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TRANSACTIONS.

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Plates I. II.

On the GENUS *BIDDULPHIA* and its AFFINITIES.

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(Read May 19th, 1858.)

THE genus *Biddulphia*, one of the most interesting of all the class of Diatomaceæ, both from the generally large size and peculiar structure of the frustules, was one of the first of the minute class of Algæ that attracted the attention of microscopists. Included by the earliest observers with a heterogeneous collection of other forms, differing widely in their structure, under the general title of *Conferva*, it was about fourteen years before its title to generic distinction was recognised, and then, together with the genus *Fragillaria* of Lyngbye, and the *Diatoma* of De Candolle, formed the whole of the order Diatomideæ, enumerated in the 'Natural arrangement of British Plants' of S. F. Gray. The genus, however, as formed by this writer, included only three species, *B. pulchella*, *B. obliquata*, and *B. stipitata*, which, as more attention was given to the lower class of Algæ, were soon found to be widely different in their organization and modes of growth; the first, however, has been ever since considered the type of the genus I am now about to describe, whilst the second formed that of the genus *Isthmia* of Agardh, and the last was included by the same writer in the genus *Achnanthes*, as established by Bory.

When Ehrenberg first began to pay attention to these microscopic forms, the constant succession of memoirs read before the Berlin Academy, induced a large number of microscopists, both here and on the Continent, to study with greater care the infinite variety and beauty of these minute plants, that had hitherto been almost unnoticed, except by a very limited number of algologists; and from that time the genus *Biddulphia* has attracted a large share of attention. The species, however, of which it is composed, being the most protean in their habits of growth of the whole order of Diatomaceæ, presenting even in the same localities very great variety both in form, size, and areolation of the entire frustules, and exhibiting such totally different appearances when only the separated valves are examined, that it has, during the last fifteen years, been divided and subdivided, on slight, and I think quite untenable, grounds, into about eight or nine genera, including, in the various papers of Ehrenberg, Kützing, Bailey, and others, nearly sixty species.

The late Professor Smith, by extensive research and considerable judgment, has placed our native species of Diatomaceæ on a tolerably sound foundation, as compared with the overloaded classification of previous observers; and by generally characteristic generic descriptions, aided by the admirable figures of Mr. Tuffen West, has enabled every careful microscopic observer to study these interesting forms of life with comparative confidence. But, as the limits of his work would not permit him to enter largely into the characters of any particular genus, and, at the same time, those from foreign habitats are altogether unnoticed, I propose, in the present communication, to bring before the Society as complete a monograph as the means at my disposal will admit of the entire genus of *Biddulphia*, and, having referred to all the authorities, to form a synonymy which will bring it into a more intelligible form than at present exists.

Professor Smith I consider has acted with sound discrimination, in again uniting the genera *Zygoceros*, *Odontella*, *Denticella*, and *Cerataulus* of Ehrenberg and Kützing, under the head of *Biddulphia*; and whilst I propose to adopt the arrangement so far, as brought forward in his 'Synopsis,' I wish to bring before the Society my reasons for dissenting from some points in his classification, which I think it very probable he would have been inclined to modify, or partially rearrange, from evidence that has lately been discovered, had he lived to bring out another edition.

The earliest notice of the genus *Biddulphia* is that in Smith's 'English Botany,' dated in 1807, where it is alluded to, under the name of *Conferva Biddulphianum*, as "a curious plant, of which we find no description, found by Miss Susan Biddulph, in November or December last, at Southampton." The figures, however, given in the plate, No. 1762, although said to be "exact copies of chosen specimens," are drawn apparently from different plants; the upper figures alone being those of *Biddulphia*, and though small and rather roughly drawn, are evidently taken from specimens of *B. pulchella*. Dillwyn, the next writer who notices it, in his 'British Confervæ,' published in 1809, merely repeats the statements in the 'English Botany,' but does not appear to have seen the plant, and gives no figures. Lyngbye, in his 'Tentamen Hydrophytologiæ Danicæ,' published in 1819—a surprising work for the extent of research and accuracy of his delineations, considering the little attention then paid to microscopic subjects, and the inferiority of his instruments to those now in use—appears not to have met with *B. pulchella*; but he describes and figures, as *Diatoma auritum*, another

species of the genus, which is so exceedingly variable in form, that it has led to many of the errors which have been propounded by subsequent observers. Agardh, in his 'Systema Algarum,' in 1824, and afterwards in his 'Conspiculus Criticus Diatomaceorum,' published in 1830, was the first who brought forward anything approaching a full classification of this tribe of plants, with an extended list of species; but he appears to have been ignorant of the classification of Gray, in his earlier work; and though he alludes to *Biddulphia* in the second, the species *pulchella* was unknown to him except by description, and he continues to retain it under the title of *Diatoma Biddulphianum*, and states that it probably may prove one of the Desmidiæ. In the same work, however, probably from having seen specimens, he appreciates the characteristic distinction between the *D. auritum* of Lyngbye and the true Diatomas of De Candolle, and founded the genus *Odontella* for its reception. M. De Brébisson, in his 'Considerations sur les Diatomées,' in 1838, having had his attention directed for some time to this class of Algæ, and aided by improved instruments, was able to make a considerable advance on the classification of Agardh, and adopting Gray's genus of *Biddulphia*, with a true appreciation of specific characters, associated with it the *Odontella auritum* of the former writer; and the same arrangement was adopted by Mr. Ralfs, apparently from independent observation, in 1843.* In this arrangement, unfortunately, these writers were not followed by other Continental observers; Kützing retaining the genus *Odontella* in his latest works; whilst Ehrenberg, having in his 'Infusionsthierchen' applied that name to a species of the Desmidiæ, proposed that of *Denticella* for the same forms. In 1839 the latter writer communicated to the Berlin Academy a paper on the marine species of Diatomaceæ found at Cuxhaven, in which, among other new genera, he described one, under the name of *Zygoceros*, to contain those species of the *Biddulphian* type which he considered to be free forms, and not concatenate; but at present we have only negative evidence in support of this being a permanent distinctive character, and, as Professor Smith has observed in describing his *Biddulphia rhombus*, the typical species of the new genus, "the form and structure are too near those of *Biddulphia* to permit its separation, and the filamentous condition of the species will no doubt reward the future explorers of the tidal harbours and estuaries of Britain."†

In 1843, Ehrenberg added another genus under the name of *Cerataulus* to include those species allied in form to his

* 'An. Nat. Hist.,' vol. xii, p. 273.

† 'Synopsis,' vol. ii, p. 50.

genus *Denticella*, but which he considered nonconcatenate, in the same way that he had already separated *Zygoceros* from *Biddulphia*; but as hitherto both *Biddulphia turgida* and *rhombus** have generally been obtained from mud deposits, and after boiling in acid, it is highly probable they will both be found, when met with in abundance in a living state, to be filamentous forms, and therefore not entitled to any other than specific distinction.

Having thus sketched the origin of the various genera into which the genus *Biddulphia* has been divided by Ehrenberg, I shall now proceed to Kützing, the most systematic of the German writers. In the arrangement of the family he chiefly follows that author, but, as I have already mentioned, retaining the name of *Odontella* of Agardh, for those species included in the genus *Denticella*; but he ignores entirely the *Biddulphia pulchella* of former authors, and separates it into three distinct species, naming them *tri-ocularis*, *quinque-ocularis*, and *septem-ocularis*, the difference being merely the number of lobes into which the valves are divided, a character utterly unworthy of notice as affording specific distinction, as no gathering can be made of *B. pulchella*, when it occurs in any abundance, without meeting with frustules divided by a different number of costæ, varying from three to seven.

