*, D'Orbigny: *a* and *b*, "*Globulina rugosa*," D'Orbigny (Miocene); *c* and *d*, "*Polymorphina rugosa*," D'Orbigny (recent, Cuba).
- Fig. 24. *P. variata*, Jones, Parker, and Brady. Drawn from a Crag specimen.

PLATE XLI.

- Fig. 25. *Polymorphina digitalis*, D'Orbigny. After D'Orbigny (Miocene).
- Fig. 26. *P. granulosa*, Egger. After Egger (Miocene).
- Fig. 27. *P. australis*, D'Orbigny. After D'Orbigny (recent, Patagonia).
- Fig. 28. *P. pulchella*, D'Orbigny. After D'Orbigny (recent, Cuba).
- Fig. 29. *P. irregularis*, D'Orbigny. After D'Orbigny (recent, West Indies).
- Fig. 30. *P. myristiformis*, Williamson: *a*, specimen with delicate markings, after Williamson (recent); *b* and *c*, specimens from Eddystone, with stronger interrupted costæ.
- Fig. 31. *P. costata*, Egger. After Egger (Miocene).
- Fig. 32. *P. regina*, n. s. Recent specimen from Storm Bay, Tasmania.
- Fig. 33. *P. frondiformis*, Searles Wood. From Crag specimens.

Fig. 34. *P. ornata*, Karrer. From Karrer's drawings (Miocene).

Fig. 35. *P. tuberculata*, D'Orbigny, sp.: *a* and *b*, after D'Orbigny (Miocene); *c* and *d*, after Egger (Miocene).

PLATE XLII.

Fig. 36. *Polymorphina spinosa*, D'Orbigny. After D'Orbigny (Miocene).

Fig. 37. *P. hirsuta*, n. s. Drawn from a Crag specimen.

Fig. 38. *P. Orbignii*, Zborzewski: *a* represents "*Globulina horrida*," Reuss (Cretaceous); *b* represents "*G. tubulosa*," D'Orbigny (Miocene); *c*, Crag specimen; *d* represents "*Polymorphina fistulosa*," Williamson (recent); *e*, recent compressed form; *f* and *g*, Crag specimens; *h* represents "*Guttulina damæcornis*," Reuss (Cretaceous), enlarged from Prof. Reuss's figure; *i* represents the parasitic variety adherent to a broken mollusk-shell, recent, from the English Channel (there is a little adherent specimen of *Polytrema* (P) on the same shell); *j*, parasitic specimen from the Crag; *k* and *l* represent a portion of the shell-wall uncovered by the breaking off of the cervicorn growths, showing large perforations; *m* represents a striato-fistulose specimen from the Crag.

DIMORPHINA.

