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THE JURASSIC LAMELLIBRANCH FAUNA OF KUCHH (CUTCH).

By

Dr. L. R. COX, M.A., Sc.D.

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THE JURASSIC LAMELLIBRANCH FAUNA OF KUCHH (CUTCH).

CONTENTS.

	Page.
Introduction	1
Systematic descriptions	4
Order : PROTOBRANCHIA	4
Superfamily : *NUCULACEA*	4
Family : *CTENODONTIDAE*	4
Genus : PALÆONEILO	5
Palæoneilo belaënsis sp. nov.	6
Palæoneilo indicus sp. nov.	7
Family : *NUCULIDAE*	9
Genus : NUCULA	11
Sub-genus : PALÆONUCULA	11
Nucula (*Palæonucula*) *cuneiformis* J. de C. Sowerby	13
Nucula (*Palæonucula*) *kaoraënsis* sp. nov.	15
Nucula (*Palæonucula*) *blanfordi* sp. nov.	16
Nucula (*Palæonucula*) cf. *menkii* Rœmer	18
Nucula (*Palæonucula*) *stoliczkai* sp. nov.	20
(Sub-genus incertum)	—
Nucula sp.	21
Genus : NUCULOMA	22
Nuculoma wynnei sp. nov.	23
Nuculoma blakei sp. nov.	24
Family : *NUCULANIDAE*	25
Genus : NUCULANA	26
Sub-genus : DACRYOMYA	28
Nuculana (*Dacryomya*) *lacryma* (J. de C. Sowerby)	29
Sub-genus PRAESACCELLA	32
Nuculana (*Praesaccella*) *juriana* sp. nov.	33
Genus : ROLLIERIA	34
Rollieria cf. *meriani* (Rollier)	35
Order : ARCACEA	36
Superfamily : *ARCACEA*	36
Family : *PARALLELODONTIDAE*	36
Genus : PARALLELODON	38
Parallelodon lerensis sp. nov.	39
Genus : GRAMMATODON	40
Sub-genus : GRAMMATODON s. str.	41
Grammatodon andhouensis sp. nov.	41
Grammatodon jurianus sp. nov.	43
Grammatodon sp.	44
Sub-genus : INDOGRAMMATODON	45
Grammatodon (*Indogrammatodon*) *virgatus* (J. de C. Sowerby)	47
Grammatodon (*Indogrammatodon*) *blakei* sp. nov.	50
Grammatodon (*Indogrammatodon*) *kantkotensis* sp. nov.	51
Grammatodon (*Indogrammatodon*) *iddurghurensis* sp. nov.	52
Grammatodon (*Indogrammatodon*) sp.	54
Genus : CUCULLÆA	55
Sub-genus : MEGACUCULLÆA	56
Cucullæa (*Megacucullæa*) *kraussii* Tate	57
Cucullæa (*Megacucullæa*) *eminens* sp. nov.	59
Order : DYSODONTA	60
Superfamily : *MYTILACEA*	60
Family : *MYTILIDAE*	60
Genus : MODIOLUS	62
Sub-genus : MODIOLUS s. str.	63
Modiolus patchamensis sp. nov.	63
Modiolus imbricatus J. Sowerby	64
Modiolus cf. *bipartitus* J. Sowerby	67
Modiolus glendayi (Weir)	69
Sub-genus : INOPERNA	70
Modiolus (*Inoperna*) *plicatus* J. Sowerby	71

	Page.
Genus : Lithophaga	73
Lithophaga sp. indet. A	73
Lithophaga sp. indet. B	74
Lithophaga sp. indet. C	74
Genus : Mytilus	74
Sub-genus : Falcimytilus	76
Mytilus (*Falcimytilus*) *tramauensis* sp. nov.	77
Genus : Brachidontes	78
Sub-genus : Arcomytilus	79
Brachidontes (*Arcomytilus*) *laitmairensis* (de Loriol)	81
Genus : Lycettia	83
Lycettia indica sp. nov.	85
Superfamily : *PTERIACEA*	86
Family : *PTERIIDAE*	86
Genus : Pteroperna	87
Pteroperna sp. indet.	88
Pteroperna ? blakei sp. nov.	89
Genus : Echinotis	90
Echinotis echinata (W. Smith)	92
Genus : Oxytoma	96
Oxytoma inequivalve (J. Sowerby)	98
Oxytoma sp.	101
Genus : Posidonia	102
Posidonia ornati Quenstedt	103
Family : *ISOGNOMONIDAE*	105
Genus : Bakevellia	108
Sub-genus : Bakevellia s. str.	108
Bakevellia waltoni (Lycett)	108
Bakevellia (*sensu lato*) sp.	111
Genus : Gervillella	112
Gervillella siliqua (J. A. Eudes-Deslongchamps)	112
Gervillella kantkotensis sp. nov.	115
Gervillella anceps (Deshayes MS., Leymerie)	117
Genus : Isognomon	120
Sub-genus : Mytiloperna	121
Isognomon (*Mytiloperna*) *patchamensis* sp. nov.	122
Isognomon (*Mytiloperna* ?) sp.	123
Genus : Inoceramus	124
Inoceramus sp.	127
Family : *VULSELLIDAE*	127
Genus : Eligmus	128
Eligmus rollandi Douvillé	128
Family : *PINNIDAE*	130
Genus : Pinna	130
Sub-genus : Pinna s. str.	131
Pinna cf. *mitis* Phillips	132
Sub-genus : Stegoconcha	133
Pinna (*Stegoconcha*) cf. *g.-mülleri* Krenkel	134
(Sub-genus incertum)	—
Pinna stoliczkai sp. nov.	135
Genus : Trichites	136
Trichites indicus sp. nov.	138

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BY

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INTRODUCTION.

The present Memoir continues the description of the Jurassic Lamellibranch fauna of Kachh begun in 1903 by the late Dr. F. L. Kitchin, whose monograph of the Trigoniidæ has become one of the classics of palæontological literature. During the latter years of his life Dr. Kitchin several times informed me that he hoped shortly to be able to resume his work on this fauna, so long interrupted by the heavy pressure of his official duties as Palæontologist to the Geological Survey of Great Britain. The fulfilment of this intention remained, however, unrealized, as Dr. Kitchin's sudden and lamented death occurred early in 1934, less than two years before retirement from his official position would undoubtedly have afforded him the time necessary for the completion of the work.

At the suggestion of Dr. Kitchin's successor, Dr. J. Pringle, I was then asked by the Director of the Geological Survey of India if I would take over the material which had been for so long in Dr. Kitchin's hands, and proceed with the work of its description. By kind permission of the Trustees of the British Museum and of Dr. W. D. Lang, F.R.S., Keeper of the Department of Geology, I have been enabled to undertake this work in my unofficial time, and hope to complete the systematic study of the fauna in three or four Parts of about the same size as the present one.