From a careful examination of the various papers referring to this genus, I find it has at various times been described under the following generic names:

1. <i>Conferva</i> ,	with	1	species.
2. <i>Diatoma</i> ,	"	2	"
3. <i>Biddulphia</i> ,	"	14	"
4. <i>Odontella</i> ,	"	10	"
5. <i>Denticella</i> ,	"	15	"
6. <i>Zygoceros</i> ,	"	13	"
7. <i>Cerataulus</i> ,	"	1	"
8. <i>Isthmia</i> ,	"	1	"
9. <i>Triceratium</i>	"	1	"

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Rejecting altogether some of the species described by Ehrenberg from small fragments, and of which it is impossible to form the least opinion, either from his descriptions or figures, I believe these may be reduced to about eleven good species, and together with two hitherto undescribed, as far as I know, include all the well-established forms that can be separated by good specific characters.

I have already alluded to the great variation that exists in

* The *Cerataulus turgidus* and *Zygoceros rhombus* of Ehrenberg.

the outline, size, and arrangement of the valve and connecting membrane in the perfect frustules of this genus; and to this cause we may trace the long list of synonyms appended to nearly every species. The determination of any constant characters upon which to fix their limits as a genus is, as stated by Professor Smith, a matter of some difficulty, but they all agree in having rounded or compressed frustules, the terminal valves having submarginal processes always placed near the extremities of the long diameter when the valve is oval or approaching lanceolate in outline, always more or less reticulate in structure, generally spinous, and united by a connecting membrane often of considerable breadth, which is also reticulated in the majority of the species, and in this and the genus *Amphitetras* frequently projects beyond the suture of the valves when undergoing self-division.

But though the exact definition of the genus presents some difficulty, when we come to consider what is or what is not a species, upon what grounds their limits are to be defined, and the terms in which any specific characters are to be drawn up, the variations that occur in different localities, and even in any abundant gathering, are so remarkable, that the greatest uncertainty prevails, and the most discordant opinions are entertained as to the limits that should be prescribed, or even upon what grounds the specific characters should be based. That Ehrenberg and Kützing have erred in placing any dependence on the presence or absence of the spines on the surface of the valves, I think, is now generally admitted by all who have carefully studied the genus. The number of lobes in those species in which they occur, is also subject to great variation, ranging from three to seven in *B. pulchella*; and if the *Denticella polymera*, of which only a separated valve appears to have been seen by either Ehrenberg or Professor Bailey, is correctly referred to *B. Tuomeyji* of the latter author—of which, from the figure and description, I think there can be little doubt—we have in that species a variation ranging from one to thirteen lobes, each of which, if the system of Kützing was adopted, would have to be made into a distinct and separate species. But this ground of specific character has been abandoned by Professor Smith in the first-named species, and is equally without weight in any other. The connecting membrane, again, is immediately after self-division exceedingly narrow, but increases in breadth as the frustules approach maturity, till from being barely perceptible, it frequently exceeds in breadth, and is sometimes nearly double the length of the valves themselves, before the act of self-division is again completed; and though in some species more or less areolate,

the markings are by no means constant, and, in fact, no dependence whatever can be placed on its size or structure alone as a ground of specific character.

On what, then, are the species to be founded? I believe that the only safe and constant characters which can be depended upon are as follows: the structure and areolation of the separated valves; the position, not the number, of the spines; the size and form of the processes, and their position on the surface of the valve.

Considering the known species with these points in view, we find them fall into two very distinct groups. The first, having *B. pulchella* as the type, with more or less elliptical lobed valves, having undulating margins, distinct and rounded areolations,* with the spines rising from the summits of the lobes, and processes distinctly areolate, placed at the extremities of the valves; including three species.

The other, having *B. aurita* as the type, with valves more or less lanceolate, elliptical, or orbicular, without undulations at the margin. The areolation generally indistinct, but when otherwise hexagonal. The spines sometimes central, sometimes submarginal; and the processes only partially areolate, varying considerably in size and length, and sometimes placed at some little distance from the margin of the valve. This division includes ten species.

I now proceed to describe the species, slightly altering the generic character as proposed by Professor Smith. The specific characters, where not inserted, are to be considered the same as in the 'Synopsis.'

Genus BIDDULPHIA, Gray.

Frustules compressed or cylindrical, adhering more or less perfectly into a continuous or zigzag filament; valves convex, elliptical, lanceolate, or orbicular, usually spinous and areolate; areolations rounded or hexagonal, with horn-like processes rising from the angles or margin of the valve.

* Professor Smith applies the term "cellules" to these markings (see Introduction to 'Synopsis,' vol. i, p. xvii; and again, vol. ii, p. xix). He has evidently adopted this designation after much thought, and a careful comparison with other forms of cell-membrane, but the distinctive physiological character of a cell, that of being a completely closed vesicle, appears to me to be entirely wanting, or at least not at present shown to exist, even in those species where the markings are most obvious, such as *Triceratium favus* and *Biddulphia pulchella*, &c. I consider that the reticulated structure of the siliceous epiderm is merely adapted to strengthen the cell-wall, and therefore prefer the use of the terms, areolation or reticulation, to distinguish those markings on the valves which are usually described as cells or cellules.

SECTION I.—Valves with undulating margins, and elevations separated by costæ or deep constrictions.

1. *Biddulphia pulchella*, Gray. ('Synopsis,' p. 48.)

Marine; not uncommon on the English coast, and generally distributed on the shores of Asia, Africa, and America.

- Syn.* CONFERYA BIDDULPHIANA. Eng. Bot., 1807, vol. xxv, t. 1762 (upper figures); Dillwyn's Brit. Conf., 1809, p. 52.
 BIDDULPHIA PULCHELLA. Gray, Ann. Brit. Pl., 1821, vol. i, p. 294; Ehr. Ber. Tran., 1843, t. ii, vi, f. 18; Ralfs, Ann. N. H., 1843, t. viii, f. 3; Pritch. Inf., 1852, p. 456; Smith's Syn., 1856, vol. ii, t. 44, 45, 46, f. 321; Mont. Fl. d'Alger., p. 196.
 DIATOMA BIDDULPHIANUM. Ag. Syst. Alg., 1824, p. 5, and Conspect. Crit. Diat., 1830, p. 54; Hooker's Brit. Flor., 1833, p. 404; Harvey, Man., 1841, p. 201.
 DENTICELLA BIDDULPHIA. Ehr. Ber. Tran., 1843, t. ii, vi, f. 19; Pritch. Inf., 1852, p. 345.
 BIDDULPHIA TRI-LOCULARIS. Kütz. Bac., 1844, t. xix, f. 89, and Sp. Alg., 1849, p. 137; Pritch. Inf., 1852, p. 456.
 BIDDULPHIA QUINQUE-LOCULARIS. Kütz. Bac., 1844, t. xix, f. 1, and Sp. Alg., 1849, p. 137; Pritch. Inf., p. 457.
 BIDDULPHIA SEPTEM-LOCULARIS. Kütz. Bac., 1844, t. xix, f. 2, and Sp. Alg., 1849, p. 138; Pritch. Inf., 1852, p. 457.
 BIDDULPHIA AUSTRALIS. Mont. Pl. Cel. de Cuba, 1845, p. 5.

This beautiful and cosmopolitan species has been so well described by Professor Smith, Mr. Ralfs,* and others, that there is little to add as to its general structure. I may, however, remark, as corroborative of the opinion maintained by Professor Smith, that the apparent openings at the extremities of the produced angles, are in fact closed by a slight siliceous membrane, that they will be found in perfect specimens to be fringed by thickened projecting points of siliceous matter, having the appearance of spines, and resembling in some degree the peristome of a moss.

