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A REVISION OF THE BRITISH FOSSIL CAINOZOIC ECHINOIDEA.

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I.—INTRODUCTION.

THE Cainozoic Echinoidea were represented in 1843 in Morris's "Catalogue of British Fossils" by a list of three species and of eight genera of which the species were not determined. Even in this meagre list only one of the generic names was correct: of the three species, one was a manuscript name which has been supplanted, another has died the death of a synonym, and the third was an erroneous identification: the genera were no better, and only one of the eight names still stands in the record of the British Cainozoic fauna. But during the eleven years that elapsed before the issue of the second edition of this Catalogue a great advance had been made. The publication of Agassiz and Desor's "Catalogue Raisonné des familles, des genres, et des espèces de la Classe des Echinodermes" (1846-7), [6]¹, had given an enormous impetus to the study of this group, both recent and fossil, and laid the foundation on which all subsequent progress in systematic Echinology has been based. One of the first results of their labours was Prof. E. Forbes' "Monograph of the British Tertiary Echinodermata," published by the Palæontographical Society in 1852.

At this time no fossils in England had been more diligently collected than those of the Cainozoics. S. V. Wood had made his great collection from the Crags, and the same deposits had been ransacked by E. Charlesworth, E. H. Bunbury, Col. Alexander and Capt. Brown: the London Clay had been worked by N. T. Wetherell at Highgate, and by J. S. Bowerbank at Sheppey; while F. Edwards, C. Stokes, and J. D'Urban had accumulated a vast mass of material from the Middle and Upper Eocenes of the Hampshire basin. As the Echinoidea from all these deposits were rare and mostly fragmentary, they had been neglected, and Forbes, with full access to all these collections, had a fresh field before him; thus of the nine species he described

¹ The numbers in solid type refer to the Bibliography at the end.

from the Eocenes eight were new. It is therefore unfortunate that Prof. Forbes' Monograph was less satisfactory than was most of his work : it shows the same lack of method, neglect of previous literature, and contempt for all rules of nomenclature that mar his "History of the British Starfish," while it lacks the exquisite humour that has given the latter work such widespread popularity. Hence his Monograph did not stimulate so keen an interest in the fossil forms as the companion volume did in the species now living on our coasts. Nevertheless, Prof. Forbes' work will always remain as the most important contribution to our knowledge of the British Cainozoic Echinoidea, and hardly anything has been added to it. The list of Eocene species stands as Forbes left it, while an examination of the table of the Echinoidea from the Crag, given in Mr. Clement Reid's recent Memoir (39, p. 283) shows that the only addition has been that of two recent species recorded as occurring in the Crag by Messrs. A. and R. Bell in a paper published in the Proceedings of this Association (9, pp. 202, 203, 208, 213, 215, 270).

Since 1852, however, a good deal of fresh material has been accumulated in museums and private collections, and this includes several new species. In connection with the description of these it has been thought advisable to undertake a general revision of the group, for such a course enables the affinities of the successive faunas to be more clearly seen.

Though under each species the present resting-place of its type-specimen has been mentioned, it seems useful to give here a general account of the collections in the various Museums. Whether judged by the number or the historical value of the specimens, the collection of the British Museum (Nat. Hist.) is the most important. The collections of S. V. Wood, J. S. Bowerbank, N. T. Wetherell, Caleb Evans, F. Dixon, and J. D'Urban have all found their way thither; while the series of Cainozoic Echinoids has been further enriched by the pick of the specimens from the collection of the late Robert Bell. Messrs. J. Middleton, W. H. Shrubsole, F.G.S., W. J. Lewis Abbott, F.G.S., R. M. Gordon, and D. Robertson, F.L.S., have also generously presented the Museum with interesting specimens. The Museum of Practical Geology must rank next, so far as this group is concerned, since it contains some valuable types from the Crag and nearly all Forbes' Eocene types. The Woodwardian Museum at Cambridge possesses an extensive series of Crag and Eocene specimens, which have yielded much information upon doubtful points of structure. The York Museum contains the Reed collection with the pick of all the Crag specimens collected during the past twenty-five years. In the Wallace collection at the Ipswich Museum there are some splendid specimens, especially of the Spatangoids. The Norwich Museum, besides material which adds fresh evidence as to the distribution of some species, has

some fragmentary remains from the Norwich Crag and Glacial drifts. The Saffron Walden Museum has a few specimens from the Red Crag of Walton; but the Echinoids in this collection cannot compete in interest with its Mollusca.

To the curators and officials of these Museums I must express my best thanks for their courteous help when examining the collections, especially to Mr. E. T. Newton for much valuable assistance in identifying the types at Jermyn Street, and to Mr. W. Reed, F.R.C.S., and Mr. H. M. Platnauer, owing to whose kindness I have had the opportunity of examining the valuable Reed Collection at leisure in London. Finally, I am indebted to Dr. H. Woodward, F.R.S., for permission to describe the new species in the National Collection, to Prof. F. Jeffrey Bell for much help in comparing the fossil with the recent forms, and to Messrs. G. F. Harris and H. W. Burrows for checking the localities of some specimens.

In regard to the synonymy of recent species only records of their occurrence as fossils have been included. The full synonymy of these forms is given by Prof. Agassiz in his "Revision." In a few cases only have the foreign references been given, except for the foundation of the species and the first reference of it to its present genus. The technical terms used in the description of the species are explained in the glossary accompanying Prof. Duncan's "Revision" (22, pp. 295-304).

II.—THE EOCENE ECHINOIDEA.

FAMILY ARBACIIDÆ.

GENUS *CÆLOPLEURUS*, Agassiz, 1840.

Cælopleurus wetherelli, Forbes, 1852.

Cælopleurus wetherelli, Forbes, 1852. Brit. Tert. Ech. p. 24, pl. iii. fig. 1.

" " Desor, 1856. Syn. Ech. Foss. p. 98.

Acrosalenia sp., Morris, 1843. Cat. Brit. Foss. p. 47.

Glypticus sp., Morris, 1843. *Op. cit.*, p. 53.

Records.—35, p. 75: 31, p. 331: 46, p. 595: 32, p. 13: 38, vol. ii., pl. xv. f. 6.

Distribution.—London Clay. Sheppey, Hampstead, Highgate.

Type-specimens.—Museum of Practical Geology (xviii. 1³), British Museum (E 1531).

Remarks.—This species must be compared with *C. spinosissimus* Ag. from the *Calcaire grossier* of the Paris basin, from which it may be distinguished by the greater prominence of the tubercles in the French species and by the fact that the smooth areas at the summit of the interradii are broader and more completely bare. The Upper Eocene species has a few granules on this region.

The occurrence of a genus so typical of the tropical regions of

the Eocene seas is of interest. The species is, however, a dwarfed one in comparison with those of the deposit of the same age in the South of France. The genus lingered on in the Northern Sea; but *Cælopleurus spinosissimus* and the two English species all belong to the same group of small ill-developed forms. With the colder conditions of the Barton epoch the genus seems to have finally disappeared from Northern Europe. Prof. Al. Agassiz accidentally quotes it from the English Pliocene.²

Cælopleurus dixonii, n. sp.

Echinus sp., Dixon, Geol. Sussex, 1850, p. 86, pl. ix. f. 27, 29; ed. 2, 1878, p. 206, pl. ix. [10] f. 27, 29.

Diagnosis.—Form:—Small, round, depressed, but conical. Apical system:—The tubercles are large, depressed, and of uniform size. Ambulacra:—with a double row of uniform tubercles which equal in size those of the interradii. Interambulacra:—at and below the ambitus there is a pair of tubercles on each plate, but above there is only one. These form a row up each side of the interradius, continuous with that of the adjoining area across the ambulacrum by a tubercle on the radial plate. The bare parts of the areas are narrow.

Dimensions.—Diameter 21 mm., height 9 mm.

Distribution.—Bracklesham beds, Bracklesham.

Remarks.—In Dixon's "Sussex" there is given a fairly good figure of an Echinoid from the Upper Bracklesham of Selsea (?), which seems to have hitherto escaped notice. It is, however, unquestionably a *Cælopleurus*, and the figure is taken as the type of this new species. It belongs to the *C. wetherelli* and *C. spinosissimus* group, but it differs from both. It may be readily separated from the former by the much greater coarseness of the tubercles, especially on the abactinal surface. From the latter, with which it is in closer alliance, it differs in having a circular instead of a sub-pentagonal form, smaller tubercles, and more uniformly-sized tubercles in the ambulacral and interradiial areas.

GENUS *ECHINOPELINA*, Cotteau, 1866.

Echinopelina edwardsi (Forbes).

- Echinopelina edwardsi*, Cotteau, 1866. Rev. Mag. Zool. (2) xviii. p. 262.
 " " Duncan, 1889. Journ. Linn. Soc. Zool. xxiii. p. 83.
Echinopsis edwardsi, Forbes, 1852. Brit. Tert. Ech. p. 23, pl. iii. f. 2.
 " " Salter, 1856. Dec. Geol. Surv. v. pl. iii. p. 6.
 " " Desor, 1856. Syn. Ech. Foss. p. 100.
- Records*.—35, p. 78; 31, p. 352; 32, p. 22; 38, pl. xv. f. 8; 27, p. 633.

Type-specimen.—Museum of Practical Geology (xix †).

Distribution.—Bracklesham series, Bracklesham.

² Illustr. Cat. Mus. Comp. Zool. vii. p. 752, 1874

Remarks.—The only doubt about this species is as to its geological range. Forbes describes it as a Bracklesham species from Bracklesham and from the upper marine bed at Barton. In the Cat. Coll. Mus. Pract. Geol. it is quoted from both Bracklesham and Hordwell. The specimen from the latter place is too imperfect for satisfactory determination; but the poriferous areas are far narrower than in this genus.

M. Cotteau and Prof. Duncan both describe it as from the London Clay, but this is a mere slip.

The closest ally of this species is the *E. gacheti* (Desmoul.)³ from the *Calcaire grossier*. The English species differs from the latter by the greater height of the interambulacral plates, which in consequence number fewer in a vertical series: in *E. edwardsi*, moreover, the secondary tubercles form a scrobicular circle with one or two scattered granules in addition. In *E. gacheti* they are more numerous and form double horizontal rows along the plate on each side of the main tubercle.

FAMILY FIBULARIIDÆ.

GENUS *SCUTELLINA*, Agassiz, 1841.

Scutellina lenticularis (Lamarck) 1816.

- Scutellina lenticularis*, Agassiz, 1841. Mon. des Scutelles, p. 101, pl. xxi. f. 20-23
nummularia, Agassiz, 1841. *Op. cit.* p. 99, pl. xxi. f. 8-14.
 „ *toilliezi*? Le Hon, 1862. Description succincte de quelques espèces animales des terrains tertiaires éocènes des environs de Bruxelles, p. 9.
Scutella lenticularis, Lamarck, 1816. Anim. S. Vert. 1st ed. vol. iii. p. 10.
 „ *nummularia*, DeFrance, 1827. Dict. Sci. Nat. vol. xlvi. p. 231.
Echinarachnius lenticularis, Agassiz, 1836. Mém. Soc. Sci. Nat. Neufchatel, i. p. 188.

Distribution.—British—Bracklesham Beds. Foreign—*Calcaire grossier*, France. *Laekenien infér*, Belgium.

Remarks.—*Scutellina lenticularis* is one of the most characteristic Echinoids of the *Calcaire grossier*, and the discovery of two specimens in the Bracklesham beds of the Hampshire basin therefore strengthens the resemblance of the Echinoid faunas of the two deposits. The exact locality of the specimens is unfortunately unknown. They belong to the Edwards Collection, now in the British Museum (49821-2), and were recorded as a new *Echinus*. One of them is half buried in matrix, and this enables Messrs. Harris and Burrows to decide that they are British, and probably from Bracklesham Bay. Those gentlemen are not acquainted with any similar matrix in the Belgian or French Tertiaries. The small size of this species may account to some extent for its rarity.

³ Desmoulins, Etudes sur les Échinides, 1837, p. 300.

FAMILY SPATANGIDÆ.

DIVISION Prymnadete.

GENUS *HEMIASTER*, Desor, 1847.*Hemiaster bowerbanki*, Forbes, 1852.

Hemiaster bowerbanki, Forbes, 1852. Brit. Tert. Ech. pp. 24, 25, pl. iii. f. 6 (non 6e). Desor, 1857-8. Syn. Ech. foss. p. 375.

Ditremaster bowerbanki, Cotteau, 1887. Pal. Franç. Eoc. Ech. i. p. 426.

non *Hemiaster bowerbanki*, J. Delanoue, 1868. Compt. Rend. lxvii. p. 706.

Spatangus sp., Prestwich, 1850. Quart. Journ. Geol. Soc. vi. p. 267.

Spatangus (? *H. bowerbanki*), Whitaker, 1872. Mem. Geol. Surv. iv. pl. i. p. 585.

Records.—35, p. 81; 31, p. 331; 46, pp. 585 and 595; 32, p. 13.

Distribution.—London Clay. Sheppey. Basement-bed; Katesgrove Kiln, Reading, and, *vide* Prestwich and Whitaker, in Sonning Railway-cutting.

Type-specimen.—Museum of Practical Geology (xviii. $\frac{3}{13}$).