The material which has thus been passed on to me consists of the collections made by the staff of the Geological Survey of India during their survey of Kachh many years ago; namely, by W. T. Blanford in 1864, by A. B. Wynne and F. Fedden from 1867-9, and by F. Stoliczka in 1871. Of these geologists, the first three, whose reports (W. T. Blanford, 1867; A. B. Wynne, 1872) were fairly soon published, had determined the stratigraphical succession only in very general terms, and the horizons of their fossils are not recorded with any accuracy. The collection made by Stoliczka—a much more experienced palæontologist than his predecessors—was made with more regard to the precise horizon from which each specimen was obtained. Unfortunately, however, his death occurred before he was able to publish the results of his observations on the stratigraphy of the area, so that some of the provisional stratigraphical terms

which figure in his MS. lists of fossils have remained undefined, and in some cases it is only possible to guess at their precise significance.

A brief outline of the classification of the Jurassic strata of Kachh proposed by Stoliczka was, however, published shortly after his death by L. Waagen (1873, introductory page), while a few further details, also taken from Stoliczka's MSS., are given by W. T. Blanford (in H. B. Medlicott and W. T. Blanford, 1879, pp. 250-265). It is in these works that such stratigraphical terms as "Patcham Group", "Chari Group", "Katrol Group", "Umia Group", "Dhosa Oolite", etc., were first introduced into the literature.

In 1895, the Rev. Prof. J. F. Blake, well known for his work on the Jurassic stratigraphy and palæontology of Great Britain, visited Kachh and appears to have made a careful study of its stratigraphy, at the same time obtaining an interesting collection of fossils acquired in 1907 by the British Museum (Natural History), following his death in the previous year. Unfortunately Blake, like Stoliczka, had found no time to publish an account of his observations on the Jurassic stratigraphy of this area prior to his death. His fossils, however, have remained carefully labelled according to the exact bed (as listed in his MS. notes) from which each specimen was obtained.

Although Blake's notes do not appear to have survived, Dr. L. F. Spath's recent work (1924; 1927-33) on the ammonites from his collection has revealed the exact horizon of the majority of the beds distinguished by him, and has added considerably to our detailed knowledge of the Jurassic stratigraphy of the region. As many of the lamellibranchs in the Blake Collection are labelled as coming from the same beds as ammonites described by Dr. Spath, it is now possible to determine their horizon with considerable accuracy, and much light is also thrown on the horizons of fossils obtained by the older workers from the same localities. Hence while Dr. Kitchin, whose work on the Brachiopoda (1900) and Trigoniidæ (1903) was carried out before the Blake Collection was available for detailed study, was obliged to confine his investigations to the older collections, it has appeared to me to be highly desirable to include in the present Memoir a description of the material in the Blake Collection.

No official geological survey of Kachh has been carried out since that of the early authors already mentioned. During the last few years, however, Mr. J. H. Smith, of Bhuj, has re-described several of the most important sections and has collected a series of fossils which have been studied by Dr. Spath. A few lamellibranchs collected by Mr. Smith, including some extracted from the matrix of ammonites, have been passed on to me by Dr. Spath and are dealt with in the present Memoir; these specimens will be deposited in the collections of the Geological Survey of India.

The Jurassic stratigraphy of Kachh has also been studied within recent years by Dr. Raj Nath, of Benares University, and a number of ammonites collected by him have been described in Dr. Spath's Monograph.

As the result of his work on the Cephalopoda Dr. Spath (1933, pp. 758-799) has shown how the main subdivisions of the Jurassic strata of Kachh are to be correlated with those of the European succession. A short correlation table

adapted from one given by him (1933, p. 758) may, for convenience, be here reproduced :—

Umia Group		Tithonian.
	Gudjinsir Beds and Zamia Shales	Portlandian.
Katrol Group	Upper	Bolonian.
	Middle	Havrian.
	Lower	Sequanian.
	Kantkote Sandstone	Argovian.
Chari Group	Dhosa Oolite	Divesian—Argovian.
	athleta Beds	Divesian.
	anceps Beds	Callovian.
	rehmanni Zone	Callovian.
	macrocephalus Beds	Bathonian.
Patcham Group		Bathonian.

A comparison of this table with those given long previously by Waagen and Blanford in the works already cited will show that it differs only in comparatively unimportant details.

During the latter years of his life Dr. Kitchin (1926 ; 1929, p. 208, etc.) was of the opinion that the higher beds of the succession, in which certain species of *Trigonia*, *Gervillia*, *Astarte*, and other genera occur, should be referred to the Neocomian rather than to the uppermost Jurassic. In a recent paper (1935), however, Dr. L. F. Spath has shown that some of the species to which Dr. Kitchin was inclined to attribute a Neocomian age occur in Wagur (eastern Kachh) in association with ammonites which he identifies with Argovian forms. I have accepted Dr. Spath's conclusions on this question, and have assigned an Argovian horizon to the lamellibranchs from the beds from which these ammonites were obtained.

It appears, however, that in the Umia and Moondan district of north-western Kachh a series of closely comparable species occur in higher beds, which are referable at least in part to the Tithonian. If Dr. Spath's conclusions are correct, this would appear to constitute an interesting example of faunal repetition. A discussion of this subject must, however, be reserved until the description of the whole lamellibranch fauna has been completed.

Dr. Raj Nath (1932, p. 170) has recorded that the highest bed in Kachh which has yielded Tithonian ammonites is succeeded, after 200-300 ft. of unfossiliferous sandstone, by a bed whose fauna appears to consist entirely of species of *Trigonia*. It is at present uncertain if this *Trigonia* horizon, which is overlain by at least 1,000 ft. of unfossiliferous rocks, belongs to the Tithonian or to the basal Cretaceous.

As regards the age of the lowest beds of the Jurassic sequence exposed in Kachh, I now take the opportunity of correcting an opinion expressed in a recent paper [1935(2), p. 2] that the *Corbula lyrata* beds towards the base of the succession are probably of Bajocian age. This opinion was based on the observation that the fauna of these beds is identical with that of certain beds in Madagascar

whose molluscan fauna was first described by R. B. Newton (1895). At the time I wrote, the most recent authorities on Madagascan stratigraphy whose works were then accessible to me appeared to incline to the view that these beds are of Bajocian age. It has, however, now been demonstrated conclusively (H. Besairie, 1932, p. 38) that the *Corbula lyrata* Beds of Madagascar are referable to the Bathonian, and probably to a fairly high horizon of that stage. I am greatly indebted to M. V. Hourcq, who has kindly sent me a series of fossils from this horizon in Madagascar for comparision with those from the Indian Patcham Beds.

There would appear to be little object in continuing to use such terms as "Patcham Group", "Chari Group", and "Katrol Group" when the more familiar European stage-names are available. Unfortunately, however, the European classification is at present far from stable, and such terms as Bathonian and Callovian are used in different senses by different authors. Thus Dr. Spath (1933, pp. 764-6) argues in favour of including the *macrocephalus* Beds in the Bathonian, although many European authors, perhaps the majority, have included this horizon in the Callovian. Dr. Spath (1933, p. 774) also considers that the *athleta* Beds are more appropriately included in the Divesian than in the Callovian, where many authors have placed them. For the sake of uniformity I have used these terms in the same sense as Dr. Spath.