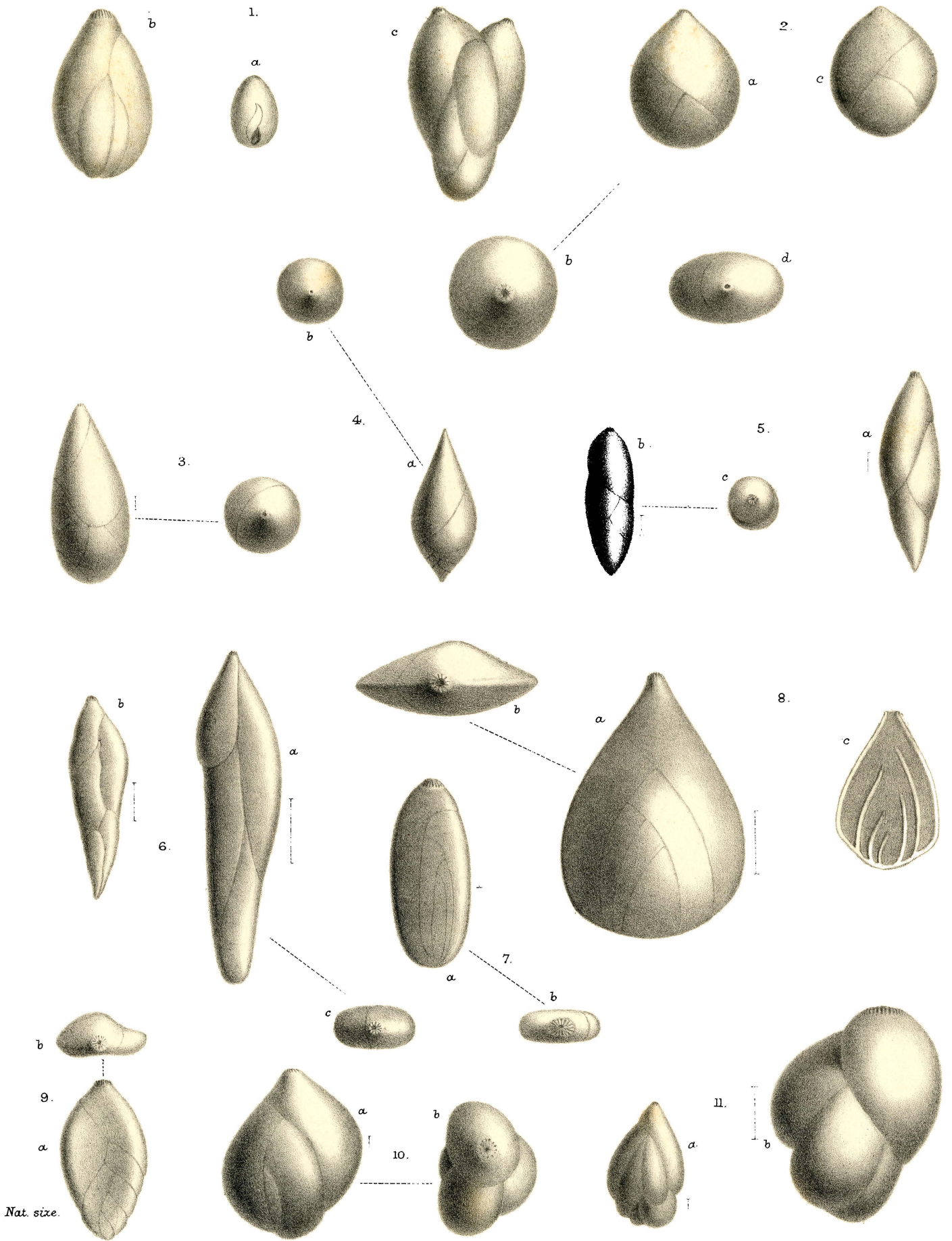
Fig. 39. *Dimorphina tuberosa*, D'Orbigny: *a*, from D'Orbigny's "Modèle no. 60;" *b*, a less regular specimen, from the Crag.

Fig. 40. *D. obliqua*, D'Orbigny. After D'Orbigny (Miocene specimen).

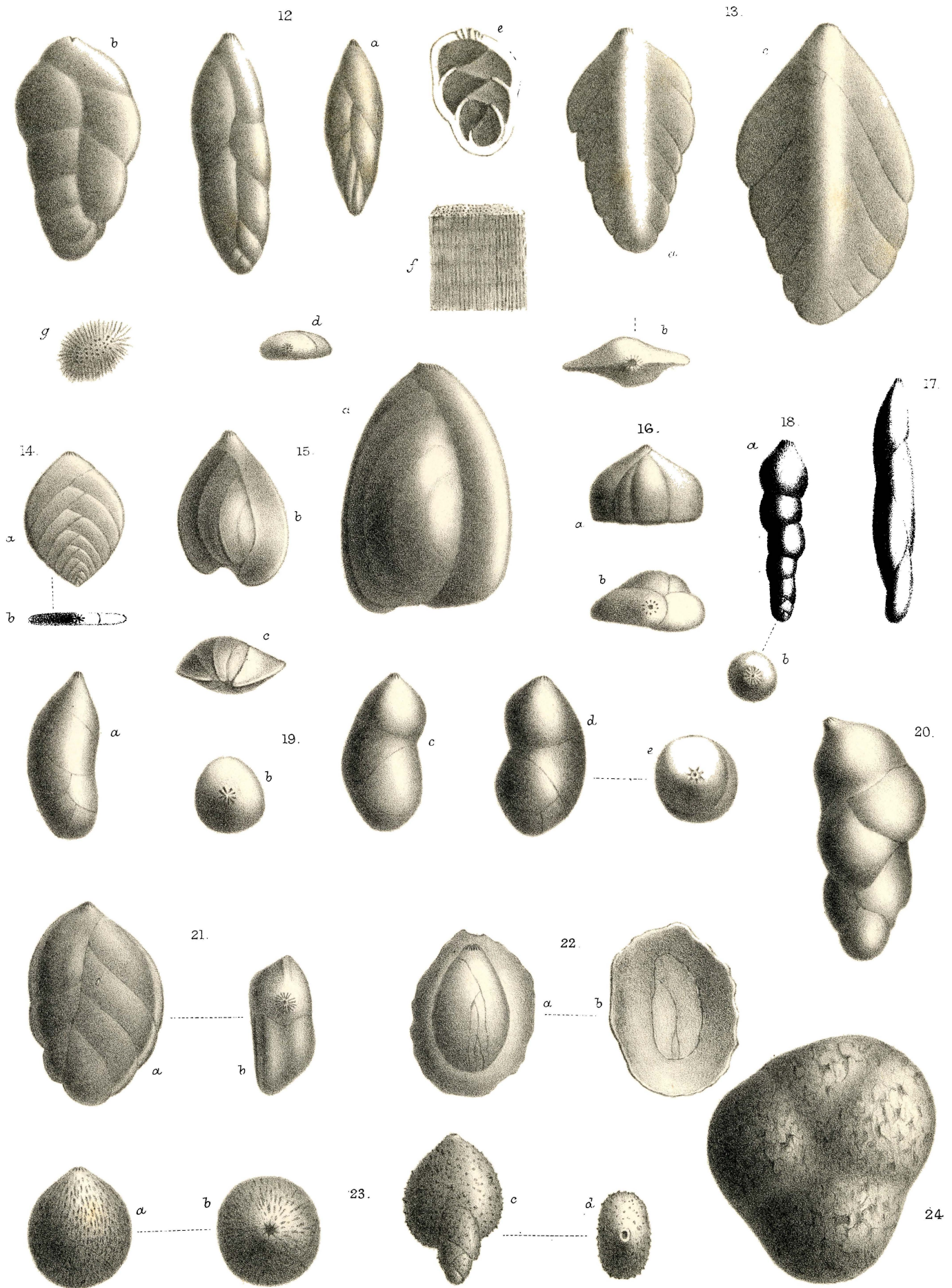
Fig. 41. *D. compacta*, Jones, Parker, and Brady. From a Crag specimen.