With respect to the synonymy, I am rather doubtful whether the *Biddulphia australis* of Montagne ought not rather to be referred to the *B. Tuomeyii* of Bailey. By the kind assistance of Dr. Hooker, I have been able to refer to his original descriptions, in which he says, "Les cinq cellules longitudinales qui terminent d'article a chacune de ces extrémités ne sont pas égales, et que ce sont les deux externes, et la moyenne qui saillent davantage, les intermédiaires restent plus courtes;"† and he states that for that reason and

* 'An. Nat. Hist.,' 1 ser., vol. xii, p. 274.

† Ramon de la Sagra, 'Hist. de Cuba,' p. 5.

some others of minor importance, he considers it distinct from *B. pulchella*, of Gray. But I find in the 'Flore d'Algerie,' he gives a description of *B. pulchella*, and there refers to his former *B. australis* as synonymous;* and as Kützing has adopted the same view,† in the absence of figures or authentic specimens, I feel bound to follow these later opinions.

The *Denticella Biddulphia* of Ehrenberg is clearly referable to this species, as the only distinguishing character, either in his figures or descriptions, is the presence of setæ or the awl-shaped spines of Professor Smith on the central lobe, which may always be seen in perfect frustules.

2. *Biddulphia regina*, W. S. ('Synopsis,' p. 50.)
Marine. Island of Skye, Barlee.

Smith's Syn. Brit. Diat., 1856, p. 50, t. xlvi, f. 323.

This fine species, described, as far as I am aware, for the first time by Professor Smith, has not hitherto been noticed in any other locality than that above referred to, nor can I find any reference among the numerous papers of Ehrenberg, or those of Kützing, or Professor Bailey, that leads me to believe they have seen a similar form. Professor Smith alludes to the possibility of its being identical with the *Zygoceros Tuomeyii* of Bailey, but I shall endeavour to show in discussing that species that there can be little doubt it is entitled to rank as a distinct form.

3. *Biddulphia Tuomeyii*, Bailey (sp.)

Valve elliptical, margin undulating, usually with one or three median elevations or lobes, occasionally more, the central one always the largest, and all more or less spinous; processes long, narrow, and turgid at the base; areolation circular, small, and generally in concentric lines on the lobes, finer and parallel on the connecting membrane. (Pl. I, figs. 1, 2.)

Marine. Petersburg (Virginia), Piscataway, and Bermuda; Bailey. Natal; Shadbolt. Californian guano; Roper. Levant mud; Williamson.

Syn. ZYGOCEROS TUOMEYII. Bailey, 1844, Sil. Journ., vol. xlvi, t. iii, f. 3, 4, 8; E. Quekett, Lon. Phys. Journal, 1843, t. ix, f. 3, 5, 8; Williamson, Mem. Phil. Soc. Manch., 1848, t. i, f. 1.

DENTICELLA TRIDENS. Ehr. Ber. Trans., 1839, p. 73.

* Mont., 'Flore d'Algerie,' p. 196.

† 'Spec. Alg.,' p. 137.

- DENTICELLA TRIDENTATA. Ehr. Ber. Pro., 1844, p. 79.
BIDDULPHIA TRIDENS. Pritch. Inf., 1852, p. 457; Ehr. Microg., 1856, t. xx, f. 53, t. xix, f. 21.
DENTICELLA SIMPLEX. Shadbolt, Mic. Jour., 1854, t. i, f. 16.
DENTICELLA MARGARITIFERA. Ibid., t. i, f. 17.
BIDDULPHIA TRIDENTATA. Ehr. Microg., 1856, t. xviii, f. 52, t. xxi, f. 24.
DENTICELLA POLYMERA. Ehr. Ber. Pro., 1844, p. 266; Bailey, Sil. Jour., 1845, t. iv, f. 20; Pritch. Inf., 1852, p. 345.
ODONTELLA POLYMERA. Kütz. Spec. Alg., 1844, p. 137.

This fine and well-marked form has been found always with the same peculiar characters in so many localities, that there can be little doubt it is entitled to rank as a distinct species; as far as I am aware, it has not yet been met with on the coasts of England, though in some respects it approaches the preceding species, *B. regina*, of the 'Synopsis.' Through the kindness of Professor Williamson, I have been able to examine authentic specimens of that species, of which the figure in Professor Smith's volume gives a very correct representation. It differs from the form described by Professor Bailey as *Zygoceros Tuomeyii*, in having all the lobes and processes of nearly equal length, in the absence of the spines on the summits of the lobes, in the greater depth of the constrictions, and in the greater size and more irregular arrangement of the granular markings or reticulations. In *B. Tuomeyii*, the processes are long, narrow, and usually twice the length of the adjacent, and about one third longer than the central lobe; all the median elevations are spinous, and always more widely separated than in *B. regina*. As I have found these peculiarities constant in specimens from various localities, as well as in the figures in Ehrenberg and elsewhere, they appear to afford sufficient ground for specific distinction.

In describing this species, Professor Bailey states, that "at the base of each of the swellings, the shell often shows perforations, and the whole surface is covered with shagreen-like asperities;"* these markings at the base of the lobes are not perforations, but appear to arise from slight depressions, which are brought more prominently into view, from the greater projection of the valve at these points than at the base of the constrictions; the same appearance is seen in *B. regina*. (See 'Syn.,' t. xlvi, fig. 323.)

In examining the synonymy of this species, Ehrenberg's name of *Denticella tridens* appears to have the priority as to date, but as it occurs not unfrequently with only one lobe,

* 'Siliman's Journal,' 1st series, vol. xlvi, p. 138.

and occasionally with ten to twelve, as shown in the *Denticella polymera* of 'Sil. Journal,' vol. xlviii, tab. iv, fig. 20, clearly only a large specimen of the present form, the designation *tridens* is so decidedly inapplicable, that I am induced to retain that of *Tuomeyji*, given by Professor Bailey. I have examined a large number of specimens of the *Denticella simplex* and *D. margaritifera*, of Mr. Shadbolt,* from Natal, and they are clearly identical with the present species, neither the number of the lobes or the spines being sufficient ground for specific distinction. The most characteristic figure of this species is given by Professor Williamson, in his paper on the "Levant Mud," in the 'Memoirs of the Philosophical Society of Manchester,' vol. viii, new series, tab. i, fig. 1; but, as that work is not generally accessible, I give a figure of a specimen from Californian guano, supplied me by my friend Mr. Ralfs. Mr. Shadbolt's figures in the 'Micros. Journ.,' vol. ii, tab. i, figs. 16, 17, are good representations of the smaller frustules, not unfrequent in the Natal gathering.

SECTION II.—Valves lanceolate, elliptical, or orbicular, without undulating margins.

4. *Biddulphia aurita*, Bréb. ('Synopsis,' p. 49.)

Marine or brackish water. A very common species on the coasts of England, and on those of Europe, Asia, Africa, and America.

Syn. DIATOMA AURITUM. Lyngb. Tent. Hydro. Dan., 1819, t. lxii; Hooker, B. Fl., 1833, p. 404.

ODONTELLA AURITA. Ag. Consp. Crit. Diat., 1830, p. 56; Smith's Eng. Bot., t. 2842, f. 2; Harv. Man., 1841, p. 201; Kütz. Bac., 1844, t. xxix, f. 88; Spec. Alg., 1849, p. 136; Pritch. Infus., 1852, p. 470.

BIDDULPHIA AURITA. Bréb. Cons. sur les Diat., 1838, p. 12; Ralfs, Ann. Nat. Hist., vol. xii, 1843, t. viii, f. 4; Pritch. Inf., 1852, p. 456; Smith, Syn., 1856, vol. ii, t. xlv, f. 319; Microg. Dict., 1856, t. xiv, f. 9.