Remarks.—The Eocene Spatangoids described by Forbes are rare, very badly preserved, and form the most difficult group of the British Eocene Echinoidea. This species, however, is one of the best known, and the questions as to the sub-division of Desor's genus *Hemiaster* may be conveniently considered in regard to it. M. Munier Chalmas,⁴ in 1885 established the genus *Ditremaster* for species of *Hemiaster* with only two genital pores: M. Cotteau⁵ has subsequently accepted and enlarged this genus and referred *H. bowerbanki* to it, although Forbes' figure clearly shows the presence of four genital apertures. Prof. Duncan and Mr. Sladen (23) have recently subjected the genus *Ditremaster* to very vigorous criticism and emphatically decline to accept it. The arguments they adduce seem to me perfectly unanswerable, proving that the number of generative pores is not of generic or even of a specific value in this group. The species is therefore retained in *Hemiaster*.

Hemiaster prestwichi, Forbes, 1882.

Hemiaster ? *prestwichi*, Forbes, 1852. Brit. Tert. Ech. p. 25, pl. iii. f. 5. Desor, 1857-58. Syn. Ech. foss. p. 375.

Ditremaster prestwichi, Cotteau, 1887. Pal. Franç. Eoc. Ech. i., p. 426. Records 35, p. 81; 31, p. 331; 46, p. 595; 32, p. 13.

Distribution.—London Clay. Sheppey.

Type-specimen.—Museum of Practical Geology (xviii. $\frac{3}{13}$).

The objections to the genus *Ditremaster* referred to in the remarks on the previous species apply with equal force to this. Forbes was in doubt as to the genus to which this belongs, and

⁴ Compt. Rend. 1885, ci, p. 1076.

⁵ Pal. Franç. Echinides Eocènes; 1887, pp. 411, 412.

suggested it might have to be transferred to *Macropneustes*. His doubts were suggested by the apparent absence of the fasciole; but the condition of preservation amply accounts for this. The whole aspect of the fossil is that of a *Hemiaster*. The species can be easily distinguished from *H. bowerbanki* by the fact that the petaloid portion of the paired ambulacra are nearly flush with the test.

Hemiaster? *branderi*, (Forbes) 1852 *pars.*

Hemiaster branderianus *pars.*, Forbes, 1852. Brit. Tert. Ech. pp. 25-26, pl. iii. f. 8, a. b. c.

Brissopsis branderiana, Desor, 1857-8. Syn. Ech. Foss. p. 381.

„ Dujardin and Hupé, 1862. Hist. Nat. Zooph. Ech. p. 598.

Trachyaster branderianus, Cotteau, 1887. Pal. Franç. Eoc. Ech. i. pp. 406-7.

Ditremaster „ Cotteau, 1887. *Op. cit.* p. 427.

Records.—35, p. 81; 31, p. 352; 32, p. 29; 27, p. 633.

Distribution.—Barton Clay. Highcliff, Barton.

Type.—M.P.G., xviii. $\frac{3}{15}$ a.

Remarks.—This species was founded by Prof. Forbes on a specimen (pl. iii., fig. 8, a. b. c.) from the Barton Beds, and on one (pl. iii., fig. 8, d. e.) from the London Clay of Haverstock Hill. The material was all so imperfect that neither the descriptions nor figures enabled subsequent palæontologists to get any clear conception of the species. Hence, as a rule, the specimens of *H. branderi* have been included under the one described British species of *Schizaster*, viz., *S. d'urbani*; while *Hemiaster branderi* has been retained for some specimens from the London Clay. Prof. Forbes' specimens belong, not only to different species, but probably to different genera; and, as his description was based on the Barton specimen, this must be regarded as the type, and a new species provided for the Lower Eocene forms.

The species is very imperfectly known and the genus is uncertain. It has been referred by Desor and others to *Brissopsis*, and as Prof. Duncan (22, p. 249) records that genus from the English Eocenes, he seems also to have shared in this opinion. As I am unacquainted with any evidence in support of this conclusion the species is here left in *Hemiaster*. If the species were better known it would not improbably have to be transferred to *Schizaster*.

Hemiaster forbesi, n. sp.

(Pl. I, Figs. 4, 5, 6.)

Hemiaster branderianus (*pars.*), Forbes, 1852. Brit. Tert. Ech. pl. iii. fig. 8 d. 6 e.

Morris, 1854. Cat. Brit. Foss. ed. 2, p. 81.

Huxley and Etheridge, 1865. Cat. Foss. Mus. Pract. Geol. p. 331.

Whitaker, 1872. Mem. Geol. Surv. iv. pl. i. p. 595.

- Hemaster branderianus*, Huxley, Etheridge and Newton. Cat. Tert. and Post-Tert. Foss. Mus. Pract. Geol. p. 13.
 " " Lobley, 1887. Trans. Middlesex Nat. Hist. and Sci. Soc. p. 93.
 " " J. Prestwich, 1888, Geol. ii. pl. xv. f. 9.

Diagnosis.—Form: an irregular rounded hexagon, broadest at apical disc. In elevation it is seen to be high; the anterior margin is tumid; the posterior interradius is carinate and terminates abruptly in a steep flat slope; the anus is high up on this and can be usually seen from above; anterior furrow broad, and makes a deep notch in the anterior margin.

Apical disc: behind the centre.

Ambulacra: in deep impressions. Anterior furrow, broad and long. Petals of the anterior pair half as long again as those of the posterior; the latter short and blunt.

Fasciole: broad, sinuous, thickening considerably at the ambulacra.

Anus: oval, high up on the posterior slope; visible from above.

Peristome: somewhat far removed from the anterior margin.

Dimensions.—

	mm.
Length	20
Height	13
Diameter	18
Length of antero-lateral ambulacrum	8
Width	3
Length of postero-lateral ambulacrum	4
Width	1.75
Distance of apical disc from anterior margin	11

Distribution.—London Clay, basement bed. Pinner; ? Hampstead and Sheppey.

Type-specimen.—In British Museum (E 3394).

Remarks.—The specimens on which this species is founded were collected by R. M. Gordon, Esq., from the basement bed of the London Clay at the Metropolitan Railway extension at Pinner, and kindly presented by him to the British Museum. It seems to have been extremely abundant there. Mr. Shrubsole has also presented to the same museum a specimen from Sheppey (E 123) which belongs to this species. It is moreover probable that the fragment from Hampstead figured by Forbes (pl. iii. fig. 8, d. e.), and referred by him to *H. branderi* may also be included here. It is certainly not the same species as the true Barton *H. branderi*.

The species finds its nearest ally in *H. bowerbanki* (Forbes), from which it differs in that the anterior margin is more affected by the groove of the unpaired ambulacrum, the lateral ambulacra are longer and more equal and the posterior margin is more vertical.

GENUS *SCHIZASTER*, L. Agassiz, 1847.*Schizaster d'urbani*, Forbes, 1852.

Schizaster d'urbani, Forbes, 1852. Brit. Tert. Ech. p. 27, fig. p. 36. No. 1.
 " " Desor, 1857-8. Syn. Ech. Foss. p. 390.
 " " Cotteau, 1887. Pal. Franc. Eoc. Ech. i. p. 364.
Records.—35, p. 89 ; 27, p. 633 ; 38, pl. xv. fig. 5 ; 12, p. 283.

Distribution.—Bracklesham Beds.⁶ Alum Bay.

Remarks.—This species, as far as I am aware, is still represented by the two specimens from the Alum Bay which were known to Professor Forbes, and are now in the British Museum. The other records have probably been due to the confusion that has long existed between this species and the *Hemiasster branderi* (Forbes) from Barton. *S. d'urbani* may be recognised by its deep, broad, and flat-bottomed anteval furrow.

Schizaster corneti? Cotteau, 1880.

Mém. Cour. Acad. Roy. Sci. Belgique, xliiii. fasc. 3, p. 63-4, pl. v., figs. 6 and 7.

Distribution.—British—Thanet Beds, E. of Canterbury.
 Foreign—*Landenien infer*, Belgium.

Remarks.—Mr. Jas. Horsley found, in the Thanet beds, east of Cambridge, three specimens, which he presented to the British Museum (39,972). The specimens are not only in the condition of mere casts, but they have been considerably distorted by pressure. Hence it is impossible to determine them with certainty. The smallest specimen suggests the reference of the specimens to the species of *Schizaster* found in the corresponding beds in Belgium. The well-rounded anterior margin, the sharp tapering posterior end, the broad anterior groove, and the position of the apical disc, are all points of agreement with this species: the great height of the crushed largest specimen, however, throws some doubt on the identification.

Schizaster cuneatus, n. sp.

(Pl. I. Figs. 1, 2, 3.)

Diagnosis.—Form: hexagonal in shape, with rounded angles. In elevation the anterior end is seen to be depressed, with a long flat slope, while posteriorly it is high and carinate. The posterior margin is vertical.

Apical system: posterior.

Ambulacra: deeply impressed. The anterior is a broad, long furrow with parallel sides, deeply notching the anterior margin. The antero-lateral ambulacra curve forward and the petaloid portions extend to about half-way to the ambitus. The petals of the postero-lateral ambulacra are short and blunt, and are close to the median keel.

⁶ Bristow, Geol. Isle of Wight, 1862, p. 124, marks this species from the Lower Greensand; but that is obviously a slip.

Interradii : the postero-laterals are the widest ; the antero-laterals and the posterior interradii forming high, narrow ridges near the apical system.

Epistroma : of close-set granules, generally uniform, but largest at the anterior margin. Fascioles : a sinuous peripetalous fasciole and a lateral one which runs from the former just behind the end of the antero-lateral petal.

Spines long and delicate, most of them on the actinal plastron curved, and some spoon-shaped.

Peristome : anterior reniform in shape ; labrum well developed.

Anus : oval, high on the vertical posterior margin.

Dimensions.—

	mm.
Length	26
Breadth, at anterior third	23
„ at posterior third	25
Height	17
Ambulacra : length of anterior petal	9
„ breadth „ „	3
„ length of posterior petal	5
„ breadth „ „	2
Distance of apical disc from anterior margin	1·7

Distribution.—London Clay, Bognor. ? Hampstead Well, B.M. (E. 1695).

Type-specimen.—Cambridge Museum ($\frac{a. 1. 18.}{F.}$)

This species belongs to the group of which *Schizaster vicinalis*, Ag. and Des.⁸ from the Upper Eocene of the South of France and North Italy is a convenient type. Its main features are the flat, gradual, anterior slope from the high carinate posterior, which gives it, when viewed from the side, a wedge-shaped form, as suggested in its name. From *S. vicinalis* it differs in that in the foreign species the anterior slope has a more rounded surface, the antero-lateral ambulacra are more than twice as long as the postero-lateral, and the test is somewhat narrower. From *S. leymeriei* Cott.⁹ it differs in the fact that that species is widest in front instead of behind.

This new species must also be compared with *S. buanesensis* Cott.¹⁰ from the Lower Eocene of the Landes. They agree in general proportions, but in the French species the apical disc is nearer the centre, and the shape is more rounded.

The only English species with which *S. cuneatus* could be confused is *S. branderi* (Forbes). The latter may be recognised by its more depressed form, the shortness and breadth of the

8 Cat. Rais. Ann. Sci. Nat. Zool. (3) viii. 1847, p. 21.

9 Catalogue des Echinides Fossiles des Pyrénées : Bull. Soc. Geol. France (2) xiii. 1856. p. 341.

10 Pal. Franç. Echinides Eocènes, vol. 1887, pp. 294-5, pl. lxxxviii. fig. 6-8.

postero-lateral ambulacra, and the shape of the anterior ambulacrum.

DIVISION PRYMNODESMIA.

GENUS *MARETIA*, Gray, 1855.

Maretia grignonensis (Desmarest), 1836.

Maretia grignonensis, Cotteau. Mém. cour. Acad. Coy. Sci. Belg. 1880, xliii. fasc. 3, p. 75.

Spatangus grignonensis, Demarest, 1836, in Desmoulins' Tableaux Synonymiques, p. 390.

" *omalii*, Galeotti, 1837, Mém. sur la constitution géologique de la province de Brabant, p. 191, pl. suppl. fig. 1.

Forbes, 1852. Brit. Tert. Ech., p. 28, pl. iii. fig. 9.

" *omaluisi*, Dewalque, 1868. Prodr. d'une description géol. de la Belgique, p. 408.

" *archiaci*, Agassiz and Desor, 1847. Ann. Sci. Nat. Zool. (3), viii. p. 8.

Hemispatangus grignonensis, Desor, 1857-8. Syn. Ech. foss., p. 416.

" *archiaci*, Desor, 1857-8, *Op. cit.* p. 416.

Records.—35, p. 89; 27, p. 633.

Distribution.—British: Barton beds, Barton. Foreign: Calcaire grossier, Paris basin; Ypresien supér., Brabant; Bruxellien, Laekenien, and Wemmeliën, Belgium; Upper Eocene, Hungary; Germany (Samland).

Type-specimen.—Museum of Practical Geology (xix. $\frac{5}{12}$ a).

Remarks.—Fragments only of this species are known from the English deposits, and these were all collected at Barton. Forbes identified them as *Maretia omali* Gal., a synonym of *Maretia grignonensis* (Desm.), a species with which he was well acquainted. Some additional fragments have been found, but, though they prove that it is a true *Maretia*, they afford no additional evidence as to the accuracy of the specific determination.