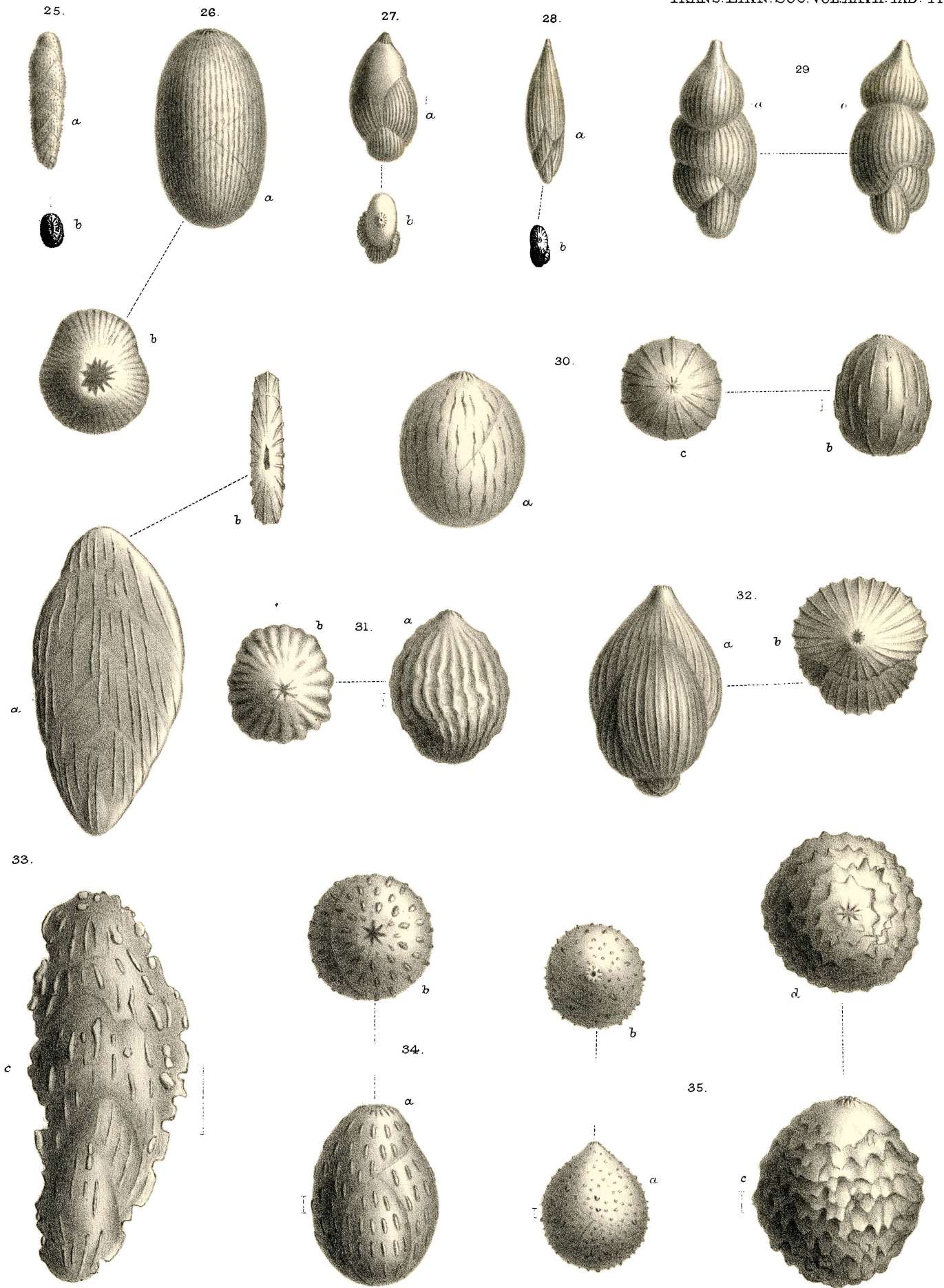
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We have not, perhaps, stated with sufficient clearness how close we regard the relationship between POLYMORPHINA and UVIGERINA. Although we have not felt justified, under the limitations of our present knowledge, in uniting these two groups, we could adduce very strong arguments in favour of such a course. We accept the separation of these genera as a provisional and convenient arrangement rather than as a fixed decision founded on definite or strongly marked characters.