DENTICELLA AURITA. Ehr. Microg., 1854, t. xxxv, A, 23, f. 7.

DENTICELLA GRACILIS. Ehr. Ber. Acad. Pro., 1840, p. 206, and B. Trans., 1840, p. 12; Pritch. Inf., 1852, p. 344.

This species, although common in most marine gatherings, rarely occurs in much abundance, and, like some other members of the genus, is subject to very great variations in form even in the same locality, as may be seen, by comparing the various figures given in the 'Synopsis' of Professor Smith, whose description, together with that of Mr. Ralfs,†

* 'Micros. Journal,' vol. ii, Transactions Micros. Soc., p. 17.

† See 'Ann. Nat. Hist.,' vol. xii, 1843, p. 272.

leave nothing to add as to its general structure. Agardh founded his genus *Odontella* on this species, apparently from the presence of the spines on the summit of the central inflation, as the only description he gives of the genus, is "Frustilla dentibus cohærentia filum formantia."* Kützing, both in his 'Bacillarien,' and also in his later work, the 'Species Algarum,' retains a large number of species under that generic name. The valves in this species vary considerable in outline, and though usually elliptical-lanceolate, as stated by Professor Smith, they occasionally occur of a nearly perfect oval. (See Plate I, fig. 3.) They are, however, readily distinguishable from all others of the genus from the presence of the central elevation, with three or more spines on its summit, which is merely a circular projection of a portion of the valve, and does not extend across it, as in *B. regina*, nor is it separated by constrictions or costæ; as is clearly shown in fig. 319 a of the 'Synopsis.'

5. *Biddulphia rhombus*, Ehr., sp. ('Synopsis,' p. 49.)

Marine or brackish water. In addition to the localities noticed by Professor Smith, in the 'Synopsis,' it has been found in a living state near Tenby by the Rev. J. Guillemard, in various localities in America by Professor Bailey, in the Baltic and North Sea by Ehrenberg, and at Gorleston by Col. Baddeley. (Plate I, fig. 4.)

Syn. ZYGOCEROS RHOMBUS. Ehr. Ber. Acad. Proc., 1839, p. 156, and Trans., 1840, t. iv, f. 11; Bailey, Sil. Jour., 1844, vol. xvi, t. iii, f. 10, 11; Kütz. Bacil., 1844, t. xviii, f. 9, and Spec. Alg., p. 139; Pritchard, Inf., 1852, p. 450; Roper, Mic. Trans., 1854, vol. ii, t. vi, f. 5.

DENTICELLA RHOMBUS. Ehr. Ber. Ac. Proc., 1844, p. 79; Pritch. Inf., 1852, p. 345.

ODONTELLA RHOMBUS. Kütz. Spec. Alg., 1844, p. 136.

ZYGOCEROS RADIATUS. Bail. Notes, 1853, t. i, f. 29.

BIDDULPHIA RHOMBUS. W. Smith, 1856, Syn., vol. ii, t. xlv and lxi, f. 320.

This fine species is not so common as the preceding, though it is by no means rare in the Thames. The finest and most abundant collection, however, that I have seen, occurs in the clay obtained by Mr. Okeden from a brickyard near Caermarthen. I know of no foreign localities in which it has been observed, excepting those noticed by Ehrenberg in the North Sea and Baltic, and in North America by Professor Bailey. The structure of the valves in this, as in all the following species, differs from those which

* Ag., 'Consp. Crit. Diat.,' p. 56.

precede it, in having no central elevation or constriction of any kind, and is the only species, excepting *B. tumida*, in which there are several short submarginal spinous processes. The minute structure of the valve itself also differs from the preceding species, having the appearance of dots or punctæ under a low power, but resolvable, with a one-eighth objective, into distinct hexagonal reticulations. It differs from *B. granulata* in the more apiculate character of the valves, in having six or more submarginal spines instead of two in the centre of the valve, and in the absence of the peculiar granular structure characteristic of that species.

6. *Biddulphia Baileyi*, W. S.

Valve imperfectly siliceous, divided into three segments by lines joining the angular processes, the central portion raised, with two slight median elevations, each armed with one or two very long awl-shaped spines; processes somewhat linear, with truncate apices; reticulation diagonal, minute. (Plate I, figs. 5 to 9.)

Marine. In addition to Professor Smith's localities—Caldy, Pembrokehire, Rev. J. Guillemard; Humber, Norman; Barking Creek, Roper; Gorleston, Col. Baddeley; coast of Northumberland, Dr. Donkin; Caermarthen, Okeden; Lymington Harbour, E. Grove; Mobile and Savannah, Bailey.

Syn. ZYGOCEROS MOBILENSIS. Bailey, 1850, Mic. Observ., t. ii, f. 34, 35; Pritch. Inf., 1852, p. 450.
BIDDULPHIA BAILEYI. W. Smith, 1852, Syn., vol. ii, t. xlv, lxii, f. 322.

This species differs from all others of the genus in the peculiar structure of the valve, which is angular, the central portion being raised and comparatively flat, whilst the sides are inclined at a considerable angle, the junction of the three portions appearing as slightly sigmoid or curved lines on the side view, as shown in figs. 7, 8, and 9. This species, like *B. aurita*, is subject to very great variation in form and size, so much so, that the specimens in one locality, without careful comparison with those from several others, might readily be considered distinct from the typical form; but though differing greatly in the proportionate length and breadth, in the size of the processes, and length of the spines, I feel convinced that all having the imperfectly siliceous character, and peculiar angular form of the valves, may safely be referred to the same species. The side view of the valve has not been given by Professor Smith, but it is almost

essential for the safe determination of the species. In some specimens the processes are short, and the spines placed not in the centre as in the normal form, but almost half way between the centre and edge of the valve.

The rough outline figure, and short description given by Professor Bailey of his *Zygocecos Mobilensis*, leave little doubt that Professor Smith was correct in considering the present species identical with the form occurring on the American coast, and though a strict observance of the rules of nomenclature would lead to his specific name being retained, I think it better to follow Professor Smith in naming it after our lamented American microscopist.

7. *Biddulphia granulata*, n. sp., Roper.

Valve elliptical, or elliptical-lanceolate, considerably raised in the centre, covered with fine diagonal reticulations, and interspersed with very short spines or small tubercles, at irregular intervals. Two long awl-shaped spines rise from the centre, generally bent about the middle at an obtuse angle; processes short, rather inflated at the base, and slightly recurved. (Plate I, figs. 10, 11; Plate II, fig. 12.)

Marine or brackish water. Dredged of Cald, Rev. J. Guillemard; Barking Creek, Roper; Gorleston, Col. Baddeley; New Brighton, Cheshire, Comber.

Syn. DENTICELLA TURGIDA. Ebr., 1840, Ber. Acad. Pro., p. 207.
ODONTELLA TURGIDA. Kütz., 1844, Bacil., t. xviii, f. 9, and Spec. Alg., p. 136; Pritch. Inf., 1852, p. 470.
DENTICELLA TUMIDA? Bailey, Soundings, 1851, t. i, f. 57.