It remains for me to express my great indebtedness to Dr. Spath, who, thanks to the experience gained in his work on the Cephalopoda, has been able to give me much helpful advice, particularly in assigning many of the fossils described to their precise geological horizons.

SYSTEMATIC DESCRIPTIONS.

Class: LAMELLIBRANCHIA.

Order: PROTOBRANCHIA.

Superfamily: *NUCULACEA.*

Family: *CTENODONTIDAE.*

The family Ctenodontidæ, founded by S. von Wöhrmann (1893, pp. 19, 28), is here considered to include genera of Palæozoic and Mesozoic Nuculacea in which the hinge is formed by a series of taxodont teeth arranged in a more or less continuous series along the dorsal margins of the shell, and in which the ligament is entirely external.[1] A definite hinge-plate is rarely developed. As in all the Nuculacea, the teeth are pronouncedly chevron-shaped.

This family, whose earliest representatives (referred to *Ctenodonta*) appear in the Cambrian, is now regarded as the parent stock from which both the Nuculidæ and Nuculanidæ were derived. Already in the Palæozoic its various

[1] W. H. Dall (1898, p. 583; 1913, p. 440) conceives the family in a more restricted sense, to include only *Ctenodonta* and *Cucullella*. Wöhrmann includes in it the Permian freshwater genus *Palæomutela* Amalitski, but its irregular pseudotaxodont teeth appear to be of secondary origin, as in the Recent family Mutelidæ, and in no way analogous to the teeth of the Nuculacea.

representatives would appear to have exhibited some divergence in anatomical characters. Thus L. Pfab (1934, p. 231) has shown that even in the Ordovician a definite pallial sinus is observable in certain forms, and, as W. Quenstedt (1930, p. 97) has pointed out, it is obvious from the external characters of the shell that many of the Upper Palæozoic species of the genus *Palæoneilo* must also have been siphonate; on the other hand, the group from which *Nucula* was derived, perhaps not until Devonian times, must have remained as primitive in anatomical characters as that genus and have possessed entirely open mantle lobes.

The persistence of the Ctenodontidæ into the Mesozoic has hitherto been ignored by the majority of authors, but A. Bittner (1895, p. 133) has recognized the presence of *Palæoneilo* in the Trias, and A. Borissiak (1904, p. 31) and myself [1937(1), p. 190] in the Jurassic. This same genus is also continued into the Cretaceous by such species as "*Nucula*" *lineata* J. de C. Sowerby [H. Woods, 1899(1), p. 7, Pl. I, figs. 28-32].

Nuculacea characterized by precisely the same type of hinge-structure as the Ctenodontidæ exist, moreover, at the present day, and form the family Malletiidæ, whose representatives have been recognized from the earliest Eocene onwards. Thus there appears to have been an uninterrupted succession of such forms with an external ligament from early Palæozoic times to the present day, and the propriety of including the earlier and later forms in two distinct families appears somewhat doubtful. In the Malletiidæ, however, the shell is porcellanous in structure, as in the Nuculanidæ, while the Ctenodontidæ, or at least the earlier representatives of that family, may be assumed to have possessed the more primitive nacreous structure still retained by the Nuculidæ.

One would have hoped that the ontogeny of the hinge in the Nuculidæ and Nuculanidæ would have been found to give some support to the view that these families were derived from members of the Ctenodontidæ by submergence of the ligament. From the description given by F. Bernard [1896(1), pp. 75-81] it appears, however, that the shell does not pass through a stage in development in which the ligament is external. In the ontogeny of the hinge of *Malletia* the internal ligament of the embryonic shell persists to a growth-stage of about 1·2 mm. and then gradually becomes external.

Genus: PALAEONEILO J. Hall, 1869.

Preliminary Notice of the Lamellibranchiate Shells of the Upper Helderberg, Hamilton and Chemung Groups, with others from the Waverley Sandstones, Pt. 2, p. 6 [spelt "*Palœaneilo*"].[1] *See also* J. Hall, Natural History of New York, Palæontology, Vol. V, Pt. 1, section II, pp. xxvii, 333 (1885) [*Palæoneilo*].

Genotype.—*Nuculites constricta* Conrad (1842, p. 249, Pl. XV, fig. 8), Devonian, North America.

[1] This pamphlet has been discussed by G. A. Cooper (1931), who considers that it was written by Hall and R. P. Whitfield conjointly. I have recently submitted to the International Commission on Zoological Nomenclature a recommendation that the generic name be officially stabilized as *Palæoneilo*.

Generic Characters.—Shell sub-elliptical, more or less inequilateral, with broad, depressed, and only slightly incurved umbones placed between the middle and the anterior quarter of the length; frequently somewhat cuneiform, with a bluntly pointed posterior end. A shallow, broad depression may run from the umbo to the posterior end of the ventral margin, but is absent in some species. Hinge-line arcuate or sub-angular, with numerous small taxodont teeth which may be arranged in an uninterrupted row, although usually there is a slight change in their orientation or a break in their alignment below the umbo. Ligament external. Adductor scars subequal, not strongly impressed, situated below the extremities of the hinge-line. Pallial line simple; valve margins closed.

Remarks.—
a continuous row, and there is only a slight change in their orientation below the umbo. In certain other species described by Hall, however, there is a distinct discontinuity in their alignment below the umbo, the posterior row tending to pass above the anterior row. It does not seem possible to base any subgeneric distinctions on such differences in hinge-structure, as these are not to be correlated with differences in the external characters of the shell. The various species included by Hall in the genus, however, differ considerably in external characters, so that it is probable that a modern reviser would group them in two or three distinct genera.

Both in hinge-structure and in the general shape of the shell the two Indian Jurassic species described below, as well as the English species *P. morrisii* (Deshayes) [*phillipsii* (Morris)[1]] and *P. galatea* (d'Orbigny), which have been recently discussed by me [1937(1), pp. 190-3], agree well with the genotype, and there seems to be no need to separate them from *Palæoneilo* s. str. The genotype is charaterized by the presence of a radial sulcus running from the umbo to the postero-ventral margin. Several other Devonian species, however, are without a definite sulcus, while in the Trias species with and without the sulcus are about equally abundant. In the Jurassic species this sulcus is usually absent, but it is obscurely developed in occasional specimens of *P. galatea* from the Lias.

Some authors have regarded *Palæoneilo* as a subgenus of *Ctenodonta* J. W. Salter (1852, p. 64; 1859, p. 34), founded on the American Silurian species *Ct. nasuta* (Hall), but, beyond a general similarity in hinge-structure, there is little resemblance between their respective genotypes. The two Ordovician species referred to *Palæoneilo* by L. Pfab (1934, p. 230, Pl. II, figs. 18, 19) are not at all like the typical Upper Palæozoic species of the genus; it is, in fact, doubtful if any true representatives occur before the Devonian.

PALÆONEILO BELAËNSIS sp. nov.

(Plate I, figs. 1, 2.)