GENUS *EUSPATANGUS*,¹¹ Agassiz, 1847.

Euspatangus hastingiæ, Forbes, 1852.

Euspatangus hastingiæ, Forbes, 1852. Brit. Tert. Ech., p. 26-7, pl. iii. fig. 7.

Records.—35, p. 79; 31, p. 352; 32, p. 29; 27, p. 633; 38, pl. xv. f. 7.

Distribution.—Barton beds, Barton.

Type-specimen.—Museum of Practical Geology.

This species remains as Prof. Forbes left it. The only specimens are in the Museum of Practical Geology. Though the species has been well diagnosed and figured by Forbes, it has escaped the notice of foreign palæontologists. It is a very close ally of *E. ornatus* (Defr.),¹² the commonest species in the Eocenes of the south of France, Italy, and Spain.

Euspatangus excentricus, n. sp.

Diagnosis.—Form: cordate elongated; widest half-way along the test, tapering gently to the posterior margin; a broad, shallow

¹¹ The name was often spelt Eupatagus.

¹² In Brongniart, Géologie des environs de Paris, 1822, pp. 86 and 389, pl. v. fig. 6.

groove slightly interrupting the anterior margin. In elevation it is seen to be depressed, terminating abruptly at both ends. The vertex is about half-way from the ends and behind the apical disc.

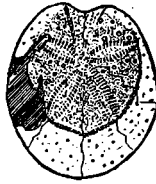


Fig. 1. *Euspatangus excentricus*.

Apical system : with four large genital pores, situated at $\frac{1}{3}$ length of the test from the anterior margin.

Ambulacra : flush with the test. The anterior with small pores is inconspicuous in the shallow anteal groove. The antero-lateral pair is very narrow close to the apical disc, with very small pores ; the petaloid portion then expands by the curvature of the anterior zones, which curve back again towards the posterior, and close the petal by an acuminate point. In the posterior pair the two halves of each petal are more equal and similar ; both being slightly convex, enclosing an interporiferous area which tapers gently in both directions.

Interradii : the posterior area is elevated, but rounded so as to make no approach to a keel.

Epistroma : a few large, deeply scrobiculate tubercles in each of the paired interradii.

Fasciole : subanal, not seen. The presence of a peripetalous fasciole is indicated by the structure of the test and distribution of the tubercles.

Anus : high on the posterior vertical margin ; oval in shape.

Distribution.—Barton beds, Barton.

Type-specimen.—British Museum (49820).

Dimensions.—

	mm.
Length	23
Height	9
Breadth	21
Length of antero-lateral petal	8
Width	2
Length of postero-lateral petal	9
Width	2.5
Distance of apical system from anterior margin	6

Remarks.—Of the Eocene species of *Euspatangus* which M. Cotteau has enumerated in his recent valuable revision of the genus this species differs from nearly all in the very excentric position of the apical disc. This is at one-third the length of the test

from the anterior margin. It most closely resembles a specimen of *E. antillarum*, Cott., figured by M. Cotteau;¹³ but the English species may readily be distinguished by its cordate form, its oval anus, and the absence of large tubercles in the unpaired interradius. The Indian *E. rostratus* has a very different form, while *E. beyrichi* has an unusual irregularity of form and distribution of the tubercles.

The following species and records have been based either on spines or indeterminable fragments, and hence for comparison with other faunas are valueless.

***Cidaris websteri*, Forbes, 1852.**

Cidaris websterianus, Forbes, 1852. Brit. Tert. Ech. p. 22, pl. iii. f. 4.

Records.—31, p. 352; 46, p. 595; 32, p. 29; 33, p. 90; 27, p. 633.

Distribution.—London Clay; Hampstead (*vide* Whitaker and Lobley. Barton beds; Barton (Spine, t., M.P.G.)

“*Echinus*” (!) *dixonii*, Forbes, 1852.

Echinus dixonianus, Forbes, 1852. Brit. Tert. Ech. p. 22, pl. iii. f. 3.

Records.—31, p. 353; 32, p. 29; 27, p. 633.

Distribution.—Bracklesham beds (hard bed), Bracklesham. Barton beds, Barton (Spine, t. M.P.G.)

Miscellaneous Indeterminable Species.

Diadema sp., Oldhaven beds (46, p. 581).

Echinus spines, Thanet Sands, Pegwell Bay (46, p. 575).

Schizaster sp., Thanet Sands, Pegwell Bay, and near Canterbury (46, p. 575).

Spatangus sp., London Clay (upper sandy bed), Hampstead (33, p. 89).

The British Museum also possesses Echinoid spines from Barton and Bracklesham, and from the London Clay at Islington.

III.—PLIOCENE.

FAMILY **CIDARIDÆ.**

GENUS *CIDARIS*, Leske, 1778.

***Cidaris* sp.**

Distribution.—Coralline Crag, Sutton.

Remarks.—The genus *Cidaris* is rare in the Pliocene, and as the parts of the test are loosely attached together, it is usually known only by disconnected plates and spines. A few such have been found in the English Crag; most of them being rolled and worn plates belonging to Chalk species but there are a few which do not agree in structure with any of those from that horizon. As the genus certainly lived in the Belgian Pliocene seas these plates were probably derived from a Crag species.

¹³ Cotteau, K. Svensk. Vet. Akad., Handl. xiii., No. 6, 1875, pl. vii. fig. 12.

Three plates and the same number of spines from the Coral-line Crag of Sutton (Wood Coll. B.M.E. 577) give us some idea of the characters of the species, which was a close ally of *Cidaris belgica*, Cott., though differing from it in several characters. The remains, however, are too fragmentary for any description to be given by which it would be possible to determine whether plates from other parts of the test, that may be discovered, belong to this species or not. The occurrence of the specimens is therefore merely recorded as showing the existence of the genus in the English Crags.

FAMILY TEMNOPLEURIDÆ.

SUB-FAMILY Glyphocyphinae.

GENUS *TEMNECHINUS*, Forbes, 1852.

The genus *Temnechinus* is one of the most interesting of those found in the English Crags. It was founded by Forbes for four species, which were all limited to those deposits. Others, however, from other formations, have since been added to it. Thus, Prof. Duncan and Mr. Sladen have referred to it a series of species from the Indian Miocene and Pliocene, and Prof. A. Agassiz has described a recent form from the West Indies. Desor, however, had in 1856 founded a genus *Opechinus* for the Indian species and for one from Java, *Opechinus percultus*, Desor.¹⁴ Prof. Duncan, in his valuable memoir on the genus *Pleurechinus*, dismissed *Opechinus* as "valueless" and as due only "to the chances of the growth of ornamentation."¹⁵ In conjunction with Mr. Sladen, in the *Palæontologica Indica*, and again in his "Revision of the Genera" (p. 108),¹⁶ Prof. Duncan followed the same course. But though Prof. Duncan's work first established a satisfactory classification of this group of Echinoids, and clearly demonstrated the fundamental differences between the pits of *Temnechinus* and *Temnopleurus*, it is possible that he and his colleague have under-estimated the differences between the typical species of *Temnechinus* and those for which *Opechinus* was founded. Prof. von Zittel has preferred to retain both genera;¹⁷ and as the Crag and the living Atlantic species form one closely-allied group, while the Oriental species form another, it seems to me that this is the wisest course. The differences between the two groups of species may be only due to the disposition of the raised epistromal ribs, but these affect so materially the whole aspect of the tests, and the epistroma plays so prominent a part in the classification of the Glyphocyphinae that it is convenient to express the differences in this way.

¹⁴ Of which *Pleurechinus javanus*, Martin; ("Die Tertiärschichten auf Java," Leiden, 1880, Anhang, p. 2, fig. 1, 1 a and b), is a synonym.

¹⁵ "On the genus *Pleurechinus*, L. Ag.; its classification, position, and alliances." Journ. Linn. Soc. Zool. xvi. 1882, p. 449.

¹⁶ Ser. xiv. vol. i. pt. 3, fasc. iii. 1884, p. 122.

¹⁷ *Palæontologie*, Bd. 1, lf. 3, 1879, p. 506.

In the "Revision of the Genera," Prof. Duncan includes *Temnechinus* in the sub-family Temnopleurinæ, but I would suggest its transference to the Glyphocyphinaæ, owing to the complete absence, at least in the genus as here limited, of the true pits of the former sub-family. In the paper on *Pleurechinus* Prof. Duncan says emphatically that "*Temnechinus*, Forbes, has no true pits," and again that in it "none of the remarkable minute structures of the test of *Temnopleurus* are present."¹⁸ But, as Prof. Duncan shows in his diagnoses of the two sub-families in the Revision, it is the presence of true pits that is characteristic of the Temnopleurinæ; the possible occasional presence of a pit that is somewhat deep but does not undermine the test not being sufficient to outweigh the identity in structure between the fossettes of *Temnechinus* and those of *Glyphocyphus* or *Zeuglopleurus*.

Temnechinus woodi (L. Agassiz), 1846.

- Temnopleurus woodii*, L. Agassiz, 1846. Ann. Sci. Nat. Zool. (3) vi. p. 360.
 " *excavatus*, Wood (name only), Morris, 1843. Cat. Brit. Foss. p. 60.
Temnechinus excavatus, E. Forbes, 1852. Brit. Tert. Ech. pp. 6, 7, pl. 1, f. 1.
 " " " Dec. Geol. Surv. No. iv. pl. 1.
 " " Desor, 1856. Syn. Ech. Foss. p. 106, pl. xvii. f. 6, 7.
 " " Gregory, 1891. Ann. Rep. Yorksh. Phil. Soc. p. 38.
 " *melocactus*, E. Forbes, 1852. Brit. Tert. Ech. pp. 7, 8, pl. i. f. 2.
 " " " Dec. Geol. Surv. No. iv. pl. i. p. 4.
 " " Desor, 1856. Syn. Ech. Foss. p. 106.
 " *turbinatus*, E. Forbes, 1852. Brit. Tert. Ech. pp. 8, 9, pl. iii. f. 11.
 " " " Dec. Geol. Surv. No. iv. pl. i. p. 4.
 " " Desor, 1856. Syn. Ech. Foss. p. 106.
Temnopleurus, sp. S. V. Wood, MS. 1843. Morris' Cat. Brit. Foss. p. 60.
 Records.—35, p. 90; 31, p. 368; 32, p. 50; 38, pl. xv. f. 14; 39, p. 283. fig. 6, p. 40.

Distribution.—Coralline Crag; Orford, Ramsholt, Sutton, Waldingfield. Red Crag; Boyton, Butley, Foxhall, Sudbourn, Sutton, Waldringfield, Woodbridge.

The "Marsupial Pouches."

The majority of the Crag Temnechinini are marked by a series of five depressions at the summits of the interradii, and these are connected by a circular depression which surrounds the apical disc; in these depressions the epistromal ridges are not developed, so that the fossettes ("sutural pits" of Forbes) are confluent. In other forms these depressions were absent and the sutural pits separate over the whole test, and these forms were at the same time much higher. The former set Prof. Forbes named *Temnechinus excavatus* (a name, however, anticipated by *T. woodi* [L. Ag.]) and the latter *T. melocactus*. Forbes gave no suggestion as to the possible nature of these depressions, the first light upon this

subject being given by M. de Loriol, who described and figured a specimen of *Tripneustes variegatus*, from Mauritius, with a similar series of structures, and this specimen, it is interesting to note, is very much depressed in its general form. Prof. F. Jeffrey Bell has kindly shown me a series of similar specimens of the same species in the British Museum Collection. There can be no doubt that the differences in this case are not of specific value, and, though the Crag specimens are far more regularly affected than those from Mauritius, it is probable that they are due to the same cause. This is rendered still more likely by the discovery of a similar series of depressions in some specimens of *Echinus henslowi* from the Red Crag. As to the cause of the depressions there is no very definite information; but as the specimens of *Tripneustes variegatus* in this condition do not seem uncommon it is to be hoped that one will be dissected, and the regularity of the depressions in the Crag specimens renders it in the highest degree improbable that they are pathological malformations. As they occur on the interradial, just below the openings of the genital glands, it is probable that they are marsupial pouches, such as occur in some Spatangoids (see, e.g., the remarks on *Schizaster d'urbani*, Forbes, p. 24 *supra*). It should be pointed out that in the previously known cases of the presence of these marsupial pouches, they are always developed on the ambulacra instead of on the interradial, and it might be thought at first that this presented a difficulty to the acceptance of the hypothesis; but it must be remembered that the ambulacral tube feet of the upper surface are of far less value, at least as locomotory organs, to the Spatangoids than to the regular Echinoids; the deep excavation of the areas would not interfere with the branchial function of the tube feet affected in the former, though it would be fatal to their powers of assisting in locomotion in the latter. Hence it is only natural that while in the Spatangoids the marsupial depressions are hollowed out of the ambulacra, in the Temnopleuridæ and Echinidæ the interradial are the regions made to accommodate these structures. The fact that the specimens of the recent *Tripneustes variegatus* with these pouches are less abundant than the normal forms may show either that this species is only exceptionally viviparous, or that the depressions are of a different nature in this case. Their irregularity in the British Museum specimens suggests that possibly they may be mere monstrosities, as M. de Loriol has supposed. If the explanation of these depressions that has been suggested is correct, then *Temnechinus excavatus* is the female, and *Temnechinus melocactus* the male of the species *Temnechinus woodi* (L. Ag.). But Prof. Forbes has noted another difference between the two than those connected with this sexual dimorphism. Thus, he emphasized as one of the important points of distinction between the two species, that in *T. excavatus* the width of an ambulacrum was to that of an interradius as one to two, whereas

in *T. melocactus* the proportion was two to three. But Prof. Forbes knew of only three specimens of the latter; whilst I have measured twenty specimens. There is a range in relative width of the two areas in the *excavatus* type from 5 : 7 to 5 : 11, and in the *melocactus* or male type of from 5 : 7.5 to 5 : 10. Similarly, though the former is usually more depressed, the proportion of height to diameter varies from 5 : 8 to 5 : 13, while in the latter of from 5 : 7 to 5 : 10. Hence neither of these characters are of any use as a specific distinction, and the two species may be merged.¹⁹

Prof. Forbes founded two other species, *T. globosus*, for a couple of specimens from Ramsholt, and *T. turbinatus*, for an immature Red Crag form. The latter is certainly only a young *T. woodi* (i.e., *T. melocactus*, Forbes), while the former is probably distinct. There are two additional specimens of it in the York Museum.