The species here figured does not appear to have been noticed by Professor Smith, who refers to the *Odontella turgida* of Kützing as a probable variety of *B. aurita*,* and his figure certainly gives ground for this opinion. Had I not met with this form in more than one locality, and always preserving the same well-marked points of distinction, I should have been inclined to have concurred in this supposition; but the want of the central inflation, and the greater length, peculiar bent form and position of the spines, which are situated near the processes, and not, as in *B. aurita*, in the centre of the valve, together with the obtuse and generally recurved form of the processes themselves, clearly separate it from that species; whilst its more robust form, distinct granulation on the surface, inflated processes, and absence on the side view of the peculiar lines, are sufficient to distinguish

* 'Syn.,' vol. ii, p. 49.

it from the preceding species, to which in general outline it more nearly approaches. Ehrenberg's definition of *Denticella turgida* is, "Testulæ subtiliter punctatæ, turgidæ, processibus duobus, lateralibus tubulosis apertis, aculeis lateribus mediis elongatis;"* and Kützing, who considers it identical with his *Odontella turgida*, adds, "cornibus recurvatis majoribus obtusis."† Although without authentic specimens, and with only the rather imperfect figure given in Kützing's 'Bacillarien,' it is impossible to speak with certainty, I think the description is sufficiently applicable to enable me to refer to these species as identical with the present form. The name, however, of *turgida* having already been appropriated to another and well-marked species, I have described this as "*granulata*," from the peculiar and distinct granular markings of the valve.

8. *Biddulphia reticulata*, n. sp., Roper.

Valve elliptical-lanceolate, flat or slightly tumid in the centre, marked with large irregular hexagonal reticulations, the surface covered with short spines; angular processes, short and subcapitate, inflated at the base; connecting membrane with rows of conspicuous dots, mostly parallel to the suture of the valve. (Plate II, figs. 13, 14, 15.)

Var. β , with smaller reticulations and very short obtuse processes. (Plate II, figs. 16, 17.)

Marine. Trincomalee and Natal, Roper; New Zealand, Dr. Walker-Arnott.

This curious and fine species does not appear to have been recorded by any previous writer, and I can find none of Ehrenberg's figures or descriptions that lead me to suppose he has seen it. It differs from all the other species of the genus in having large and distinct hexagonal reticulations, which are, however, rather irregular in outline and size. The side view of the valve is more broadly elliptical than in *B. aurita*, and wants the central inflation of that species. It differs from *B. rhombus* in the absence of the pointed apices, and awl-shaped spines, and in the processes being inflated on the outer instead of the inner margin. The species which most nearly approaches it is Ehrenberg's *B. ursina* ('B. Proc.,' 1844, p. 200), of which he gives no figure, but describes it as large, turgid, sides covered with hairs, but not cellular, and central area smooth. He appears doubtful, however, if this is correctly placed with the *Biddulphias*, and asks, "Does it belong to *Hemiaulus*?" stating at the same

* 'Ber. Acad. Pro.,' 1840, p. 207.

† 'Spec. Alg.,' p. 136.

time that its hairiness resembles *Tetrachæta*, the *Triceratium spinosum* of Bailey. The distinctly cellular appearance of the surface is, however, sufficient evidence that the present form is distinct from the *B. ursina*, and as I have met with it in three localities, and with strong similarity in structure, I think it may safely be considered a good and well-marked species.

The variety β , I at one time thought might be a distinct species, as, although agreeing in form, the reticulations of the valve are much smaller, and the processes shorter, than in the typical valve; but I have since met with intermediate specimens that are sufficient to induce me to include it as a variety of the present species, and should have adapted the characters to include it, had it not been confined to one gathering, and may therefore be the result of some local variation.

9. *Biddulphia tumida*, Ehrenberg (sp.)

Valve orbicular-lanceolate, with minute reticulations radiating from the centre, and two or three curved submarginal spines; processes rather hyaline, slightly capitate, and rising abruptly from the surface of the valves which are subglobose on the front view. (Plate II, figs. 18, 19.)

Marine? Gomera, one of the Canary Islands; Californian guano, Roper.

Syn. DENTICELLA TUMIDA? Ehr. Ber. Pro., 1844, p. 266.
ODONTELLA TUMIDA. Kütz. Sp. Alg., 1849, p. 137.

This species I first met with in some slides received from Mr. Topping, said to be from Gomera, and I conclude therefore marine. Ehrenberg has described a form from Bermuda under the name of *Denticella tumida* as "Testulæ turgidæ (subglobose) septis lobisque destitutæ, superficie subtilissime punctata, tubulis finis, setisque totidem utrinque longè exsertis;" and although I can find no figure, and have not been successful in meeting with any species in the Bermuda slides I have examined, that agrees with this description, I think the present form so nearly accords with his specific characters, that I am justified in adopting his name.

The peculiar subglobose form of the valves is sufficient alone in the perfect frustule to distinguish it from all the other species of the genus. The detached valves have somewhat the form of those of *B. rhombus*, and the spines are similarly placed, but it is much smaller, less apiculate, and the processes more hyaline and more turgid at the base.

The markings on the surface of the valve, with a magnifying

power of 200 diam., appear to be granules or dots; but are resolvable, with an eighth objective, into minute hexagonal reticulations, which radiate from the centre to the circumference of the valve. The spines are rather long, slightly curved inwards, and arise about midway between the angular processes. The connecting membrane is closely covered with longitudinal rows of punctæ.

10. *Biddulphia Indica*, Ehrenberg (sp.)

Valve lanceolate, slightly tumid in the centre, minutely punctate, with two long awl-shaped spines near the angular processes, which are long, narrow, somewhat capitate, and with the pseudo-apertures at right angles to the length of the valve. The surface of the valve covered with minute pointed spines; connecting membrane marked with diagonal striæ. (Plate II, figs. 20, 21, 22.)

Marine? Natal, Shadbolt.

Syn. DENTICELLA INDICA? Ehr. Ber. Pro., 1845, p. 362.

TRICERATIUM CONTORTUM. Shadbolt, Micr. Jour., vol. ii, t. i, f. 7b.

This small and peculiar form is rather hyaline in structure, and is not unfrequent in the Natal gathering described by Mr. Shadbolt in vol. ii of the 'Microscopical Journal,' p. 15; but I am at a loss to imagine how he could describe and figure it as a front view of *Triceratium contortum*. I have carefully examined more than twenty slides of this gathering, and though there are several good single valves, I have only met with one perfect frustule, and this, as we should naturally expect, clearly shows the three angles and spines, of which there is no trace in the small form figured in tab. i, fig. 7 b, of the Journal. The marginal row of spines plainly visible on the side view of *T. contortum*, are also shown to arise from a siliceous fringe, somewhat similar to that figured by Mr. Brightwell in *T. undulatum*,* and they are entirely absent in the frustules I am now describing, and their whole structure so entirely accords with that of the *Denticella* of Ehrenberg, now included in the present genus, that I have no doubt as to their proper generic position.

With respect to its specific name there is the same doubt as with *B. tumida*. Ehrenberg describes a species obtained from the Indian seas, under the name of *Denticella Indica*, as "Testula lævi (an subtilissime punctata) tubulis valde productis, sub-capitatis, aculeis longissimis, tubulos excedentibus, area inter tubulos aspera;"† but I can find no figure among

* 'Micros. Journ.,' vols. vi, tab. viii, figs. 4, 5.

† 'Ber. Proc.,' 1845, p. 162.

his works. The description and locality from which this was obtained, induce me, however, to adopt his name rather than add another to the already overburdened list.

The perfect frustules of this species are not uncommon, but I have only met with a single detached valve showing the S.V., in which there appears to be a slight depression in the centre as shown in fig 22, from which the small spines are absent.

This species is readily distinguished from any other of the genus by the peculiar subcapitate form of the processes, and from the so-called apertures being at right angles to the suture of the valve instead of being parallel with, or slightly inclined towards it.

11. *Biddulphia turgida*, Ehrenberg. (sp.)

Valve elliptical or suborbicular, minutely reticulated, with small spines scattered at irregular intervals over the surface, occasionally furnished with a submarginal circlet of short obtuse spines, and with two long submedian spinous processes. Angular processes large, linear, and truncate. (Plate II, fig. 23.)