Description.—The shell is of medium size for the genus, compressed, elongate-ovate, very slightly inequilateral, with a pronounced postero-dorsal angle

[1] In the paper cited I overlooked the fact that the English Oxford Clay species "*Nucula*" *phillipsii* Morris was renamed *Leda morrisii* by G. P. Deshayes (1853, p. 282) as it is a homonym of *Nucula phillipsii* McCoy, 1844.

which forms its posterior extremity. The ratio of length to height is about 5 : 3. The umbones, which are just anterior to median, are slightly incurved, and are directed towards neither end of the shell. The dorsal profiles, which meet in an obtuse umbonal angle, are straight, sloping gently at almost equal angles. The ventral margin is symmetrically convex, merging with the strongly convex anterior margin and the feebly convex, oblique posterior margin in even curves; the projecting postero-dorsal angle is approximately equal to 90°. A lunule and an escutcheon are absent, and the whole shell is evenly inflated. The surface is ornamented with fine concentric threads.

The hinge consists of two almost straight rows of chevron-shaped teeth, which meet below the umbo in a very obtuse angle, equal to about 150°; the posterior row immediately adjoins the dorsal margin, while the anterior is separated by a narrow space from the margin. The outer teeth of the anterior row (which contains 20 teeth in all in one specimen examined) are slightly longer than the corresponding ones of the posterior row (which contains 22 teeth in the same specimen); in both rows the teeth decrease in size more or less regularly towards the umbo, below which they are minute. The absence of an internal chondrophore can be clearly observed. The muscle scars and pallial line are not visible.

Holotype.—G. S. I. type No. 16503.

Dimensions.—The measurements of the holotype, a left valve, are as follows:—

Length	13·2 mm.
Height	8·0 ,,
Inflation	3·6 ,,

Remarks.—The softness of the matrix has enabled the interior of the shell to be developed in two of the specimens, and there can be no doubt that the hinge has the essential features of that of the genus *Palæoneilo*. In its external characters, particularly in its projecting postero-dorsal angle, this species closely resembles certain other Jurassic representatives of this genus, such as the Liassic species *P. galatea* (Dumortier *ex* d'Orbigny), the Oxford Clay species *P. morrisii* (Deshayes) [*P. phillipsii* (Morris)][1], and the two Swiss Oxfordian species "*Leda*" *phaseolus* (Merian MS., de Loriol) and *L. hordeum* (Merian MS., de Loriol), internal casts of which are figured by de Loriol (1899, pp. 161-2, Pl. X, figs. 26-28). It is, however, less inequilateral than these other species.

Occurrence and Material.—Bathonian, Patcham Beds ["Upper *Corbula* Beds" of Stoliczka, MS.], S. W. of Bela—the holotype (fig. 1) and two broken paratypes (G. S. I. type No. 604 and No. K40/486) whose interiors have be developed.

PALÆONEILO INDICUS sp. nov.

(Plate I, figs. 3, 4.)

Description.—The shell is of medium size for the genus, compressed, evenly ovate, pronouncedly inequilateral. The length is usually slightly less than twice the height. The umbones, which are level with the postero-dorsal margin, but

[1] For figures of these two species, see L. R. Cox. 1937 (1), Pl. XV.

rise slightly above the antero-dorsal margin, are placed at about the anterior third of the length; they are obtusely and rather sharply angular and not at all incurved, pointing slightly in an anterior direction. The postero-dorsal margin is sub-horizontal and very feebly convex, meeting the strongly convex posterior margin in an uninterrupted curve which is continued by the moderately and evenly convex ventral margin and the strongly convex anterior margin. Lunule and escutcheon are absent; the whole shell is evenly inflated. The surface is smooth except for occasional growth-rugæ.

The hinge consists of a long anterior row and a comparatively short posterior row of small chevron-shaped teeth. The posterior row is almost straight and recedes slightly from the actual valve margin at its posterior end; the anterior row, which is rather distant from the valve margin, bends up sharply near the umbo so as to meet the posterior row in a well-defined angle, which is equal to about 120°. The teeth number about 14 in the anterior row and 30 in the posterior row; the outer teeth of the anterior row are slightly larger than the corresponding ones of the posterior row; in both rows they decrease gradually in size towards the umbo, below which they are minute. The absence of an internal chondrophore can be clearly observed. The pallial line and muscle scars are not visible.

Holotype.—Brit. Mus. L. 71405*a*.

Dimensions.—The measurements of the holotype and of the largest paratype are as follows:—

	Length.	*Height.*
Holotype	10·0 mm.	6·0 mm.
Paratype	13·8 „	7·5 „

Remarks.—The interior of the specimen selected as holotype is very clearly preserved, and there can be no doubt that this species, like *Palœoneilo belaënsis*, described above, has the hinge-characters of the genus *Palœoneilo*. It is distinguished from *P. belaënsis* by its strongly inequilateral and evenly ovate shape. The absence of a projecting postero-dorsal angle distinguishes it from *P. galatea* (Dumortier *ex* d'Orbigny) and *P. morrisii* (Deshayes), mentioned in connexion with *P. belaënsis*. Its less prominent umbones[1] distinguish it from "*Leda*" *phaseolus* (Merian MS., de Loriol) and from the two Russian Upper Jurassic species *P. amygdala* and *P. choroschowensis*, figured by A. Borissiak (1904, p. 32, Pl. II, figs. 8, 11).

Occurrences and Material.—Divesian, lower *athleta* Beds, east of Juria ["Middle Zone" of Blake, MS.[1]]—several specimens on a single slab of soft limestone, containing also *Nuculana* (*Præsaccella*) *juriana* sp. nov., *Pteroperna blakei* sp. nov., *Entolium partitum* (J. de C. Sowerby), and "*Astarte*" *pisiformis* J. de C. Sowerby (Brit. Mus. L. 71405, colld. J. F. Blake).

Horizon uncertain, probably approximately the same, river at Jenane—several poorly preserved specimens, preserved in much-weathered shale occurring just below the laterite (G. S. I. No. K40/487, colld. A. B. Wynne).

[1] See L. F. Spath, 1924, p. 25.

Family : *NUCULIDAE.*

The Nuculidæ differ from the related living families Nuculanidæ and Malletiidæ in that the mantle lobes are entirely free, with the pallial line in consequence always entire, and in the nacreous structure of the inner layer of the shell ; these may be regarded as primitive characters. The most peculiar feature of the shell is the position of the umbones, which are posterior to median and frequently opisthogyrous. The ligament is completely internal and is borne by a spoon-shaped chondrophore which separates the anterior series of hinge-teeth from the posterior series.

Most authorities now consider that the Nuculidæ were derived from the Ctenodontidæ, discussed above. Even in the Ordovician, derivatives of that family with a partly internal ligament are known, and one such species has been made the type of a genus *Prænucula* by L. Pfab (1934, p. 234). In external characters, however, these forms do not resemble true Nuculidæ and it must remain conjectural if they were the actual ancestors of the family.

W. Quenstedt (1930, p. 56) has discussed the occurrence of *Nucula* in the Devonian. His " opisthogyrous Devonian Nuculas " (p. 64) are probably true representatives of the Nuculidæ, but when he speaks (p. 61) of " prosogyrous Nuculas," in which the posterior end of the shell is the more elongated, he makes the fundamental assumption that forms in which the pallial line is entire must belong to the Nuculidæ rather than to the Nuculanidæ.[1] As shown below (page 27), however, even in the Jurassic there occur representatives of the Nuculanidæ with an entire pallial line. Hence it would be possible to interpret these " prosogyrous Nuculas," and even *Prænucula*, as ancestral or primitive Nuculanidæ. From the Carboniferous onwards undoubted representatives of the Nuculidæ are met with in most marine formations.