Temnechinus globosus, Forbes, 1852.

- Temnechinus globosus*, Forbes, 1852. Brit. Tert. Ech. p. 8, pl. i. f. 3.
 " " " Dec. Geol. Surv. No. iv. pl. i. p. 4.
 " " E. Desor, 1856. Syn. Ech. foss., p. 106.
 " " H. Nyst, 1868, in Dewalque Prodr. descr. Géol. Belgique, p. 433.
 " " A. Agassiz, 1870. Illustr. Cat. Mus. Comp. Zool., No. vii. pl. viii. fig. 30.

Records.—35, p. 90; 31, p. 368; 32, p. 50; 39, p. 283.

Distribution.—British: Coralline Crag, Ramsholt. Belgium—Diestien and Scaldisien (*vide* Nyst: a record never since confirmed).

Type-specimen.—British Museum (E. 583).

FAMILY ECHINIDÆ.

GENUS *ECHINUS*, Linn., 1758.

Echinus woodwardi, Desor, 1846.

- Echinus (Psammechinus) woodwardi*, Desor, 1846. Cat. Raiss. Ann. Sci. Nat. Zool. (3) vi. p. 369.
Psammechinus woodwardi, Desor, 1856. Syn. Ech. foss. 1856, p. 121.
 " " G. Dollfus, 1875. Bull. Soc. Géol. France (3) iii. p. 474.
 " " " 1880. Bull. Soc. Géol. Normandie, vi. p. 515.
Echinus lamarcki, Forbes, 1852. Brit. Tert. Ech. pp. 2-4, pl. i. f. 4.
 " " Desor, 1856. Syn. Ech. Foss. p. 123.
 " " H. Nyst., 1868, in Dewalque. Prod. Descr. Géol. Belgique, p. 433.
 " *sp.* H. B. Woodward, 1881. Geol. Norwich, p. 54.
 " *sp.* Cl. Reid, 1882. Geol. Cromer, p. 66.

Records.—35, p. 79; 31, p. 368; 32, p. 49; 38, xv. f. 16; 37, p. 123; 39, p. 283; 30, p. 39.

¹⁹ Since writing the above, I have had the advantage of discussing the matter with Mr. Sladen, whose opinion on the group is of especial value, owing to his experience with the Indian species. I am glad to find that he agrees with me on all three points, *viz.*, that *Opechinus* is generically distinct from *Temnechinus*; that both belong to the Glyphocyphinae; and that the depressions in *T. woodi* are marsupial.

Distribution.—British: Coralline Crag, Aldborough; Broom Hill; Diss; Gedgrave; Iken; Layston Rd.; Orford; Ramsholt; Sudbourne; Sutton. Red Crag, Butley; Valley Farm, Sudbourne; Walton. Norwich Crag, Lower, Bramerton; Kirkby. Norwich Crag, Upper, Bramerton. Chillesford Crag, Aldeby. Weybourne Crag, E. Runton (Spines, M.P.G.). Foreign: Conglomérat à Térébratules des Bohons, Normandy (*vide* Dollfus).

Remarks.—Desor's original description was meagre, and made no mention of the most reliable character by which the species can be distinguished from its near ally *Echinus esculentus*, Linn., the commonest sea-urchin of British seas. The characteristic Crag species can be recognised by the granule between the pores; and the tuberculation is moreover far more prominent than in the recent form. As there can be no doubt of the species that Desor intended, his name must supersede that of Forbes, though the former failed to recognise the identity of the two species. *E. nysti*, Cott, which was originally referred to this species is unquestionably a very close ally.

Echinus esculentus, Linn., 1758.

Echinus esculentus, Linn., 1758. Syst. Nat. ed. 10, 1758, p. 663.

" " Gregory, 1891. Ann. Rep. Yorksh., Phil. Soc. p. 39.

Echinus sphaera, O. F. Müller, 1776. Prodr. Zool. Danic., p. 235, n. 2845.

[For detailed Synonymy of recent form see A. Agassiz, Revision of Echini Illustr. Cat. Mus. Comp. Zool. No. vii., 1872, p. 122-23].

Distribution in Pliocene.—Coralline Crag, Gedgrave; Orford, St. Erth (?). Chillesford Crag, Sudbourne.

Remarks.—This species is now the commonest Echinoid on the coasts of the west of Europe, but no reliable record has been previously made of its occurrence in deposits older than the Pleistocene. At least two good specimens have been found in the Crag, the one preserved in the Wallace Collection at Ipswich, and the other in the Reed Collection at York. The former is a large specimen, 19 mm. in diameter, and 9.5 mm. in height. There are some plates and spines in the Cambridge Museum from the Crag at St. Erth, labelled as *E. sphaera*; but the plates are oligoporous, and lack the granule between the pores, so that it is quite possible that they belong to this species.

Echinus miliaris, P. L. S. Müller, 1767.

Echinus miliaris, P. L. S. Müller, 1767, in Knorr. Deliciae Naturæ selectæ, Nuremberg; p. 130, pl. D, f. 1.

" " A. Bell, 1872. Proc. Geol. Assoc. ii. p. 270.

" " C. Reil, 1890. Plioc. Brit. p. 283.

" " J. W. Gregory, 1891. Ann. Rep. Yorksh. Phil. Soc. p. 39.

[For Synonymy, see A. Agassiz, Illustr. Cat. Mus. Comp. Zool., No. vii., 1872, p. 125].

Distribution in Pliocene.—Coralline Crag, Orford. Red Crag, Foxall.

Remarks.—Of this well-known recent species there is a specimen from the Crag in the British Museum, to which it was presented by Mr. Bayfield. It differs from the recent forms in the greater uniformity of the secondary granules, but this is not a character of specific value. The occurrence of the species in the Crag was first noted by Mr. A. Bell. A second specimen belongs to the York Museum.

Echinus woodi, Desor, 1856.

(Pl. II, Fig. 8).

- Echinus woodi*, Desor, 1856. Syn. Ech. Foss., p. 124.
 " " Gregory, 1891. Ann. Rep. Yorksh. Phil. Soc. p. 40, pl. i. f. 8.
 , *melo*? Forbes, 1852. Brit. Tert. Ech. p. 4, pl. iii. f. 10.
 " " A. and R. Bell, 1872. p. 203.
 " " C. Reid, 1890. Plioc. Brit. p. 283.

Distribution.—Coralline Crag, Sutton, Orford.

Type-specimen.—British Museum (E. 567).

Forbes figured a fragment from the Wood Collection, which he referred to the characteristic Mediterranean species *E. melo*, Lam. Desor subsequently based a new species on this specimen, as he doubted the correctness of the identification. The species is known only by the type, and a specimen in the York Museum; but as the tuberculation is different to that of the Mediterranean species, Desor's doubts were well justified. I am not aware of any evidence of the existence of *Echinus melo* in the English Pliocene.

Echinus lyelli, Forbes, 1852.

- Echinus lyelli*, Forbes, 1852. Brit. Tert. Ech. p. 4, pl. i. f. 5.
 " " Desor, 1856. Syn. Ech. Foss. p. 124.
Records.—35, p. 79; 39, p. 283.

Distribution.—Coralline Crag, Ramsholt.

Type-specimen.—British Museum (E. 580).

Remarks.—This species is also still known only by the type, and in consequence there is nothing to add to Forbes' description. He remarks that the spines are unknown, but he figures one (fig. 5^e). The tuberculation is very different to that of any other Crag species.

Echinus charlesworthi, Forbes, 1852.

- Echinus charlesworthi*, Forbes, 1852. Brit. Tert. Ech. p. 5, pl. i. f. 6.
Psammechinus " Desor, 1856. Syn. Ech. Foss. p. 121.
Arbacia sp. S. V. Wood, MS., 1843. Morris, Cat. Brit. Foss. p. 48.
Records.—35, p. 79; 31, p. 368; 32, p. 50; 39, p. 283; 30, p. 39.

Distribution.—Coralline Crag, Ramsholt, Sutton.

Type-specimen.—British Museum (E. 582).

Remarks.—This is the commonest species of the group of small *Echini* (sub-genus *Psammechinus*) which is such a striking feature in the Pliocene Echinoid fauna. It is allied to *E. monilis*. The tuberculation of this and the next species are well shown diagrammatically, in Forbes' figures.

Echinus henslovi, Forbes, 1852.

(Pl. II, Fig. 2, 3, 4).

Echinus henslovi, Forbes 1852. Brit. Tert. Ech. p. 5, pl. i. f. 7.

„ *henslovi*, Gregory, 1891. Ann. Rep. Yorksh. Phil. Soc., 1890, p. 40, pl. i. figs. 2, 3, 4.

Psammechinus henslovi, Desor, 1856. Syn. Ech. Foss. p. 121.

Records.—35, p. 79; 47, p. 31; 39, p. 283.

Distribution.—Red Crag, Walton (fairly common).

Type-specimen.—British Museum (40182).

Remarks.—As already remarked in the notes on *Temnechinus woodi*, the same phenomenon of sexual dimorphism has been discovered in this species. The female has been described and figured in the Rep. Yorksh. Phil. Soc. 1890.

Echinus sphæroideus, (Cott.), 1880

(Pl. II, Fig. 5, 6).

Psammechinus sphæroideus, Cotteau, 1880. Mém. Acad. roy. Belgique xliiii., pp. 20-22, pl. ii. f. 1, 5.

„ „ Mourlon, 1881. Géol. Belgique ii., p. 235.
Echinus „ „ Nyst. MS. 1868, in Dewalque Prod. descript. géol. Belgique, p. 433.

„ „ Van den Broeck, 1878. Esquisse géol. and pal. des dépôts pliocenes des environs d'Anvers, p. 135.

„ „ J. W. Gregory, 1891. Ann. Rep. Yorksh. Phil. Soc. 1890, p. 41, pl. i. f. 5, 6.

Distribution.—British—Red Crag, Boyton. Belgium—Diestien and Scaldisien.

Echinus paucimiliaris, J. W. Gregory, 1891.

(Pl. II, Fig. 1).

Ann. Rep. Yorksh. Phil. Soc. 1890, p. 39, pl. i. fig. 1.

Distribution.—Red Crag, Butley. York Museum.

[*Echinus nortoni*, A. Bell, MS.

This name was given by Mr. A. Bell to a specimen from the lower part of the Red Crag at Walton, in the Collection of H. Norton, Esq., F.G.S., of Norwich; it was recorded in Proc. Geol. Ass. ii., 1872, p. 208, but has neither been figured nor described, and the specimen cannot now be traced.]

FAMILY ECHINOMETRIDÆ.

GENUS *STRONGYLOCENTROTUS*, Brandt, 1834.***Strongylocentrotus drobachiensis*** (O. F. Müller), 1776.*Echinus drobachiensis*, O. F. Müller, 1776. Prodr. Zool. Dan. p. 235.*Strongylocentrotus* „, A. Agassiz, 1872. Ill. Cat. Mus. Comp. Zool. vii. pp. 162-3.*Toxopneustes* „, L. Agassiz, 1846. Cat. Rais. Ann. Sci. Nat. Zool. (3), vi. p. 367.*Records*.—7, p. 217; 8, p. 452; 9, p. 213; 39, p. 283.*Distribution*.—Coralline Crag, Aldborough (Cambridge Museum). Norwich Crag, Suffolk.

The Cambridge Museum possesses a fine specimen of a *Strongylocentrotus*, from the Coralline Crag of Aldborough, which differs from typical specimens of *S. drobachiensis* in having fewer ambulacral granules; but, considering the great variability of this species, it is advisable to include the Crag form within it. The specimen is 65 mm. in diameter and 29 mm. in height. The species is new to the Crag fauna. The specimen which Mr. A. Bell has recorded from the Red Crag of Butley belongs to another genus.

Strongylocentrotus lividus has been recorded from the Chillesford Crag [A. Bell, 9, p. 215] but I have not been able to verify the record.

Sp. 2. ***Strongylocentrotus scaber***, Gregory, 1891,

(Pl. II, Fig. 7.)

(Ann. Rep. Yorksh. Phil. Soc. pp. 41, 42, pl. i. f. 7.)