Marine. Neyland, near Haverfordwest; Okeden. Milton, Pembroke Harbour, and Pater, Milford Haven; Roper. Menai Straits; Shadbolt. Hudson River and West Point; Bailey.

Syn. CERATAULUS TURGIDUS. Bailey, 1850, Mic. Obs., t. ii, f. 26, 27;

Ehr. Ber. Proc., 1843, p. 270; Pritch. Inf., 1852, p. 330.

BIDDULPHIA TURGIDA. W. Smith, 1856, Synopsis, vol. ii, t. lxii, f. 384.

The figures and description of this species in the 'Synopsis' give a very correct idea of the fine specimens first discovered by my friend Mr. Okeden, but in order to include the smaller forms since found in a living state on the coast, I have slightly altered the specific characters. Professor Bailey states that he met with it, in 1843,* in a living state, and forming zigzag chains as in other species of the genus. Since the publication of the second volume of the 'Synopsis,' I have met with it in two gatherings from the neighbourhood of Pembroke, and Mr. Shadbolt also records it from a gathering made at the Menai Straits.† The connecting membrane in this species is peculiar, in almost always showing a sigmoid flexure on the front view of the perfect frustule. The very large and prominent angular processes readily distinguish it from all the other species of the genus.

* 'Mic. Observ.,' by Smithson. Instit., vol. ii, p. 39.

† 'Mic. Journ.,' vol. vi, p. 123.

12. *Biddulphia laevis*, Ehrenberg.

Valve orbicular or suborbicular, minutely punctate, with minute submedian spines; processes large and truncate, frustules adhering by alternate angles, connecting membrane with fine oblique striæ. (Plate II, figs. 24, 25, 26.)

Marine. West Point, New York; Bailey. Natal; Roper.

Syn. GALLIONELLA ? Bailey, 1842, Sil. Jour., vol. xlii, t. ii, f. 8.

BIDDULPHIA LAEVIS. Ehr. Ber. Trans., 1843, p. 122; Pritch. Inf., 1852, p. 457.

ODONTELLA POLYMORPHA. Kütz. Bacil., 1844, t. xxix, f. 90; Spec. Alg., 1849, p. 136; Pritch. Inf., 1852, p. 470.

ISTHIA POLYMORPHA, Montagne, { quoted in Kütz. Sp. Alg.,
MELOSIRA THERMALIS, Meneghini, { 1849, p. 136.

This species was discovered and first described by the late lamented Professor Bailey, as a species of Gallionella, as follows: "Corpuscles long, cylindrical, with two lines of constriction, adhering by alternate angles, so as to form long zigzag chains, and occasionally auricled;"* and he proceeds to say, "These curious bodies appear to partake of the characters of both Gallionella and Bacillaria, showing the cylindrical corpuscles of the former united by alternate angles as in the latter. It is perhaps related to the *Diatoma auritum* of Lyngbye." On sending specimens to Ehrenberg, he at once detected its true character, and named it *Biddulphia laevis*, which name I have therefore retained. The *Bid. laevis* of the 'Mikrogeologie,' t. xxxiii, xv, fig. 6, from Virginia, is quite distinct from the present form, and appears doubtfully placed in the genus.

Through the kind assistance of M. De Brébisson and Dr. Walker-Arnott, I have been able to examine authentic specimens from Professor Bailey, and that it is correctly referred to the present genus I consider there can be little doubt. In form the valves are nearly allied to *B. turgida*, the large truncate processes and orbicular outline being characteristic of both, but the translucency and imperfectly siliceous character of *B. laevis*, the position and slight projection of the angular processes, the absence of the long awl-shaped spines, and the much finer character of the striation, are at once sufficient to render it easily distinguishable.

In a very interesting slide of this species, mounted in fluid, by Professor Bailey, in the natural state, kindly lent me by Professor Quekett, there are apparently sporangial frustules formed in the same manner as those in *Melosira Borrerii*,† and

* 'Sil. Jour.,' 1 ser., vol. xlii, p. 92.

† See Smith's 'Synopsis,' vol. ii, t. 1.

I believe it is the first time that any signs of the reproductive process have been noticed, in any species of the genus.

I have a few orbicular valves from the Thames, which appear to belong to the present species, but I have not met with a perfect frustule in any English gathering.

13. *Biddulphia radiata*, Smith (sp.)

Valve orbicular, distinctly reticulated, with small, but rather irregular hexagons; processes short, broad at the base, reticulated and rather obtuse, with two short sub-marginal spines midway between them; connecting membrane faintly striated. (Plate II, figs. 27, 28, 29.)

Marine or brackish water. Thames and Orwell, Mr. T. West; Barking Creek, Roper; Gorleston, Col. Baddeley.

Syn. EUPODISCUS RADIATUS. Smith, Syn., 1853, vol. i, t. xxx, f. 255; vol. ii, t. lxii, f. 255.

The late Professor Bailey described, in his 'Microscopical Observations in South Carolina,' &c., published by the Smithsonian Institution in 1850, a species of Diatom under the name of *Eupodiscus radiatus*, with the following brief characters: "In form, size, and reticulation resembling the *Coscinodiscus radiatus* of Ehrenberg, but having four (or more) foot-like projections near the margin." But there is no figure given, and though he states it is a common form in the South of the Union, I have been unable to meet with specimens. Professor Smith has adopted this name for the species now under discussion; but, in his specific character, states that the 'cells' are circular, whereas, in *Coscinodiscus radiatus*, to which Bailey compares his form, they are distinctly hexagonal; whether the two forms are synonymous I am unable to say with certainty, but, as I stated in a preceding number of the Journal,* I feel convinced that the generic position assigned to it in the 'Synopsis' cannot be maintained, as the whole structure of the valve and processes differs materially from any of the genuine Eupodisci. In that genus the projections are apparently hyaline siliceous tubes, rising immediately from the surface of the valve, without any trace of structure whatever, and I am not aware that any species has long spines; the connecting membrane also is simply a circular ring, as in *Coscinodiscus*. In the present species, however, there are two processes, agreeing exactly in structure with those in *Biddulphia*, reticulated in the same manner as the valve itself, nearly to their points, and between them two acute spines; and the connecting

* 'Mic. Jour.,' vol. vi, p. 19.

cf p 262 -
after 31 inf.

membrane, which is reticulate or punctate, forms the same peculiar projection beyond the suture of the valve, which is, I believe, characteristic alone of *Biddulphia* and its immediate allies; and though Professor Smith lays some stress on the orbicular outline as a distinctive character,* we have seen that this is also to be found in *B. turgida* and *B. laevis*, and certainly forms no good ground for its separation from the present genus. Professor Smith appears himself to have had some doubts, as notwithstanding the argument he adduces for its present position, I find it is figured in the plate, No. lxii, as *Biddulphia radiatus*; and I have little doubt that a careful examination of a larger number of specimens would have induced him to adopt the generic position I now assign it.

It appears to be by no means common on our coasts, as though I meet with it in tolerable abundance in some gatherings from the coast of Norfolk, of Col. Baddeley's, and in most gatherings from the lower part of the Thames, I have not seen specimens from any other parts of England, and I do not see any form in Ehrenberg's numerous figures with which it can be compared.

It is readily distinguished from *Biddulphia turgida* and *B. laevis* by its reticulated valves, and from all other species by its orbicular outline.