The evolution and classification of the Nuculidæ are dealt with at length by W. Quenstedt (1930). Starting with certain Triassic species, he claims to demonstrate an evolutionary trend from forms with non-opisthogyrous umbones, a straight anterior row of hinge-teeth, and a moderately wide, unprojecting chondrophore whose median axis has a more or less dorso-ventral orientation, to the Recent forms with opisthogyrous umbones, an arcuate anterior row of hinge-teeth, and a narrow, projecting, spoon-shaped chondrophore whose axis is directed towards the anterior end of the shell. Quenstedt also attaches great importance to the presence of a tooth (or corresponding pit) adjoining the chondrophore on its posterior side, and differing in its orientation from the remaining teeth of the posterior series, from which he considers it to be of quite different origin. This chondrophore tooth, he alleges, is present in most modern species, but absent in the Jurassic and earlier forms. Accordingly he divides *Nucula* (treated as a genus co-extensive with the family) into two main groups. *Nucula* s. str. and *Palæonucula*, which he regards as subgenera.

[1] Quenstedt's method of determining the anterior end of the shell by assuming that the median axis of the chondrophore is directed towards that end in the Nuculanidæ as well as in the Nuculidæ is open to criticism. This is the case in a large number of species of the former family, but in the genotype of *Nuculana*, for instance, the axis of the chondrophore is directed posteriorly.

Nucula s. str. is considered by him to be characterized by strongly opisthogyrous umbones, a narrow, curved, anteriorly directed chondrophore projecting into the cavity of the shell, a curved anterior row of teeth, and a chondrophore tooth (or occasionally two such teeth) in at least one of the valves; a posterior area is usually present; the shell-margin may either be denticulate or smooth. *Palæonucula*, typified by *Nucula hammeri* Defrance, of the Upper Lias, is stated, on the other hand, to have umbones which are not at all or only moderately opisthogyrous, a wide, straight chondrophore whose main axis has a predominantly dorso-ventral orientation, and which does not project into the cavity of the shell, a straight anterior row of hinge-teeth, no chondrophore tooth, and smooth ventral margins; a posterior area is stated to be seldom present.

H. G. Schenck (1934, p. 36, Pl. II, fig. 20) has already shown that Quenstedt's diagnosis of *Palæonucula* is not even applicable to its genotype. Such forms as *Nucula cuneiformis* J. de C. Sowerby, *N. kaoraënsis* sp. nov., and *N. blanfordi* sp. nov., described in the present Memoir, are undoubtedly closely related to this genotype. In these forms the umbo is more strongly opisthogyrous than in most Recent species of *Nucula*, while the anterior row of hinge-teeth is very definitely arched. The chondrophore is clearly visible in specimens of *N. blanfordi*, and can be seen to be narrow and slightly curved, projecting, in an antero-ventral direction, into the cavity of the shell. A chondrophore tooth is well developed in *N. kaoraënsis*. The posterior area, moreover, is more impressed in these species than in most Recent forms, and the pouting of its marginal region is less noticeable.

Quenstedt himself recognizes that some Jurassic species have not the internal characters ascribed by him to *Palæonucula*. Such forms, which include *N. menkii* Rœmer, as figured by A. Rœder (1882, p. 70, Pl. III, figs. 7*a-e*)—a species surely belonging to the same group as *N. hammeri*—he would, however, assign to *Leionucula* (treated as a section of the subgenus *Nucula*).

It is thus obvious that a primary subdivision of the Nuculidæ into two groups *Nucula* and *Palæonucula* by the characters enumerated by Quenstedt is not admissible. There can be no doubt, however, that in the general external characters of the shell the type-species of *Palæonucula* and related forms differ appreciably from any of the Recent representatives of *Nucula*. The umbonal region is more inflated, the umbones are more incurved, and the ventral margin is much less symmetrical, with a distinct tendency towards a flattening of its posterior end. There appears, however, to be no clear line of demarcation between such species and certain others (such as the Indian Jurassic species *N. stoliczkai* sp. nov.) which differ less markedly in shape from some Recent forms.

One difference between the Jurassic and earlier forms and the Recent genotype of *Nucula* lies in the absence of the internal marginal denticulations which characterize that species. Such denticulations are not, however, present in all the Recent species, some of which have completely smooth margins, while others (*N. obliqua* Lamarck, *N. expansa* Reeve, *N. superba* Hedley), smooth-margined to the naked eye, may be seen under a lens to have very finely denticulate margins. The denticulation of the margins appears, therefore, to be a matter of

degree and not a clear basis for generic separation. The complete absence of denticulations in the earlier fossils forms is, however, significant.

A tentative classification of the Nuculidæ, based on an examination of the type-species of the various taxonomic groups proposed within the family, has been put forward recently by H. G. Schenck (1934, p. 46), who considers that the family may be divided into at least six genera, with several subgenera distributed between them. In this scheme we find *Palæonucula* separated generically from *Nucula*.[1] One is certainly tempted to follow this course when one considers only the type-species and its close relatives, but since there is no clear dividing line between this group and contemporaneous species more closely resembling the Recent forms I have decided to regard it merely as a subgenus of *Nucula*.

There is, however, one small group of Jurassic species which differ considerably from *Nucula* in external characters. This group, *Nuculoma* Cossmann, seems to be sufficiently well characterized to rank as a distinct genus, and as such is here treated.

Representatives of the Nuculidæ are very common in the Jurassic of Kachh, frequently covering the bedding-planes of the strata in such a manner as to have suggested to J. F. Blake the term "*Nucula* flags". The occurrence of this genus in such abundance in beds of a calcareous type appears, in fact, to be a feature peculiar to the Jurassic deposits of this area.

Genus: NUCULA J. B. de Lamarck, 1799.

"Prodrome d'une nouvelle classification des coquilles," *Mém. Soc. Hist. nat. Paris*, 1799, p. 87.

Genotype.—Arca nucleus Linné (1758, p. 695), Recent, European seas.

Generic Characters.—Shell trigonal, trapezoidal, or ovate, more or less inequilateral, with the umbones posterior to median and usually opisthogyrous. Hinge consisting of an anterior and a posterior series of chevron-shaped, taxodont teeth, interrupted below the umbo by a trigonal or spoon-shaped chondrophore for the support of an internal resilium. No external ligament. Pallial line entire.

Subgenus: PALÆONUCULA W. Quenstedt, 1930.

"Die Anpassung an die grabende Lebensweise in der Geschichte der Solenomyiden und Nuculaceen," *Geol. u. pal. Abhandl.*, N. S., Vol. XVIII, Pt. 1, p. 112.

Type.—Nucula hammeri M. J. L. Defrance (1825, p. 217),[2] Upper Lias—Bajocian, Europe, etc.