Distribution.—Coralline Crag, Aldborough.*Type-specimen*.—York Museum (Reed Coll.).

FAMILY FIBULARIIDÆ.

GENUS *ECHINOCYAMUS*, Van Phelsum, 1774.***Echinocyamus pusillus*** (O. F. Müller), 1776.*Spatangus pusillus*, O. F. Müller, 1776. Prod. Zool. Danica, p. 236.*Echinocyamus pusillus*, Gray, 1825. Ann. Phil. x. p. 429.

„ „ Forbes, 1852. Brit. Tert. Ech. pp. 10, 11. pl. i. f. 8-15.

„ „ Desor, 1857. Syn. Ech. Foss. p. 218.

„ „ H. Nyst. in Dewalque, Prod. descrip. géol. Belgique, p. 433.

Echinocyamus suffolciensis, L. Agassiz, 1841. Mon. Scut. pp. 129-30, pl. xxvii. f. 9-13.

„ „ E. Forbes, 1852. Brit. Tert. Ech. p. 11, pl. i. f. 16.

„ „ Desor, 1857. Syn. Ech. Foss. p. 218.

„ *hispidulus*, E. Forbes, 1852. Brit. Tert. Ech. pp. 11, 12, pl. i. f. 14. a. b. c.

„ „ Desor, 1857. Syn. Ech. Foss. p. 219.

- Echinocyamus oviformis*, E. Forbes, 1852. Brit. Tert. Ech. p. 12, pl. i. f. 17, 18.
 " " Desor, 1857. Syn. Ech. Foss. p. 219.
 " *forbesi*, Cotteau, 1880. Mém. cour. Acad. roy. Sci. Belg. xliii.
 p. 42, pl. iii. f. 23-8.
- Records*.—*E. pusillus*: 35, 78; 31, 371; 37, 332; H. Nyst. in Dewalque
 Prod. descrip. géol. Belgique, 433; 8, 452; 9, 213, 215; 32, 62; G. Doll-
 fus, 1880, Bull. Soc. géol. Normandie, vi. p. 519; 49, 54; 38, pl. xv.
 f. 12; 39, 283; 30, p. 42.
- E. suffolciensis*: 35, 78; 31, 371; 47, 31; 32, 62; 49, 54; 39, 283.
- E. hispidulus*: 35, 78; 31, 368; 47, 31; 32, 50; 7, 217; 39, 283.
- E. oviformis*: 35, 78; 31, 368; 47, 31; 32, 50; 7, 217; 39, 283.

Pliocene Distribution.—British: Coralline Crag, Orford; Ramsholt; Sutton. Red Crag, Alderton; Butley; Hollesley; Valley Farm, Sudbourne; Sutton; Walton. Norwich Crag, Beccles. Chillesford Crag, Aldeby. Foreign: Diestien and Scaldisien, Belgium. Conglomérat à Térébratules, Gourbesville, Normandy.

Remarks.—Prof. Forbes recorded four species of *Echinocyamus* from the Crag: the old *E. pusillus*, L. Agassiz' *E. suffolciensis*, and two new species. The whole of the types studied by Forbes are now in the British Museum, and a careful examination of these, and of a large series of others from the Crag has suggested that they are all but one species. Prof. Prestwich suggested, in 1871,²⁰ that *E. suffolciensis* was only a variety of *E. pusillus*, and this seems to be also the case with Forbes' two species. Both *E. oviformis* and *E. hispidulus* are mainly based on the position of the anus, which is a most unreliable character in this group, as it varies so much with age. In *E. oviformis* the anus is infra-marginal, and the test very small, both characters suggesting that it is only a young form. In *E. hispidulus* the tuberculation is described as minute; but this feature varies considerably, and in this form is not sufficiently marked to warrant specific separation. This and *E. suffolciensis* seem to be only depressed pentagonal varieties, and a complete series of forms intermediate between them and the normal *E. pusillus* can be easily obtained.

As far as can be judged from the figures and descriptions *E. forbesi*, Cott., may also be included in *E. pusillus*.

GENUS *RHYNCHOPYGUS*.

Rhynchopygus woodi (Forbes, 1852).

- Echinarachnius woodi*, Forbes, 1852. Brit. Tert. Ech. pp. 12, 13, pl. ii. f. 56.
Rhynchopygus woodi, J. W. Gregory, 1890. Geol. Mag. (3) vii. pp. 300-3.
Pourtalesia sp. A. Agassiz, 1883. Mem. Mus. Comp. Zool. x. No. 1, p. 91.
Records.—35, p. 78; 9, p. 197; 39, p. 283.

Distribution.—Coralline Crag: Layston Road Pit, Aldboro'. Red Crag: Bullock Yard Pit; Walton (?) Suffolk.

Type-specimens.—British Museum (E 602, E 3207).

Remarks.—This species was based on a couple of fragments from the Red Crag, which always attracted a good deal of attention, as they obviously belonged to a genus not now living in the British area. Still greater interest was aroused in them by the suggestion of Prof. A. Agassiz, that they were the remains of a Pourtalesian,²¹ an opinion more definitely repeated in the Report on the Blake Echini, though Profs. Lovén and Bell had expressed doubts as to its truth.²²

Another fragment having been found by Mr. W. J. Lewis Abbott, F.G.S., in the Coralline Crag at Aldboro', the present writer was able to demonstrate that the species was one of *Rhynchopygus*.

All the specimens known are in the British Museum (Nat. Hist.).

GENUS *ECHINOLAMPAS*, Gray, 1825.

Echinolampas subrostratus, n. sp.

Diagnosis.—Form: ovoid, well rounded at the anterior end, but prolonged into a slight rostrum at the posterior. It is widest at about one-third the length of the test from the posterior end: it thence tapers gently forward till level with the ends of the petals of the anterior ambulacra, when it curves sharply round. In elevation it is seen to be depressed, with tumid margins, especially well rounded at the anterior end. The highest point is slightly behind the centre.

Apical disc: excentric anteriorly.

Ambulacra: the petals are tumid, expanded above the level of the test: they reach nearly to the ambitus. The poriferous areas are of unequal length: in the antero-lateral pair those of the posterior sides are the longest; whilst in the postero-laterals the anterior pair is the longer.

Anus: oval; inframarginal at the end of a slight rostrum.

Mouth: opening in a depression, slightly before the centre.

Phyllodes well developed. (A rudimentary perignathic girdle.)

Dimensions.—

	mm.
Length	44
Width at anterior third	31
Width at posterior	34
Height	24
Distance of apical disc from anterior margin	19
Ambulacra: length of antero-lateral	17
„ width	4'5
„ length of postero-lateral	22
„ width	5

²¹ Chall. Rep. Zool. iii. No. 1, p. 1881, p. 30.

²² "On Pourtalesia," Kongl. Svensk. Vet. Akad. Handl. (New Ser. xix. No. 7, 1883, (p. 86).

Distribution.—Coralline Crag. Suffolk.

Type-specimen.—British Museum (E 1530).

Remarks.—This species is based on a specimen in the Natural History Museum. As it is completely overgrown by Bryzoa it is impossible to determine the structure of the apical disc or the nature of the tuberculation. The species belongs to the group of which *E. affinis* (Goldf.)²³ is a convenient type. Among the species which are more of the same age, it must be compared with *E. lycopersicus* Guppy, from the Upper Cainozoic of the West Indies. From this, which has been admirably illustrated by M. Cotteau,²⁴ it may be distinguished by its greater proportional length to breadth, by the greater excentricity of the apical system, and the greater irregularity of the poriferous zones.

Amongst recent Echinolampads it most resembles *E. depressus*, Gray,²⁵ also from the West Indies. With this it agrees in its elongated form, the less excentricity of the mouth compared with the apical disc, the tendency towards an anal rostrum, and the inequality of the poriferous zones. *E. subrostratus* may be distinguished from this species by the greater breadth of its postero-lateral inter-radius, by the more advanced position of its apical system, and by the narrowness of the test.

GENUS *AGASSIZIA*.

Agassizia æquipetala, n. sp.

(Pl. I, Fig. 7.)

Diagnosis.—Form: of fairly large size; elongated, elliptical, somewhat narrow at posterior end. Seen in elevation it presents on the abactinal side a regularly-rounded but depressed outline; the highest point being slightly behind the apical system.

Apical system: slightly antero-central, ethmolysian, with four large genital pores.

Ambulacra: anterior, flush with the test and with very small pores. The lateral pairs are strongly divergent and very slightly depressed: the pores are large and the petaloid portions extend nearly to the ambitus.

Epistroma: tubercles perforate and non-crenulate, of medium size, uniform, sparsely scattered. Spines: fine, often curved, marked by delicate reticulate ridges.

Arms: high on the truncate posterior margin.

Fascioles and actinal side unknown.

²³ Petref. Germ. 1829, p. 134, pl. xlii. f. 6.

²⁴ Ech. Tert. Isles St. Barth. and Anguilla, K. Svens. Vet. Akad. Handl. xiii. No. pl. iii. f. 22-26.

²⁵ Compare with the figures given by A. Agassiz, Blake Echini, Mem. Mus. Comp. x. No. 1, pl. xvi.

<i>Dimensions.</i> —						mm.
Length	...	...	...	...	...	38
Width	...	...	...	...	...	33
Height	...	...	...	...	(about)	17
Ambulacra :	length of antero-lateral				...	15
„	„	postero-lateral			...	17
„	width of antero-lateral				...	3
„	„	postero-lateral			...	3

Distribution.—Coralline Crag : Aldboro'.

Type-specimen.—British Museum (33645).

Remarks.—The genus *Agassizia* is not known from modern seas, except in the North American province, where it is represented by a species in the Antillean region, and by another on the west coast. Some fossil species are also known from the West Indian Cainozoics, though the precise horizon of these is as yet uncertain. The European species once attributed to this genus have now been referred elsewhere, and the only previously-recorded evidence of its existence in the Old World is a species from the Egyptian Miocene.²⁶ The discovery of a true *Agassizia* in the English Pliocenes is therefore an interesting addition to the evidence which connects the Crag Echinoid fauna with that of the present West Indian seas. In spite of the imperfect preservation of the fossil there is no doubt of its generic position; the fact that, owing to a slight weathering, the fascioles cannot be traced being negative evidence of little value. In regard to its affinities, just as it has been seen that the closest ally of *Rhynchopygus woodi* is the living West Indian *R. caribbearum* (Lam.), so this species most resembles *Agassizia excentrica* from the same area. From this species it can be distinguished by its being more depressed, and especially by the fact that in the Pliocene species the petaloid portions of the ambulacra are nearly equal in length; whereas in the recent species they are strikingly unequal. The former, moreover, has the summit coincident with the apical disc. The two species agree, however, in the central position of the latter.

A. æquipetala must also be compared with *A. porifera* (Rav.)²⁷ from South Carolina; this species may be identical with *A. excentrica*, as suggested by Prof. A. Agassiz,²⁸ and, if so, the latter name must be abandoned. It differs, however, from the new species in that the ambulacra are depressed, and the shape of the test is very different. *A. æquipetala* also differs from *A. clevei*

²⁶ "*Agassizia zitteli*, Th. Fuchs. Beiträge zur Kenntniss der Miocæn Fauna Ægyptens und der libyschen Wüste." Palæontographica xxx. Th. 1, p. 62, pl. vi. f. 5-8.

²⁷ E. Ravenal, Echinidæ, Recent and Fossil of South Carolina. Charlestown, 1848, p. 4 and fig. 5, 6: and M. Tuomey and F. S. Holmes, "Pleiocene Fossils of S. Carolina." Charlestown. No. 1, 1855, pp. 5, 6, pl. i. f. 5, pl. ii. f. 4.

²⁸ A. Agassiz. Ill. Cat. Mus. Comp. Zool. vii. 1872, p. 353.

Cott,²⁹ in that in this species the apical disc is excentric posteriorly and the paired ambulacra are consequently very unequal.

GENUS **BRISSUS**, Gray, 1825.

Brissus unicolor (Leske), 1778.

Spatangus brissus, var. *unicolor*, Leske. Addit. Klein. p. 248, pl. xxvi. fig. B.C.
Brissus unicolor, A. Agassiz, 1872. Ill. Cat. Mus. Comp. Zool. No. vii., pp. 97, 357.

" " F. J. Bell, 1879. Proc. Zool. Soc., pp. 249-52.
Brissus scillæ, L. Agassiz, 1835. Mém. Soc. Sci. Nat. Neuchâtel i. p. 185.
 " " " 1847. Cat. Rais. Ann. Sci. Nat. Zool. (3) viii. p. 13.
 " " E. Forbes, 1852. Brit. Tert. Ech. pp. 15, 16, pl. ii. f. 4.
 " " E. Forbes, 1856. Dec. Geol. Surv. No. v. pl. x.
 " " E. Desor, 1858. Syn. Ech. Foss. p. 403.

Brissus dimidiatus, L. Agassiz, 1847. Ann. Sci. Nat. Zool. (3) viii. p. 13.

" *cylindricus* " " " " " " " "

" *cordieri* " " " " " " " "

Spatangus carinatus, Lamarck, 1816. Anim. sans. vert. iii. p. 30.

Brissus " J. E. Gray, 1825. Ann. Phil. 1825, p. 431.

Records.—*B. unicolor*, 30, p. 42; *B. scillæ*, 35, p. 73; 31, p. 368; 9, p. 202; 32, p. 50; 38, pl. xv. f. 15; 39, p. 283.