The following list contains all the other species I have met with, which, for want of specimens or good specific characters and figures, I can only refer doubtfully to known forms:

BID. ? LUNATA. Ehr. B. Proc., 1844, p. 77, Virginia	} = <i>Bid. Tuomeyii</i> ?
BID. ? GIGAS. Ibid., p. 265, Bermuda	
DENTICELLA LAEVIS. Ibid., p. 201, Antarctic Sea	
ODONTELLA LAEVIS. Kütz. Spec. Alg., p. 136, ditto	} = <i>Bid. pulchella</i> ?
BID. ELONGATA. Menegh., quoted in Kütz. Spec. Alg., p. 137	
DENTICELLA DUBIA. Bailey, Soundings, t. i, f. 57	
ODONTELLA SUBAEQUA. Kütz. Bac., t. viii, f. 4, 5	} = <i>Bid. aurita</i> ?
ODONTELLA OBTUSA. Ibid., t. viii, f. 1-3, 6-8	
ZYGOCEROS BALÆNA. Ehr. B. Proc., 1853, p. 529, and Microg., t. xxxv, a. xxiii, f. 17	} These forms being without angular processes, should probably be united with <i>Terpsinoe</i> .
ZYGOCEROS ? AUSTRALIS. Ehr. Ber. Proc., 1844, p. 205	

* Smith's 'Syn.,' vol. ii, p. 47.

ZYGOCEROS STILIGER and Z. BIPONS, Ehr. Ber. Pro., 1844, p. 273, Bermuda, are considered doubtful forms, both by Ehrenberg and Professor Bailey. From an examination of many specimens, I consider they should be united with the *Hemiaulus* of Ehrenberg.

ZYGOCEROS SURIRELLA. Ehr. Ber. Trans., 1840, t. vi, f. 12. Probably allied to the forms figured as *Denticula*, by Professor Gregory, in his 'Memoir on the Diatoms of the Clyde,' tab. ii.

ZYGOCEROS NAVICULA. Ehr. Microg., t. xix, f. 22. Probably an *annulus* of *Rhabdonema*.

The following are species described from small fragments erroneously referred to the genus, or altogether unknown to me:

BID. URSINA. Ehr. Ber. Pro., 1844, p. 200	} Parts of valves only known.
BID. GIGAS. Ehr. Microg., t. xxxiii, xii, f. 11	
DENTICELLA FRAGILLARIA. Ehr. Ber. Proc., 1844, p. 79	} The generic position quite unknown.
ODONTELLA AMPHICEPHALA. Ehr. Ber. Proc., 1845, p. 363	
ZYGOCEROS SICULUS. Ehr. Microg., t. xxii, f. 53	
ZYGOCEROS PARADOXA. Ibid., f. 54	
ZYGOCEROS CIRCINNUS. Bailey, Notes, t. i, f. 19, 20	
BID. ? BREVIS. Ehr. Ber. Proc., 1845, p. 361.	} Unknown.
BID. CIRRHUS. Pritch. Inf., p. 457	

Before concluding, I propose to offer a few remarks on the affinities of the genus, and the forms that should be grouped in proximity with it, in any natural arrangement of the class. I have already stated my reasons for placing the *Eupodiscus radiatus* of Smith in the present genus, which he had included as a free form in his first sub-tribe; but I should also propose to place the whole genus *Triceratium*, included by him under the same head, as an intermediate connecting link between *Amphitetras* and *Biddulphia*, to which, in the structure of the frustules, they nearly approach, and then together with *Isthmia*, and perhaps the five-angled *Amphipentast* of Ehrenberg, we should form a group most closely allied, both in habit and growth. This arrangement has already had its advocates to a certain extent, as Kützing places his families of *Biddulphiæ* and *Angulatæ* in juxtaposition; and Meneghini states,^x that according to him, the former group has affinity with none but the following one (*Angulatæ*), and, in a letter he had received from Kützing, he intimated his thoughts of reuniting them with the *Tripodisceæ* (*Eupodiscus*, Smith). Mr. Brightwell, also, in his paper on *Triceratium*, remarks,[†] "that looking at *Triceratium favus* as the most perfect plan on which this group is constructed, we find all the species diverging from it, and carrying us to analogous forms in other groups; and further, that placing

* Ray Soc., 1853, p. 486.

† 'Mic. Journ.,' vol. i, p. 252.

T. favius in the centre, we may diverge in lines ending amongst others in one like *Zygoceros rhombus*, especially in the front view, and in another analogous to *Amphitetras antediluviana*;" and Meneghini, in his remarks on *Triceratium*, states that "the perfect resemblance of the primary surfaces, and the large apertures at the three processes in the secondary, render this genus precisely intermediate between *Amphitetras* and *Zygoceros*,"* and in this opinion I fully concur.

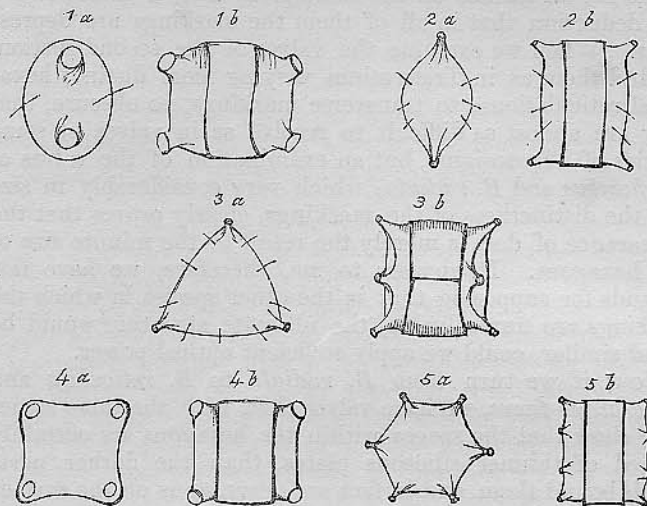
Professor Smith, in his divisions of the order, has formed his first sub-tribe out of those genera, with a deciduous connecting membrane, which he believed to be free or adherent, and excluding *Triceratium*, of which some species have been shown by Colonel Baddeley's gatherings to be filamentous. *Eupodiscus radiatus*, and probably *E. sculptus*, the remainder of this tribe, might probably be well grouped together. The species of *Triceratium*, however, he states had only been met with as isolated specimens, and the points which now show clearly their affinity with *Biddulphia* were then unknown to him, or I hardly think he would have included them in his first sub-tribe, whilst he places the latter genus in the fourth.

If we take the genera *Amphitetras*, *Triceratium*, and *Biddulphia*, we find them all formed on one common plan, composed of two valves, as in the annexed figures, 1 a and 2 a, of various outline, but all having two or more processes, and with a few exceptions two or more spines; and these, as in all others of the class, united by a connecting membrane, but frequently of much greater breadth and persistence of character than in the other sub-tribes. In these characters they differ from all the other genera included by Smith in the 'Synopsis,' and if the forms with five or six angles, probably included by Ehrenberg under the name of *Amphipentas*, be added, we find, as in the annexed diagram, that a complete series may be formed, of which *Triceratium* is the connecting link between the orbicular forms of *Biddulphia* and the many-angled valves of *Amphipentas*.

The only other genera noticed by Ehrenberg or Kützing that appear to be allied to *Biddulphia*, are *Terpsinoe* and *Hemiaulus*. If to the former the *Zygoceros balana* and *Zyg. australis*, Ehr., were added, we should have a genus distinguished from *Biddulphia* by the absence of the angular processes, but with frustules formed very much on the same plan, and separable into two groups of undulating and non-undulating valves, as in that genus, and it should probably be placed between *Biddulphia* and *Isthmia*, instead of being

* Ray Soc., 1853, p. 487.

connected with *Tabellaria* and *Grammatophora*, as proposed by Kützing. Ehrenberg's genus *Hemiaulus* I have had no



1 a and b. Side and front view of *Biddulphia turgida*.
 2 a and b. Ditto, ditto, *Biddulphia rhombus*.
 3 a and b. Ditto, ditto, *Triceratium striolatum*.
 4 a and b. Ditto, ditto, *Amphitetras antediluviana*.
 5 a and b. Ditto, ditto, *Amphipentas*?

opportunity of examining, but his figures and descriptions lead me to suppose it is distinct from *Biddulphia*, but that the position assigned to it by Kützing in the same group is probably correct.