Subgeneric Characters.—Shell well inflated, elongate, trapeziform or trapezoidal, with posteriorly placed and sometimes terminal umbones which are opisthogyrous and usually well incurved. The antero-dorsal margin is usually slightly arched, but occasionally straight. The ventral margin, which is asymmetrical to a varying extent, is never more than feebly convex, and more frequently straight or slightly sinuate, along the posterior half of its length; at its anterior end it sweeps up in a broad curve which is often rather truncated. A well-defined

[1] Actually Schenck regards it as a subgenus of *Nuculopsis* Girty. This point is discussed on page 12.

[2] See also W. Quenstedt, 1930, Pl. II, fig. 9; and H. G. Schenck, 1934, p. 35, Pl. II, fig. 20, and Pl. IV, figs. 1, 1*a*, *b*.

posterior area is present, and is usually well impressed, with the pouting of its marginal region scarcely appreciable. The surface of the shell is smooth or ornamented with concentric threads; the valve-margins are smooth internally. The hinge-structure is similar to that of *Nucula* s. str., except that the teeth of the posterior series are usually somewhat reduced in number owing to the posterior position of the umbones.

Remarks.—In Quenstedt's original diagnosis of *Palæonucula* this subgenus was stated to be distinguished from *Nucula* s. str. by certain differences in hinge-structure which, as I have already pointed out,[1] are non-existent. The name may, however, usefully be applied to a group of species which is well represented in the Jurassic deposits of Kachh.

The greatly elongated and inequilateral shape of the more typical species of this group and their well inflated umbonal region and incurved umbones give them a distinctive appearance quite unlike that of species of the group of *Nucula* s. str., from which they also differ in the much less pronounced pouting of the marginal region of the posterior area, as well as in the smoothness of the ventral margins. Similar differences in shape distinguish them from *Nucula albensis* d'Orbigny, the Cretaceous type-species of *Leionucula* Quenstedt (1930, p. 112), a subgenus to which J. Thiele (1934, p. 786), as well as Quenstedt, refers the smooth-margined Recent forms. A few species, however, such as *Nucula stoliczkai* sp. nov., described in the present Memoir (p. 20), appear to be on the border-line between *Palæonucula* and *Leionucula*.

Schenck (1934, p. 36) points out the close external similarity between the type-species of *Palæonucula* and *Nucula ventricosa* J. Hall, the Carboniferous genotype of *Nuculopsis* G. H. Girty (1911, p. 133)[2]; he suggests, therefore, that *Palæonucula* should be regarded as a subgenus of *Nuculopsis*. The latter was originally supposed by Girty to be characterised by the presence of an external ligament and by the absence of an internal chondrophore, while the shorter side of the shell was regarded as anterior. Schenck (1934, p. 29, Pl. II, fig. 19), however, considers Girty's erection of this genus to have been based upon "imperfect assumptions and observations," and shows that its type-species has the hinge-characters of a perfectly normal Nuculid.

Nuculopsis presumably includes the Carboniferous species *Nucula gibbosa* Fleming, whose hinge has been well figured by W. Hind (1897, p. 178, Pl. XIV, figs. 4-15) and shown to be that of a normal Nuculid. The general shape of this species is very similar to that of the type-species of *Palæonucula*, but its chondrophore is wider and shorter, and does not project into the cavity of the shell; in consequence, the end hinge-teeth of the anterior series do not lie above those of the posterior series below the umbo. These differences probably indicate that the chondrophore in *Nuculopsis* is somewhat more primitive in character than in *Palæonucula*, so that the two groups are not to be regarded as absolutely synonymous.

[1] See page 10.

[2] *N. ventricosa* Hall, 1858, being a homonym of *N. ventricosa* R. B. Hinds, 1843, is renamed *N. girtyi* by Schenck (*loc. cit.*, p. 30).

NUCULA (PALÆONUCULA) CUNEIFORMIS J. de C. Sowerby.

(Plate I, figs. 5-10.)

Nucula cuneiformis J. de C. Sowerby, 1840, "Description of Fossils from the Upper Secondary Formation of Cutch," *Trans. Geol. Soc.*, ser. 2, vol. V, Pl. XXII, fig. 4, and Explanation.

Description.—The shell, which attains a fairly large size for the genus, is trapezoidal in outline and well inflated, with opisthogyrous, well incurved, terminal or sub-terminal umbones and an obtusely rounded umbonal profile; the ratio of length to height is usually about 3 : 2. The antero-dorsal profile is nearly straight, sloping at a gentle angle; the antero-dorsal margin is gently arched. The anterior end of the shell is rather pointed, the oblique and more or less flattened anterior margin meeting the antero-dorsal margin in a sharp curve and merging with the ventral margin in an obtuse curve. Along the posterior half of its length the ventral margin is flattened or feebly convex, and is sub-parallel to the antero-dorsal profile. The posterior margin is also flattened, and makes a fairly well-defined right or slightly obtuse angle with the ventral margin. The posterior area (escutcheon) is wide, cordiform, and well impressed, with a scarcely appreciable median pout; it is limited by fairly well-defined umbonal ridges. Anterior to the umbones is a narrow and very slightly impressed antero-dorsal area, limited by obtuse ridges; the anterior umbonal ridges are moderately well defined. The surface of the shell is smooth except for occasional growth-rugæ.

The hinge-teeth of the anterior series number 21-23, and are large and thick at the anterior end, decreasing in size regularly towards the umbo. The teeth of the posterior series number six or more, and are elongate, narrow, closely spaced, and rather irregularly curved; a narrow tooth bordering the chondrophore is not appreciably separated from the remaining ones. The chondrophore itself is not clearly visible in any of the specimens examined.

Dimensions.—Specimens from different localities vary somewhat in average size. The measurements of several are as follows:—

Specimen.	*Length.*	*Height.*	*Inflation.*
	mm.	mm.	mm.
No. K40/492 (S. W. of Lodai)	27·3	17·8	19·0
do. (do.)	25·5	17·5	16·4
do. (do.)	25·2	18·0	17·5
No. K40/490 (Juria hills)	27·5	15·1	15·4
No. K40/491 (?Khera Hill)	21·1	15·0	13·7
do. (do.)	20·3	14·2	13·7

Remarks.—The holotype of this species, which came from Khera Hill, near Chari, is no longer extant, but the identity of the species could not be mistaken; the type horizon was most probably Divesian (*athleta* Beds). The best preserved specimens in the G. S. I. collection, a series of 18 shells preserved in a matrix of soft yellowish limestone which may weather pink, are unlocalised, but include examples agreeing very well in size and shape with Sowerby's figure, and not

improbably came from the type-locality, from which Blanford is recorded to have collected specimens. Three of these specimens are represented in figs. 5, 6, 9, while specimens of a larger race, from S. W. of Lodai, are represented in figs. 7, 10, and an unusually elongate specimen, from the Juria hills, in fig. 8.