Distribution in Pliocene.—British: Coralline Crag, Aldborough; Iken; Orford; Ramsholt; Sudbourne. Foreign: Astien; Palermo.

Remarks.—*Brissus scillæ* was a species founded by L. Agassiz on the figure given by Scilla of a Mediterranean specimen.³⁰ This differed from what was then regarded as the typical *B. carinatus*, Lam., in the vertical border, the flatness of the posterior inter-radius, and the disposition of the fascioles. The specimen figured by Forbes agreed in these three points with Scilla's figure, so that he adopted Agassiz' name. At the same time he followed the great French echinologist in including in this species Brissi from the Miocene of Malta, *B. tuberculatus*, and *B. imbricatus* Wr.,³¹ which are, however, clearly distinct.

Prof. A. Agassiz' knowledge of the earlier literature of the century enabled him to show that his father's species had been anticipated by *B. unicolor*, which dates back to its first post-Linnean definition by Leske in 1778. The relations of this species, and its close ally *Brissus carinatus* (Lam.), were carefully considered by Prof. A. Agassiz in his "Revision,"³² and he concluded that the two could be distinguished by several characters.

Prof. Jeffrey Bell³³ readvocated the views expressed by Salter³⁴

²⁹ G. Cotteau, "Description des Echinides Tertiaires des Isles St. Barthélemy et Anguilla." K. Svensk. Vet. Akad. Handl. xiii. No. 6, 1875, pp. 33, 34, pl. vi. f. 2-10.

³⁰ Scilla. De Corporibus marinis, pl. iv. f. 2, 3.

³¹ Wright, T., "On the Fossil Echinidæ of Malta." Quart. Journ. Geol. Soc. xx. p. 486, pl. xxii. figs. 1, 2.

³² Ill. Cat. Mus. Comp. Zool. vii. p. 357.

³³ Proc. Zool. Soc. 1879, pp. 249-52.

³⁴ Dec. Geol. Surv. No. v. pl. x. p. 2.

in 1855, by urging that the two species should be united, as none of the points relied on for the separation were constant in a large series of specimens; and, moreover, that the most striking difference, *viz.*, that in *B. carinatus* there are two re-entering angles in the course of the fasciole across each anterior interradius, while in *B. unicolor* there is only one, does not hold for single specimens, as in some one side conforms to the *B. carinatus* and the other to the *B. unicolor* type.

M. de Loriol³⁶ has, however, subsequently thrown the weight of his influence on to the side of the separation of the two species, regarding the presence of a keel in *B. carinatus* as a good distinctive character; whilst a second character he finds in the fact, that in this species the anus is only visible from below, and in *B. unicolor* from above.

The Crag specimens strongly support the views of Salter and Bell. The species is usually very carinate (see, *e.g.*, Dec. Geol. Surv. No. v. pl. x. f. 3), so that, judging by this character, it would go with *B. carinatus*; but the flexure of the fasciole agrees with *B. unicolor*, while the truncation of the posterior margin varies so much that in some cases the anus can be seen from above, and in others it cannot. As, then, the Crag specimens belong to one species by one character, to the other by the second, and to either by the third, the wisest course seems to include them all under the name *B. unicolor*. Salter, it may be remarked, quoted a *B. carinatus* from Mauritius with a posterior border that was almost vertical.

GENUS SPATANGUS.

Spatangus purpureus, O. F. Müller, 1776.

- Spatangus purpureus*, O. F. Müller, 1776. Prod. Zool. Dan. p. 236.
 " " Forbes, 1852. Brit. Tert. Ech. pp. 13, 14, pl. ii. f. 3.
 " " Desor, 1858. Syn. Ech. Foss. p. 419-20.
 " *reginæ*, Gray, 1851. Ann Mag. Nat. Hist. (2) vii. p. 130.
 " " Forbes, 1852. Brit. Tert. Ech. p. 14, pl. ii. f. 2.
 " " Desor, 1858. Syn. Ech. Foss. p. 420.
 " *rhodi?* Cotteau, 1876. Rev. Mag. Zool. (3) iv. pp. 323-5, pl. ii. f. 4.
 " *sp.* J. Morris, 1843. Cat. Brit. Foss. p. 58.
Records.—*S. purpureus*: 35, p. 89; 9, p. 213, 215; 39, p. 283; 30, p. 42.
S. reginæ: 35, p. 89; 31, p. 368; 32, p. 50; 39, p. 283.

Distribution in Pliocene.—British: Coralline Crag, Aldborough; Orford; Ramsholt; St. Erth? Red Crag, Sutton; Walton?; Woodbridge; Chillesford; Loc.? Foreign: Antium; Palermo; Rhodes, &c.

Remarks.—The identification of the species of the genus *Spatangus* is usually somewhat difficult, as it is on a combination of characters rather than on any single feature that any conclusions

³⁵ Catalogue raisonné des Echinodermes recueillis par M. V. de Robillard à l'île Maurice. Mém. Soc. Phys. Hist. Nat. Genève, xxviii., No. 8, 1883, p. 47.

can be based. When, therefore, the specimens are fragmentary, as, owing to the fragile nature of the tests of these forms, is too often the case, it becomes difficult, if not impossible, to determine the species with certainty. Prof. Forbes referred most of the fragments he studied to *S. purpureus*, but one he identified as *S. regina*, Gray. This species has, however, been merged by "neontologists" in the former, and there seems no reason why the Crag specimens should not share the same fate. *S. grandis*, Forbes; *S. meridionalis*, Risso; and *S. spinosissimus*, Ag. and Desor, may also go to enlarge the Müllerian species, while *S. rhodi*, Cotteau, is very close, if not identical, to some Crag varieties.

Spatangus raschi, Lovén, is, however, clearly distinct, and there are one or two Crag fragments (*e.g.* the actinal half of a small specimen 53 mm. long, by 50 mm. wide, in the Reed Collection at York), which may turn out to belong to this species. But none of the specimens show the whole of the anterior half, so that it is uncertain whether they possessed the steep anterior slope as well as the great height, which are the essential features of *S. raschi*. Until better specimens are known, it seems wisest to leave them all in the one species.

GENUS ECHINOCARDIUM, Gray, 1825.

Echinocardium cordatum (Penn.), 1777.

Echinus cordatus, T. Pennant, 1777. Brit. Zool. iv. p. 58, pl. xxxiv. f. 75.

Amphidetus sp., J. Morris, 1843. Cat. Brit. Foss. p. 47.

„ *cordatus*, Forbes, 1852. Brit. Tert. Ech. pp. 16, 17, pl. ii. f. 1.

Echinocardium cordatum, Desor, 1858. Syn. Ech. Foss. p. 407.

? *Amphidetus sartorii*, L. Agassiz, 1847. Ann. Sci. Nat. Zool. (3) viii. p. 12.

Records.—*Amphidetus cordatus*: 35, p. 71; 39, p. 283. *E. cordatum*: 30, p. 42.

Distribution in Pliocene.—British: Coralline Crag, Boyton (spines); Ramsholt; Sutton. Red Crag, Aldborough Waterworks; Valley Farm, Sudbourne; Sutton (?); Walton; Chillesford Crag; Alderby.

Remarks.—The test of this species is so fragile, that in most localities fragments only have been found; but nevertheless, the tuberculation is so characteristic that these can be safely determined. At Walton some perfect specimens have been found with all the spines attached.

The synonymy of this species is fairly straightforward, provided no attempt be made to introduce pre-Linnean names. If, however, we follow the example of some eminent French palæontologists, as has recently been done in England, and accept the names of Breynius, we must alter both the generic and specific names of this fossil. In 1732 Breynius gave an admirable figure of this Echinoid, and of species belonging to three other genera, and

to this *omnium gatherum* he applied the term, "*Echinospatangus cordiformis*." In his description he first treats of the species under discussion, and calls it "*vulgatissimus*," so that he obviously regarded this as the type. Hence, if the first two words of Breynius' descriptive sentences are to be accepted as names, then clearly *Echinocardium cordatum* must be abandoned in favour of *Echinospatangus cordiformis*, and a fresh name found for the common Lower Cretaceous fossil at present known as such. But these changes, and others that would follow a consistent introduction into modern binomial nomenclature of pre-Linnean terms, need not be made, as in accordance with the British Association rules such names may be allowed to rest undisturbed in their dusty tombs.

Miscellaneous Records.

Diadema? *sp.*, Iron Sandstone. Lenham Wood, 48, p. 334; 46, p. 601; 39, p. 58.
Strongylocentrotus lividus (Müll.). Norwich Crag, 9, p. 215.

IV.—THE PLEISTOCENE ECHINOIDS.

In Prof. Forbes' Monograph no Pleistocene species were recorded, and our knowledge of them is mainly due to the workers among the Scotch Glacial Deposits. In addition to these there are a few post-Glacial species found in the various raised beaches and the Belfast so-called "Pliocene" clays. The whole of the Pleistocene forms are identical with existing species and they will be fully described by Prof. F. Jeffrey Bell in his forthcoming Catalogue of the British Echinodermata. There are, in addition, a number of derived fragments in various Pleistocene deposits, such as at Copford, but these may be excluded.

A. The Glacial Species.

But for the marine clays associated with the Glacial deposits of the south of Scotland, and especially in the Clyde Valley, the list of Echinoids from this series would be very meagre, and would probably include only *remanié* material. The specimens are fragmentary, but the plates in most cases admit of identification.

ECHINIDÆ.

GENUS *ECHINUS*, Linn. 1758.

SPECIES I. *Echinus esculentus*, Linn. 1758.

For Synonymy see *ante*, p. 33.

Records.—*E. esculentus*: 1, 336 (1).

„ *E. sphaera*: 18, iii. 124 (2), iv. 44 (3), 133 (4); 45, 262 (5); 43, 26 (3).

Distribution.—Scotch Glacial series: Loch Lomond (1); Loch

Gilp ⁽²⁾; Garvel Park, near Greenock ⁽³⁾; Kilchattan, Bute ⁽⁴⁾; Gourrock ⁽⁵⁾.

[*Echinus norvegicus*. Dub. and Koren, 1846. K. Vetensk, Akad, Handl. 1844 (1846) pp. 268-272, pl. ix. fig. 33-39. This species has been recorded in some manuscript lists, but I have seen no specimens of it from any British deposit.]

SPECIES 2. **Echinus woodwardi**, Desor, 1846.

For Synonymy see *ante*, p. 32.

Distribution.—Mid-Glacial. Hopton, Billockby, and quarter of a mile north of Sockford Hall. Spines, Norwich Museum.

The spines from these localities have probably been derived from the Craggs; and the idea of a similar origin for the mollusca of the same beds and of other drifts seems to be steadily gaining ground. The spines at Billockby are accompanied by others of such species as *Cidaris clavigera*, *C. serrifera*, &c., which have unquestionably been derived from the Chalk.

FAMILY **ECHINOMETRIDÆ**.

GENUS *STRONGYLOCENTROTUS*, Brandt. 1834.

Strongylocentrotus dröbachiensis (O. F. Müller).

For Synonymy see *ante*, p. 36.

Records.—*Echinus dröbachiensis*—18, ii. 282 ⁽¹⁾, iii. 117 ⁽²⁾, 124 ⁽³⁾, 323 ⁽⁴⁾, 326 ⁽⁵⁾, 328 ⁽⁶⁾, 330 ⁽⁷⁾, 333 ⁽⁸⁾, 340 ⁽⁹⁾, iv. 44 ⁽¹⁰⁾, 133 ⁽¹¹⁾, v. 35 ⁽¹²⁾; 42, 296 ⁽¹³⁾, 308 ⁽¹⁴⁾; 45, 262 ⁽¹⁵⁾; 43, 26 ⁽¹⁶⁾.

" *E. (Strongyl.)* " 44, 270 ⁽¹⁶⁾.

" *Echinus*, n sp., 18, iii. 114, 115, pl. I ⁽²⁾.

Distribution.—Crinan ⁽⁶⁾; Cumbrae College ⁽²⁾; Dalmuir ⁽¹⁾; Duntroon ⁽⁷⁾; East Tarbet, Loch Fyne ⁽⁴⁾; Garnock Water ⁽¹³⁾; Garvel Park ⁽¹⁰⁾; Gourrock ⁽¹⁵⁾; Greenock ⁽¹⁶⁾; Kilchattan, Bute ⁽¹¹⁾; Kyles of Bute ⁽¹²⁾; Loch Gilp ⁽³⁾, Misk Pit, near Kilwinning ⁽¹⁴⁾; Old Mains, Renfrew ⁽⁸⁾; Paisley ⁽⁹⁾; West Tarbet ⁽⁵⁾.

Messrs. Crosskey and Robertson, after consultation with Prof. Sars, figured some worn plates which they referred to a new species of *Echinus*. On enquiry of Mr. Robertson, he told me that he had since concluded that the plates in question were those of *Strongylocentrotus dröbachiensis*; and, as he has kindly presented the original specimens to the British Museum, he has enabled me to express agreement with this opinion.

FAMILY **SPATANGIDÆ**.

GENUS *ECHINOCARDIUM*, Gray, 1825.

Echinocardium, sp.

Record.—*Amphidotus*, sp., 18, iv. p. 133.

Distribution.—Kilchattan Tile Works, Bute.