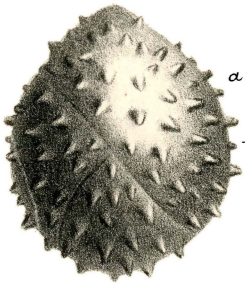


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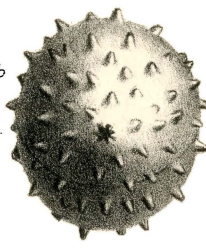




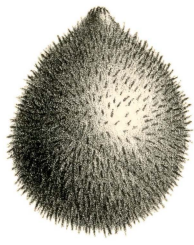
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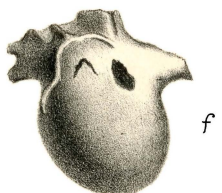
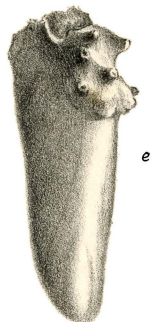
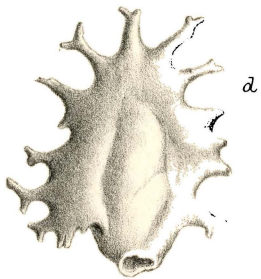
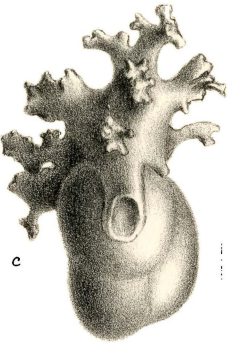
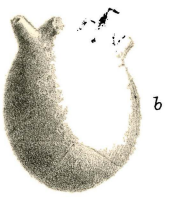
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37.

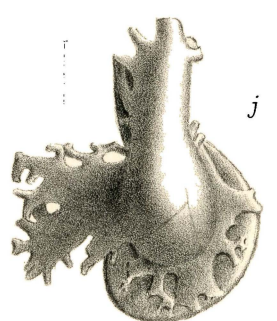
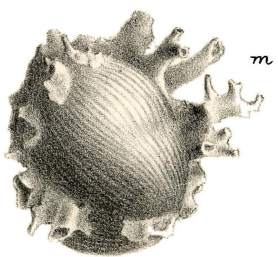
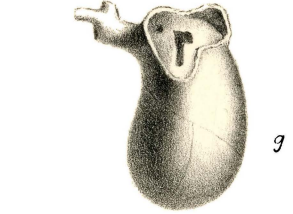
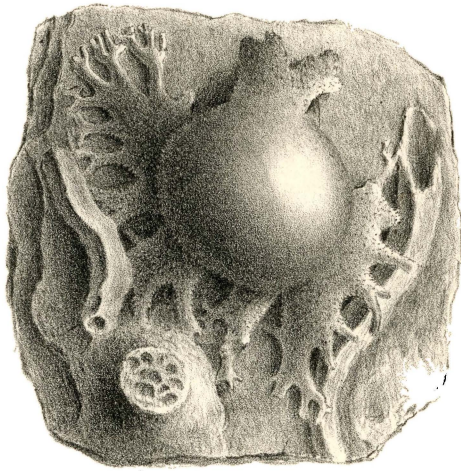
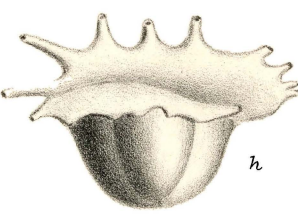


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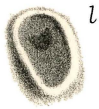


38.

38.



P



k



39.



b



40.



c



a



41.