N. cuneiformis bears the closest resemblance to the European Upper Liassic species *N. hausmanni* Rœmer (1836, p. 98, Pl. VI, fig. 12)[1] and it is possible to select individual specimens of the two forms agreeing in every detail. In *N. hausmanni*, however, a tendency for the posterior end of the shell to project slightly beyond the umbones is observable in a greater number of specimens than in *N. cuneiformis*. In the Divesian of Europe the same group is represented by *N. subhammeri* Rœder (1882, p. 74, Pl. III, figs. 8*a*, *b*)[2], the original figure of which represents a shell scarcely distinguishable from *N. cuneiformis*.

It could scarcely be doubted that the *Nucula* of the Spiti Shales described by K. Holdhaus (1913, p. 430, Pl. XCV, figs. 14-17) under the name *N. hyomorpha* (with which *N. spitiensis* Holdhaus, 1913, p. 428, Pl. XCV, figs. 11-13, should probably be united) is the lineal descendant of *N. cuneiformis*. The same species abounds in the Kimmeridgian of Arabia and Somaliland, whence I have recently had the opportunity of studying a considerable number of specimens. Notwithstanding the considerable difference in horizon, I have been unable to distinguish between this species and *N. cuneiformis*, and accordingly have recorded [1935(1), p. 160] the specimens from Somaliland under that name, as others have done before me. So far, however, we have no records of *N. cuneiformis* from the Argovian to connect the occurrences in Kachh with those from the higher horizon in the other areas.

Occurrences and Material.—Upper Bathonian [*vel* Callovian], Lower Chari, *macrocephalus* Beds, between Kumagoona and Meera[3]—four specimens (G. S. I. No. K40/488, colld. F. Stoliczka).

Callovian or Divesian of the following localities:—West of Ler ["Bed No. 19" of Blake, MS.]—one specimen (Brit. Mus. L. 71406, colld. J. F. Blake), south of Tramau ["Nucula Flags" of Blake, MS.]—three specimens (Brit. Mus. L. 71407-9, colld. J. F. Blake); south of Deysulpur ["Kelloway Shales," according to Stoliczka, MS.]—two specimens (G. S. I. No. K40/489, colld. F. Stoliczka); Juria hills, on road from Juria to Dhosa—one specimen (G. S. I. No. K40/490, colld. A. B. Wynne).

Divesian, *athleta* Beds, of the following localities:—Khera Hill, near Chari(?)—numerous specimens (G. S. I. No. K40/491, colld. W. T. Blanford)[4]. S. W.

[1] See also W. Ernst, 1923, p. 64, Pl. I, fig. 16. Ernst disagrees with some authorities who have united *N. hausmanni* with *N. hammeri* Defrance. He accepts, however, Brown's (1836, p. 370 and Pl. XX, fig. 8, of Atlas) interpretation of *N. hammeri*, since the original type described by Defrance (1825, p. 217) has not yet been figured. Both forms occur at Hildesheim, the type-locality of *N. hammeri*, and notwithstanding Ernst's opinion to the contrary, it seems probable that they will ultimately be united in synonymy.

[2] P. de Loriol (1897, p. 114) considers *N. subhammeri* to be a synonym of N. *cottaldi* de Loriol, which, however, is typically a much shorter shell.

[3] Recorded from this horizon in Stoliczka's MS. list. I suspect, however, that the specimens came from a higher horizon.

[4] A series of specimens of uncertain locality, but probably those from Khera Hill recorded by F. Stoliczka in T. Oldham's Appendix to W. T. Blanford (1867, p. 19). This is the type-locality of the species.

of Lodai [" *pseudobiplicata* Bed ?" according to Stoliczka, MS.[1]]—numerous specimens (G. S. I. No. K40/492, colld. F. Stoliczka); Charwar [" Bed No. 2 " of Blake, MS.[2]]—three specimens (Brit. Mus. L. 17410-2, colld. J. F. Blake); Samatra [" Bed No. 2 " of Blake, MS.]—two specimens (Brit. Mus. L. 71413-4, colld. J. F. Blake).

NUCULA (PALÆONUCULA) KAORAËNSIS sp. nov.

(Plate I, figs. 11-14.)

Description.—The shell, which attains a fairly large size for the genus, is trapezoidal in outline and strongly inflated, with well incurved and rather pronouncedly opisthogyrous umbones placed from about the anterior sixth to the anterior eighth of the length; the profile of the umbonal region is obtusely rounded; the ratio of length to height is about 3 : 2. The antero-dorsal profile and corresponding margin are both feebly convex, the former sloping at a gentle angle. The anterior end of the shell is rather pointed, the feebly convex, oblique anterior margin making a rounded-off, acute angle with the antero-dorsal margin and merging with the ventral margin in an obtuse curve. The ventral margin, which is sub-parallel to the antero-dorsal profile, is flattened, and may be very slightly sinuate towards its posterior end, the sinus corresponding to a shallow sulcus of the side of the shell. The posterior margin is flat or feebly convex, sloping steeply to meet the ventral margin in a rather sharp curve. The posterior area is wide, cordiform, deeply impressed, and limited by rounded umbonal ridges; anterior to the umbones there is a narrow and very slightly impressed antero-dorsal area limited by obtuse ridges; anterior umbonal ridges are just perceptible. The surface of the shell is smooth except for occasional growth-rugæ, which tend to be pronounced near the ventral margin.

The hinge-teeth of the anterior series number about 22, and are moderately large at the anterior end of the hinge-line, decreasing regularly in size towards the umbo. The teeth of the posterior series are somewhat irregularly arranged, and number 6-7, including a moderately thick and prominent chondrophore tooth (observed in a right valve), well separated from the remaining teeth by a triangular space. The chondrophore is obscured or damaged in all the specimens examined.

Holotype.—G. S. I. type No. 16505.

Dimensions.—The following are the measurements of the holotype and a paratype, both single valves:—

Specimen.	*Length.*	*Height.*	*Inflation.*
Holotype (E. of Kaora)	23·5 mm.	16·8 mm.	6·5 mm.
Brit. Mus. L. 71415 (Kaora)	24·7 „	16·6 „	7·5 „

[1] The identity of the branchiopod to which F. Stoliczka applied the MS. name *Terebratula pseudobiplicata* is uncertain, and the name was not adopted by Kitchin. The species may, however, be the one figured by J. de C. Sowerby (1840, Pl. XXII, fig. 11) as *Terebratula biplicata* and described by Kitchin (1900, p. 18, Pl. IV, figs. 1-4) as *T. aurata*. According to W. T. Blanford (in H. B. Medlicott and W. T. Blanford, 1879, pp. 256, 262) this species misidentified as *T. biplicata* is particularly characteristic of the *anceps* Beds, but the " *pseudobiplicata* Beds " of Stoliczka's MS. list appear to include also the *athleta* Beds and the Dhosa Oolite.

[2] See L. F. Spath, 1933, p. 753.

Remarks.—This species is distinguished from *N. cuneiformis* J. de C. Sowerby by its more strongly opisthogyrous umbones, its deeper posterior area, its definitely, although not strongly, projecting posterior end, and by the sulcus in its side and the corresponding sinus in the ventral margin. There is no indication in the material studied by me that the two forms intergrade, and it is doubtful if they ever occur at the same horizon.