GENUS ? Sp ?

Record—*Spatangoid*, plates and spines; 45 262.

Distribution.—Gourrock.

V.—THE POST-GLACIAL.

FAMILY ECHINIDÆ.

GENUS *ECHINUS*, Linn. 1758.***Echinus miliaris***, P.L.S. Müller, 1771.For Synonymy see *ante*, p. 33.*Record.*—*Echinus lividus*—31. 78.*Distribution.*—Pleistocene Clays. Belfast Lough (*e.g.*, Brit. Mus. 56835).***Echinus esculentus***, Linn. 1758.*Records*—*Echinus sphaera*—40, 199.*Distribution.*—Cumbrae.

FAMILY FIBULARIIDÆ.

GENUS *ECHINOCYAMUS*, Van Phelsum, 1774.***Echinocyamus pusillus*** (O. F. Müller), 1776.For Synonymy see *ante*, p. 36.*Records.*—*E. pusillus*, Prestwich, 1878, in Dixon Geol. Sussex, ed. 2 p. 87 (1).
A. Bell, 1878 " ed. 2, p. 54 (2),
32, 85 (2).*Distribution.*—Airsford Pit (1); Waterford Sand Pit, Goodwood Park (1); Mud Deposit, Selsea (2).

FAMILY SPATANGIDÆ.

GENUS *SPATANGUS*, O. F. Müller, 1776.***Spatangus purpureus***, O. F. Müller, 1776.For Synonymy see *ante*, p. 42.*Record.*—Dixon, 21, ed. 2, p. 54.*Distribution.*—Mud Deposit, Selsea.GENUS *ECHINOCARDIUM*, Gray, 1825.*Record.*—*Amphidotus*, sp., 40, 199.*Distribution.*—Cumbrae.

VI.—STATISTICAL SUMMARY.

In the following summary species based on spines are excluded, as they afford no basis for real comparison. Some doubtful records in distribution are also omitted.

In Prof. Forbes' Monograph eight species were described from the Eocene. These still stand, with the addition of four new species, and of two species new to England. Of these fourteen species, one comes from the Thanet Sand, five from the

III. PLEISTOCENE.

SPECIES.	AUTHOR.	GLACIAL.			POST-GLACIAL.			
		Billockby.	Hopton.	S. Scotland.	Cumbræ.	Airsford & Goodwood.	Selsey.	Belfast.
<i>Echinus esculentus</i>	Linn.	—	—	—	—	—	—	—
„ <i>woodwardi</i>	Des.	—	—	—	—	—	—	—
„ <i>miliaris</i>	(P.L.S. Müll.)	(derived)						—
<i>Strongylocentrotus dröbachiensis</i>	(O.F.M.)			—				
<i>Echinocyamus pusillus</i>	„				—	—	—	—
<i>Spatangus purpureus</i>	„					—	—	
<i>Echinocardium</i> sp.	„			—	—			

London Clay, four from the Middle, and four from the Upper Eocenes; and one species is possibly common to the two last series.

The Pliocene material is richer as well as in better preservation. Prof. Forbes described eighteen species, but six of these are dismissed as synonyms. Two species have been added by subsequent writers, and the number is now raised to twenty by the addition of two species new to the Crag, and of four new species; two of the latter belonging to genera new to England.

Of the non-derived Pleistocene species two belong to the Glacial and four to the Post-Glacial.

VII.—THE AFFINITIES OF THE ECHINOID FAUNAS.

After having thus taken “stock” of our British Cainozoic Echinoids we may turn from the dull discussion of synonymy to the more interesting questions connected with the relations of the faunas. One might expect an examination of the Echinoids in the successive deposits of so long a series as the British Tertiaries to afford some evidence as to the evolution of the class; but the geological record is here so imperfect that it is safer to use them to trace the migration of the faunas rather than in the erection of phylogenetic trees.

The conclusions as to the physical conditions of any area in the past, afforded by the study of any one group, must always be received with a considerable amount of caution, especially when the group is represented by so few species as the Echinoids are in the British Cainozoics. But the smallness is, in another way, of advantage, as the materials can be handled with more care; the distribution and the synonymy can be better determined, and the fossils compared in greater detail, when one is dealing with forty species than when one is dealing with 4,000.

In the first place, it may be well to consider why the Echinoidea are so few in the British Cainozoic deposits, while contemporaneous seas were crowded with a rich and varied fauna. The explanation is partly climatic and partly lithological. In the first place, the Echinoidea flourish most in tropical and sub-tropical seas. The rich fauna of the Eocenes of the south of France lived in an ocean that stretched away into Spain on the west, across Egypt to Persia on the east, and was probably warmed by currents that flowed over Egypt from the Indian Ocean. The English seas were then barred from the south, and were fully open to the chilling influences of the northern ocean. In the second place, the paucity of Echinoidea is due to the nature of the shores and sea-bottoms. The gnathostome (*i.e.*, jaw-bearing) Echinoids live mainly among rocks, browsing on the algæ that grow thereon, whilst the edentulate Spatangoids and their allies prefer a sharp, fine, sandy or calcareous sea-bottom, into which they can burrow, and by swallowing which they can obtain their food, much as a worm does from the mould in which it lives. But throughout the whole Cainozoic era the British seas seem to have been comparatively free from reefs and rocks, while in the Eocenes the sea-bottom was mostly of mud and clay. Hence the conditions of life were in all ways unfavourable to the Echinoidea.

The Relations of the British Eocene Echinoidea.

a.—To the Cretaceous.

In the Upper Chalk there is a very rich Echinoid fauna, including some of the best-known of English fossils. It is totally unlike that of the Eocene beds which succeed it. Not one species is common to the two deposits, and the genera belong mostly to different groups. In the Eocene the Ananchytidæ have disappeared entirely, while the Adete *Epiaster* and the Prynmodesian *Micraster* are replaced by the Prynmodete *Hemiaster* and *Schizaster*. *Cidaris*, with its narrow ambulacra of simple primaries, is succeeded by *Cælopleurus*, with its "arbacoid" plates, and *Echinopedina*, with its still more complicated structure. Among the Prynmodesmiæ *Micraster*, with its uniform epistroma, gives place to *Marettia* and *Euspatangus*, with their specialised tubercles set in deep scrobicules.

At first one might think that these radical changes indicated the lapse of an enormous interval of time, but it must be remembered, as was shown by Prof. Prestwich in 1854,³⁶ that the contrast is rather due to the different conditions of life. If we compare the Eocene Echinoids with those from the Lower Chalk, or, better

³⁶ Prestwich, J. Quart. Journ. Geol. Soc. x. p. 443-4. See also J. G. Goodchild, Proc. Geol. Assoc. Lond. ix. 1886, p. 213, and A. J. Jukes-Browne, Historical Geology, 1886, pp. 43-6. No reliance, however, can be placed on the generic determination of the Asteroidea quoted by the last author.

still, the Chalk Marl, we find no such striking contrast ; the genus *Hemiaster*, e.g., is not only common to the two deposits, but the species are very near allies ; thus, the Chalk Marl, and even Gault species *H. minimus* (Ag.), is probably the closest ally of the London Clay *H. bowerbanki*. *Echinopedina*, again, has more in common with *Codechinus*, a genus especially characteristic of the Cenomanian, than with any Senonian form.

b.—To the Echinoidea of the Continental Eocene.

The English Eocene Echinoids are derived from four horizons ; the Thanet Sand, the London Clay, and the Bracklesham and Barton series. From the first of these we have only a few specimens from eastern Kent. Only one species, *Schizaster corneti*, Cott., can be identified, and that with considerable doubt, as from the Belgian *Landénien*. I am not aware that any Echinoderms have been found in the *Heersien* ; therefore we are unable to derive any assistance in deciphering our imperfect fragments from the Belgian equivalents of the Thanet Sands.

The London Clay fauna includes four species, and these are all peculiar to the deposit ; but this is easily explained by the facts that in the Belgian area this bed is doubtfully represented by the almost unfossiliferous clays of the *Yprésien inférieur*, while in the Paris basin it is wanting, unless the upper part of the *argile plastique* or *marls de Rilly* be of this age. The southernmost point of the London Clay is at Dieppe and no Echinoids have been recorded from that locality ; whilst the species from the lower Eocenes of the south of France are altogether different to those of the British area.

There seems a general agreement among Tertiary geologists, that in the period of the London Clay a land barrier stretched across France, separating the English sea from that of the Mediterranean region ; and further, that in Middle Eocene times this barrier was breached, and a colony of the southern forms entered the British area, but withdrew or perished as the closing of the connection in the Upper Eocene reduced the temperature of the northern sea.

The Echinoidea give a general support to this hypothesis. The London Clay Echinoids are of tropical or sub-tropical genera, but their dwarfed size and rarity show that they were living under unfavourable conditions. The *Cælopleurus* is a very small species, and the English Schizasters of the period compare very unfavourably with the *S. pyrenæicus*, Mun. Chal., and the *S. buiannensis*, Cott., from the Lower Eocene of the south of France. But the sea in which the Bracklesham beds were deposited had a much wider extension to the south and east ; its waters were purer than those of the London Clay, and its bottom of shell sand afforded better feeding ground ; and though the numbers of species had not much increased, the greater size of the specimens shows the

improvement of the conditions. *Schizaster d'urbani*, Forbes, is especially emphatic on this point; its deep, anterior furrow indicates that the species was viviparous, a sure sign of a warm climate. The *Scutellina lenticularis*, now added to the British record, has a wide distribution in the *Calcaire grossier* of France, and occurs in the *Laekenien inférieure* of Belgium. In the Barton beds there is no indication, as far as the Echinoidea go, of any serious modification of climate. A very rich and varied Echinoid fauna flourished throughout the Middle and Upper Eocene in the great sea that occupied the south of France and north of Italy, and stretched into Spain on the west, and over Egypt on the east. Enormous Echinolampads and Spatangoids, with large species of *Cidaris*, *Cælopleurus* and *Conoclypeus*, and other tropical genera were characteristic of this area. A few of these genera gained a footing in the Barton Seas; such as *Maretia* and *Euspatangus*. Our *Maretia grignonensis* occurs no further south than the Paris basin, but the two nearest allies of our Barton *Euspatangi* are common species of the Upper Eocene of the south of France. The *Schizaster branderi* has, however, some points of resemblance to the London Clay *S. forbesi*, and this may represent the admixture of London Clay forms, which is conspicuous in other groups.

The Pliocene Echinoidea.

It has been the almost universal custom to compare the fauna of the Craggs with that of the Mediterranean, and there are so many points of resemblance between them that some close connection between the Pliocene seas of the two areas has been generally assumed. Prof. Forbes followed the general rule, and in his Monograph constantly compared the Crag Echinoids with those that he knew so well, from his extensive dredging expeditions in the Mediterranean. But the additional facts that have come to light have by no means strengthened the supposed affinities between the two faunas. Carus, in his "Prodromus Faunæ Mediterraneæ,"³⁷ enumerates 19 species from that area, and of these only five are found in the Craggs, and these are the common Echinoids of Western Europe; the strictly Mediterranean species do not occur in the Craggs.³⁸ And when we compare the Crag Echinoids with those from the Mediterranean Pliocenes the difference is still more striking. None of the characteristic genera of either formation occur in the other; thus, *Temnechinus*, *Rhynchopygus*, and *Agassizia* are absent from the Italian Pliocene, while *Stirechinus*, *Dorocidaris*, *Schizaster*, *Conoclypeus*, and the *Paæolampas* group of Echinolampads have not been found in the Craggs. Mr. Clement Reid, in his recent Memoir, remarks that the Crag fauna resembles the Mediterranean fauna as it exists now

³⁷ Pars. I. 1884, pp. 97-104.

³⁸ Though Prof. Forbes regarded the characteristically Mediterranean *E. melo* as a Crag species, there seems no adequate evidence of its occurrence.

rather than as it was in Pliocene times [39, p. 215]; and the difference between the Echinoidea of the English and those of the Mediterranean Pliocenes is far greater than those of the existing seas.

The Pliocene fauna that agrees most closely with that of England is the Belgian; M. Cotteau, in his "Description des Echinides Tertiaires de la Belgique," describes nine species from this series. Only one of these species occurs in England,³⁹ but the general facies of the two faunas is alike; the main differences between them are the occurrence in Belgium of the Mediterranean *Schizaster scillæ* (Desml.), and the absence there of the genera *Rhynchopygus*, *Temnechinus*, *Agassizia*, *Echinolampas* and *Strongylocentrotus*. It is the presence of the three first of these genera that forms the distinctive feature of the English Crag Echinoid fauna, and, as I have shown in a note on *Rhynchopygus* [29], it is to the west that we must go to find their allies. The Crag Echinoids may be divided into two groups: the first includes the common species of Western Europe, with some boreal forms, and extinct species allied to these; such are the nine species of *Echinus*, the two species of *Strongylocentrotus*, *Echinocyamus pusillus*, *Spatangus purpureus*, and *Echinocardium cordatum*; with these must be associated ubiquitous species, found on the American coasts and elsewhere, as *Brissus unicolor*. The remaining five species, viz., the two species of *Temnechinus*, *Rhynchopygus woodi*, *Agassizia æquipetala* and *Echinolampas subrostrata* are distinctly tropical American. The genus *Echinolampas*, it is true, has now a wide distribution, but among existing forms it is to the West Indian species that the Crag one is most allied. The other genera are either exclusively Caribbean, as *Temnechinus*, or occur elsewhere only on the Pacific side of Central America. Thus, the two living species of *Rhynchopygus* are *R. caribbearum* (Lam.) (the nearest to the Crag *R. woodi*), on the one side of America, and *R. pacificus* (A. Ag.) in the corresponding latitudes on the other side. Similarly, the genus *Agassizia* is now represented only by *A. excentrica* (A. Ag.) from the West Indies, and *A. scrobiculata*, Val., from Panama.