The study of the valves of *Biddulphia*, along with its allies, *Amphitetras*, *Isthmia*, and *Triceratium*, are of considerable interest to the microscopical observer, as from the size and distinctness of the reticulations in some of the species, we are enabled to form a clearer idea as to their structure, than from an examination of forms which require high magnifying powers and careful illumination to elucidate. I believe it is generally admitted that the markings in *Isthmia* and *Biddulphia pulchella* are of the same nature, and from some interesting experiments of Professor Bailey on the action of hydrofluoric acid on the desiccated valves, we learn that in *Isthmia* the "spots gradually become holes" as the valves dissolve;* we may therefore safely conclude that the siliceous matter is thinner in those parts, than in the general frame-

* See 'Sil. Jour.' vol. ii, new series, p. 349.

work of the valve. Now, in the three species included in the first section of my proposed arrangement of the genus, the valves are all formed on the same plan, and, I think, it is a safe deduction that in all of them the markings are depressions. When we examine the valves of the second section, we find them as in *Triceratium* varying from distinct hexagonal reticulations, to transverse markings, so obscure, that they are almost as difficult to resolve as in valves of some species of *Pleurosigma*, but an examination of the valves of *B. rhombus* and *B. radiata*, which vary considerably in size and the distinctness of the markings, clearly proves that the appearance of dots is merely the result of the minute size of the hexagons. It appears to me, therefore, we have fair grounds for supposing that in the other species in which the markings are unresolvable, the ultimate structure would be found similar, could we apply sufficient optical power.

Now, if we turn from *B. radiata* to *B. reticulata* and *Triceratium favus*, we have valves that, with the same structure, show that the spaces within the hexagons are certainly formed of thinner siliceous plates, than the darker parts which bound them, and in fact are depressions on the surface of the valve; and, as it is contrary to all analogy that we should have in the same genus a total difference of structure in the substance of the siliceous membrane of the frustules, I think we may safely conclude that in those species which exhibit merely diagonal lines of apparent dots, as in *B. Baileyi* and *Triceratium striolatum*, when of small size, the structure is of a similar character to that in the species in which it is more clearly defined; and I am inclined, therefore, to agree with Dr. Griffith in the opinion that in these forms, as well as in *Pleurosigma*, the markings are depressions, and not elevations, on the surface of the valve.

PLATE I.

Fig.

- 1.—Front view of *B. Tuomeyii*.
- 2.—Side view of a detached valve of *B. Tuomeyii*.
- 3.—Side view of *B. aurita*, oval variety.
- 4.—Front view of *B. rhombus*.
- 5.—Front view of *B. Baileyii*.
- 6.—Front view of *B. Baileyii* immediately after self-division.
- 7.—End view of *B. Baileyii*, showing the flat central portion of the valve.
- 8, 9.—Side views of detached valves of *B. Baileyii*.
- 10, 11.—Front views of *B. granulata*.

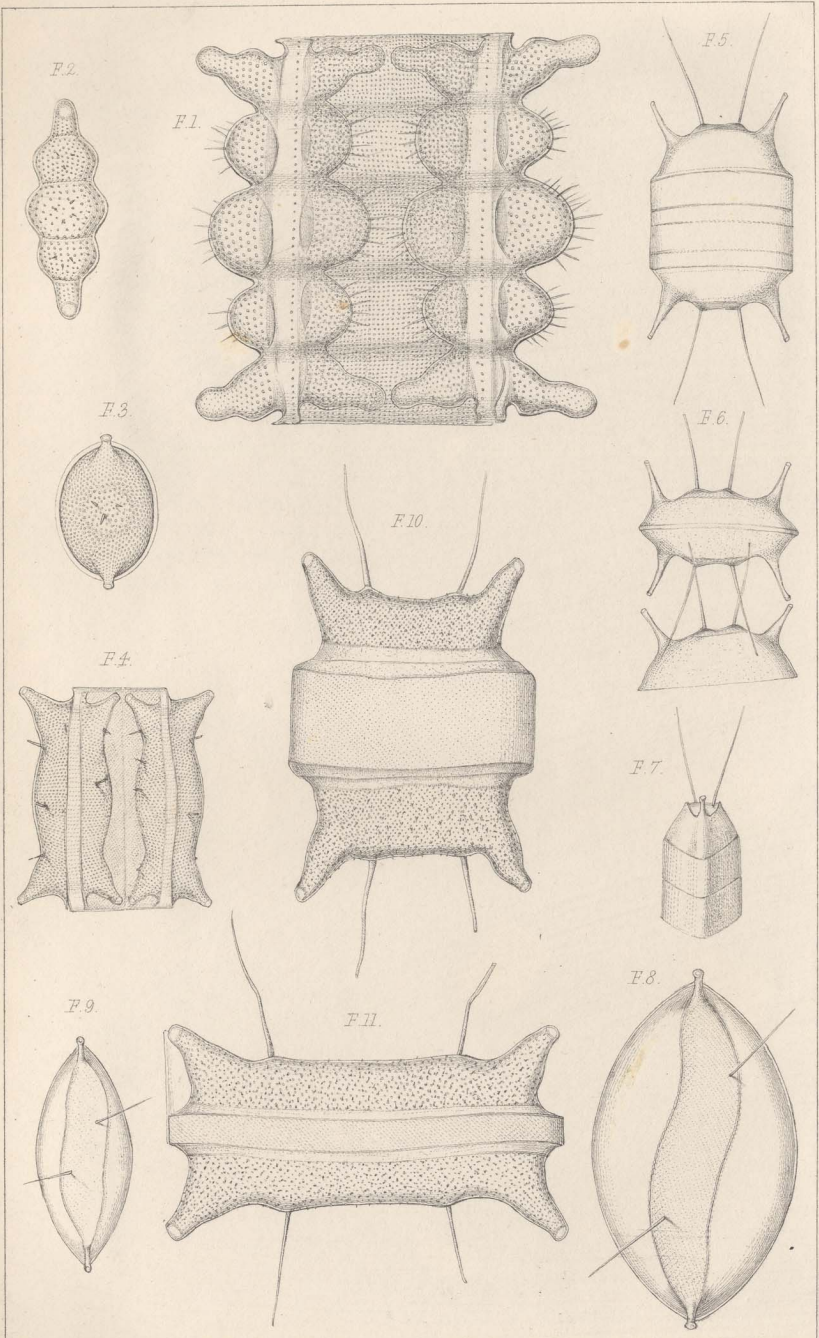


PLATE II.

- 12.—Side view of *B. granulata*.
13, 14.—Front views of *B. reticulata*.
15.—Side view of *B. reticulata*.
16.—Front view of *B. reticulata*, var. β .
17.—Side view of *B. reticulata*, var. β .
18.—Front view of *B. tumida* approaching self-division.
19.—Side view of *B. tumida*.
20, 21.—Front views of *B. Indica*.
22.—Side view of *B. Indica*.
23.—Front view of *B. turgida* from Pembroke Harbour.
24.—Front view of *B. lævis* from West Point, New York.
25.—Front view of *B. lævis* from Natal.
26.—Side view of *B. lævis*.
27, 28.—Front views of *B. radiata*.
29.—Side view of *B. radiata*.

All the figures are \times 400 diameters.