The points of resemblance between the Echinoid faunas of the English Pliocene and of the present West Indian seas are too striking to admit of any other explanation than a direct connection between the two areas and a common origin of at least a part of the species. It becomes, then, of interest to enquire what evidence there is as to the nature of the connection, and this can best be discussed if it be first determined where the common element in the two faunas originated, and when it entered the two areas.

³⁹ Nyst (in Dewalque Prod. descript. géol. Belgique, 1861, p. 433) gave a list of several species, which has been again quoted by Van den Broeck (Esquisse géol. et pal. des dépôts pliocène des environs d'Anvers, 1878, p. 135): as, however, Cotteau has not been able to confirm these records they are neglected.

The absence of the West Indian genera in the Belgian Pliocenes suggests that they came from the west and that they did not arrive till after the Diestien times; the Diestien beds, it may be remarked, are somewhat older than the base of the Coralline Crag.

In the case of the West Indies the evidence is also tolerably definite. In his "Report on the Echini of the Blake Expedition" Prof. Al. Agassiz has most carefully analysed the geographical relations of the Echinoid fauna of that region; he points out that its great wealth of species is due to the migration of a group of North Atlantic forms into an area originally stocked from the Indo-Pacific ocean. For our present purpose it is convenient to separate from the latter those tropical genera which occurred also in the European Pliocenes, including *Rhynchopygus*, *Agassizia*, *Temnechinus*, &c. Their absence in the North Atlantic justified Prof. A. Agassiz in regarding them as of Indo-Pacific origin, though the palæontological evidence now adduced is conclusive against this.

The fossil Echinoidea of the West Indies are also well known from the works of Cotteau, Guppy, Lovén, Michelin, Duchassaing, d'Orbigny, and others.⁴⁰ The Miocene fauna is the richest, but it does not contain representatives of the genera which ally the Crag Echinoids with those of the existing West Indian seas; but all these genera, except *Temnechinus*, are known in the Pleistocene deposits; thus, *Rhynchopygus*, *Strongylocentrotus*, *Agassizia*, *Brissus*, and *Echinocardium* occur in deposits of this age. The last three genera are quoted from the Pliocene of South Carolina,⁴¹ but there seems a general agreement that the deposits in which they occur are more recent than the beds known as the Pliocene in Europe. It therefore seems fairly certain that these genera did not enter the Caribbean region till Post-Miocene times; and as these genera are represented by closely-allied species on each side of Central America, they must have entered the area before the loss of the connection between the two seas; and this must have been closed at a sufficiently early age for the invertebrates to have developed an entirely distinct set of species. Hence, these genera cannot have entered later than the Pliocene.

As to the possible line which the migration followed we are limited to two alternatives by the fact that such tropical and comparatively shallow-water dwellers as *Agassizia*, *Rhynchopygus*, &c., could never have traversed the deep and cold abysses of the Atlantic. Either they worked their way round the belt of shallow sea (less than 1,000 fathoms) that skirts the northern shores of the Atlantic, or, if the connection were restricted to the same latitude to which these genera are now confined, then an area of shallow sea must have extended nearly, if not quite, across the

⁴⁰ Mem. Mus. Comp. Zool., vol. x., No. 1, 1883, pp. 79-84.

⁴¹ McCrady, in M. Tuomey and F. S. Holmes' "Pliocene Fossils of South Carolina," Charleston, 1855, pp. 5-8.

mid-Atlantic. The former hypothesis is that which one is at first tempted to accept, as it is consistent with that doctrine of the permanence of oceans and continents now so strongly urged by zoologists. But this view does not account for all the facts. A comparison of the recent and Miocene Echinoidea of the West Indian area with those of the Mediterranean, Portugal, the North-west of Africa, and the Azores, shows that the resemblance between the faunas of the two sides of the Atlantic was not confined to the Pliocene; it was anticipated in the Miocene and is very striking at the present day. Thus, of the 43 species (excluding *Calymne*) recorded by Prof. A. Agassiz from the coasts of Portugal and North-western Africa, 29 occur in corresponding latitudes on the opposite shores. Had the connection between the two areas been established by the northern route some traces of the migration ought to be found in higher latitudes: we might expect the faunas of various zones to be mingled together; but, except a slight overlap of the tropical and sub-tropical with the temperate and northern forms, no such mingling occurs. There is no evidence that many of the genera in question ever occurred further north than they do to-day, either in Europe or America, and in the latter it is only in South Carolina and Alabama, both near the Caribbean area, that they have been found fossil. The occurrence of some of the Miocene forms in Madeira and of some West Indian species (as *Temnechinus maculatus*) no further east than the Azores is further evidence against the northern route.

The probabilities are therefore all in favour of the other view, that within late Cainozoic times a belt of shallow water connected the south of Europe with the opposite coasts of America. As to the width of the shallow area it is difficult to surmise: it may have been a shoal, of which the well-known "Connecting Ridge" is the depressed representative, possibly rising into a chain of islands of which the Azores is the last survivor; or it may have been an extensive area in which successive faunas were reared which at intervals invaded the continental areas on either side. Recent work in the West Indies has demonstrated the submergence of that area to an enormous depth in apparently Pliocene times; and the subsidence of this shallow area across the mid-Atlantic to its present depth may have been one of the compensating movements that accompanied the elevation of the abyssal radiolarian marls of Barbados and the pteropod marls of Jamaica to elevations of sometimes 1,200 feet above the sea.

[Though in the present paper attention is restricted to the Echinoidea the evidence of other groups is in agreement with it; thus, in the case of the corals, Count de Pourtales has pointed out that "there are less deep-sea genera common to the tertiary and living faunæ of the West Indies than there are common to the European tertiary and the living West Indian ones," and he explains this by a westward migration of the European genera. L. F. de Pourtales' "Zoological Results of the Hassler Expedition: Crinoids and Corals." Ill. Cat. Mus. Comp. Zool., No. viii., 1874, p. 49.]

VIII.—SUMMARY OF CONCLUSIONS.

A. (1) The following species are added to the English fossil fauna :—

<i>Scutellina lenticularis</i> (Lam.).	<i>Echinus esculentus</i> , Linn. (to Crag).
<i>Schizaster corneti</i> , Cott.	" <i>spheroideus</i> (Cott).
	<i>Strongylocentrotus dröbachiensis</i> (O. F. Müll.) (to Crag).

(2) The following species are new :—

<i>Cælopleurus dixonii</i> .	<i>Echinus paucimiliaris</i> .
<i>Hemiasaster forbesi</i> .	<i>Strongylocentrotus scaber</i> .
<i>Schizaster cuneatus</i> .	<i>Echinolampas subrostrata</i> .
<i>Euspatangus excentricus</i> .	<i>Agassizia æquipetala</i> .

The two last belong to genera new to the British area.

(3) The following English species are regarded as synonyms :—

<i>Temnechinus melocactus</i> , Fbs.	<i>Echinocyamus hispidulus</i> , Fbs.
" <i>turbinatus</i> "	" <i>oviformis</i> "
<i>Spatangus regina</i> (Gray).	" <i>suffolciensis</i> , Ag.

(4) The genus *Opechinus* is retained as distinct from *Temnechinus*, and both are transferred to the sub-family *Glyphocyphinae*.

B. (1) *Schizaster d'urbani* is regarded as viviparous.

(2) Sexual Dimorphism. In two cases (*Temnechinus excavatus* and *Echinus henslowi*), supposed specific differences are explained as instances of this phenomenon.

C. Faunal affinities. It is suggested :—

(1) That the London Clay Echinoids are dwarfed sub-tropical forms.

(2) That the Lower Eocene Echinoids are more allied to those of the Lower than of the Upper Chalk.

(3) That some connection must have been established between the British sea and that of the Mediterranean basin in the Middle, and perhaps Upper, Eocenes.

(4) That the most striking feature in the Crag Echinoid fauna is that it is of twofold origin ; since in addition to the ordinary North Atlantic forms, it contains a series of genera found in the Mexican and Antillean regions, or of species most closely allied to these. That this implies some direct connection of warm, shallow sea, and probably points to the past existence of at least a ridge or chain of islands across the southern part of the North Atlantic.

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EXPLANATION OF THE PLATES.

PLATE I.

FIG. 1, 2 and 3.—*Schizaster cuneatus* n. sp. Bracklesham Beds. Stubbington. (Cambridge Museum.) Nat. size.

FIG. 4, 5 and 6.—*Hemiaster forbesi* n. sp. London Clay. Pinner. (Brit. Mus., E. 3394.) Nat. size.

FIG. 7.—*Agassizia æquipetala* n. sp. Coralline Crag. Aldboro. (Brit. Mus., E. 33645.) Nat. size.

FIG. 8 and 9.—*Echinolampas subrostrata* n. sp. Coralline Crag. Suffolk. (Brit. Mus., E. 1530.) Nat. size.

PLATE II.

Reprinted from the Ann. Rep. Yorks. Phil. Soc., 1890, by the kind permission of W. Reed, Esq., M.R.C.S.

FIG. 1.—*Echinus paucimiliaris*, J. W. Gregory. Red Crag. Butley. Nat. size. (York Mus.)

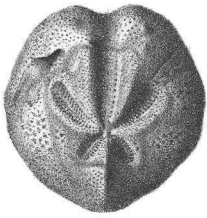
FIG. 2, 3 and 4.—*Echinus henslowi*, Forbes, female form. Red Crag. Walton. Fig. 2. Side view, mag. 2 diam. Fig. 3. Abactinal view; showing the depressions: mag. 2 diam. (Brit. Mus., E. 3107.) Fig. 4a, enlarged plates at the ambitus. 4b, plate below the ambitus.

FIG. 5.—*Echinus sphaeroideus*, Cotteau. Coralline Crag. Boyton: mag. 4 diam.

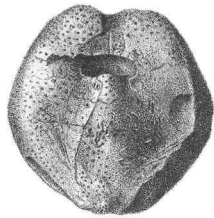
FIG. 6.—Ditto; ditto, ambital plates of same specimen enlarged.

FIG.—*Strongylocentrotus scaber*, J. W. Gregory. Coralline Crag. Aldboro. Nat. size.

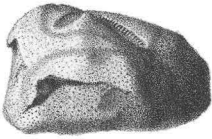
FIG. 8.—*Echinus woodi*, Desor. Coralline Crag. Orford. Nat. size.



1



2



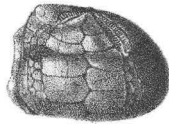
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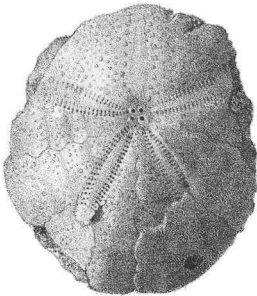
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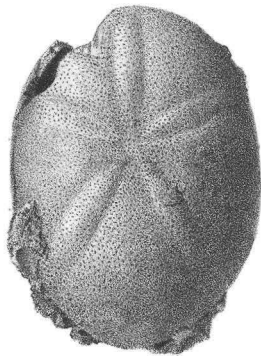
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6



7



8

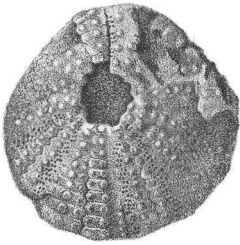


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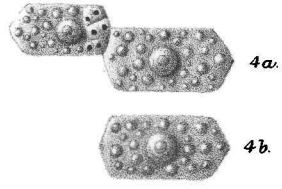
G. M. Woodward lith.

West, Newman. imp.

BRITISH CAINOZOIC ECHINOIDEA.

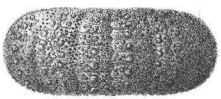


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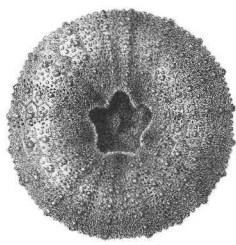


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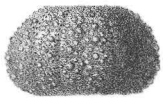
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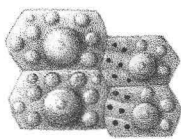
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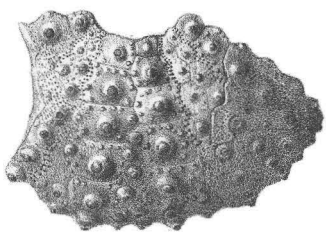
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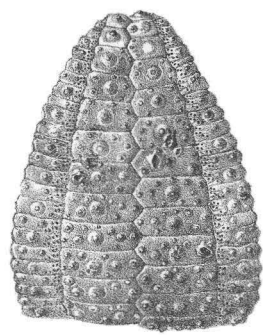
5.



6.



7.



8.

G.M. Woodward lith.

West, Newman. imp.

BRITISH PLIOCENE ECHINOIDEA.