It is possible that this may be the species from Kachh described by J. de C. Sowerby (1840, Pl. XXII, fig. 3, and Explanation) as *N. tenuistriata*, but, even after studying what remains of Sowerby's type-material, I am unable to decide definitely upon this point. *N. tenuistriata* was founded on a number of specimens contained in the same slabs of rock as the figured types of "*Cucullæa*" *virgata*. The interiors of numerous *Nucula* shells, clearly showing the taxodont dentition, are exposed on one face of these slabs, but the group of shells marked as being the original of Sowerby's figure of *N. tenuistriata* disagrees with the figure in several details, while nowhere on any of the slabs is the exterior of a shell exposed on the same face as two interiors, as appears to be indicated in the figure. In none of the specimens, in fact, is the exterior well preserved; hence the character of the surface-ornamentation cannot be ascertained, although Sowerby's trivial name refers to this feature. Since, moreover, all the shells whose interior is visible have their margins broken away, it is impossible to form any precise idea of their original shape, and, rather than guess at the identity of the species, it seems advisable to allow the name *N. tenuistriata* to lapse. The association of the type-specimens of this species with "*Cucullæa*" *virgata*, which usually occurs at a higher horizon than that of the specimens of *Nucula kaoraënsis* now recorded, suggests that it may be a distinct form.

Occurrences and Material.—Upper Bathonian [*vel* Callovian], Lower Chari, *macrocephalus* Beds, of the following localities:—East of Kaora (Patcham)—the holotype and one paratype (G. S. I. type No. 16506, both colld. F. Stoliczka); Kaora ["*Nucula* Flags" of Blake, MS.[1]]—one specimen (Brit. Mus. L. 71415, colld. J. F. Blake); Andhou (Patcham)—a slab exposing numerous interiors, associated with *Nuculana* (*Dacryomya*) *lacryma* (J. de C. Sowerby) (G. S. I. type No. 16507, colld. A. B. Wynne); north of Kumagoona—one specimen (G. S. I. No. K40/493, colld. F. Stoliczka); Habo ["*Nucula* Flags" of Blake, MS.[2]]—three specimens (Brit. Mus. L. 71416-8, colld. J. F. Blake); south of Juria ["Nucula Flags" of Blake, MS.]—one specimen (Brit. Mus. L. 71419, colld. J. F. Blake).

Nucula (Palæonucula) blanfordi sp. nov.

(Plate I, figs. 15-19.)

Description.—The shell, which attains a fairly large size for the genus, is strongly inflated, and ovate in outline, with a low and rather pointed, rostrum-like posterior end which projects to a varying extent; the umbonal profile is obtusely rounded, the umbones opisthogyrous and slightly incurved, and placed

[1] See L. F. Spath, 1933, p. 738.
[2] See L. F. Spath, 1933, p. 745.

at about the posterior quarter of the length; the ratio of length to height varies from about 5 : 3 to 7 : 4. The antero-dorsal profile is feebly convex, sloping at a gentle angle; the antero-dorsal margin is straight or feebly convex along the greater part of its length, but curves down near the umbo. The oblique and rather flattened anterior margin makes a rounded-off, acute angle with the antero-dorsal margin and merges with the ventral margin in an obtuse curve. The ventral margin is straight except for a slight sinus which may be present near its posterior end; it is usually sub-parallel with the postero-dorsal profile. The posterior margin is straight or feebly convex, and slopes steeply to meet the ventral margin in a sharp curve. The posterior area is wide, cordiform, and well impressed, with no appreciable pouting of its marginal region; it may or may not be limited by definite umbonal ridges. There are no anterior umbonal ridges, but a narrow and scarcely impressed antero-dorsal area is present, limited by obtuse ridges. The surface is ornamented with somewhat irregular, raised concentric threads, which are absent from the posterior area.

The hinge-teeth of the anterior series number about 26-27, and are moderately large at the anterior end, decreasing in size regularly towards the umbo. There are about 9 irregular teeth in the posterior series; the most posterior ones are fairly thick, the remainder narrow and very closely spaced with the exception of the terminal one, which is thicker and more prominent than those nearest it; in the right valve this terminal tooth is well separated from the margin of the chondrophore. The chondrophore, which extends sub-horizontally below the teeth of the anterior series, is spoon-shaped, curved, and strongly excavated.

Holotype.—G. S. I. type No. 16508.

Dimensions.—The measurements of the holotype and two paratypes are as follows :—

Specimen.	*Length.*	*Height.*	*Inflation.*
Holotype (N. W. of Jumara)	26·5 mm.	15·4 mm.	15·4 mm.
G.S.I. type No. 16509 (do.)	24·7 ,,	13·4 ,,	12·0 ,,
G.S.I. type No. 16511 (do.)	34·8 ,,	19·8 ,,	(crushed).

Remarks.—This species, which is represented by numerous well-preserved specimens, is distinguished from *N. cuneiformis* and *N. kaoraënsis* by its very produced, rostrate posterior end, and by the concentric threads which ornament its surface. *N. menkii* Rœmer, discussed below, is comparable in shape, but smaller, with a more evenly convex ventral margin.

Occurrences and Material.—Upper Bathonian [*vel* Callovian], Lower Chari, *macrocephalus* Beds, of the following localities :—N. W. of Jumara—the holotype and numerous paratypes (G. S. I. type Nos. 16509-11 and Nos. K40/494, K40/495[1], all colld. F. Stoliczka); Jumara [" Beds No. 11 and 13*a* " of Blake, MS.][2]—two specimens (Brit. Mus. L. 71420-1, colld. J. F. Blake); Khera Hill, near Chari [" Bed No. 11 " of Blake, MS.][3]—one specimen, associated with *Nucula*

[1] Most of the specimens come from about the base of the *macrocephalus* Beds and were found associated with *Eligmus rollandi* Douvillé and other species; No. K40/495 is in a limonitic matrix from a higher horizon.

[2] See L. F. Spath, 1924, p. 22, and 1933, p. 740. The preservation of the specimen from Bed No. 13*a* agrees with that of the majority of the specimens collected by Stoliczka from N. W. of Jumara.

[3] See L. F. Spath, 1924, p. 22, and 1933, p. 743.

(*Palæonucula*) *stoliczkai* sp. nov., *Nuculoma wynnei* sp. nov., *Nuculana* (*Dacryomya*) *lacryma* (J. de C. Sowerby) and "*Astarte*" *pisiformis* J. de C. Sowerby (Brit. Mus. L. 71422, colld. J. F. Blake); same locality ["Bed No. 13*b*" of Blake, MS.]—one specimen (Brit. Mus. L. 71423, colld. J. F. Blake); north of Kumagoona—one specimen, associated with *Chlamys* sp. (G. S. I. No. K40/497, colld. F. Stoliczka); east of Kaora (Patcham)—one specimen (G. S. I. No. K40/498, colld. A. B. Wynne); Kaora ["*Nucula* Flags" of Blake, MS.][1]—one specimen (Brit. Mus. L. 71425, colld. J. F. Blake); north of Lodranee (Bela)—one specimen (G. S. I. No. K40/499, colld. A. B. Wynne).

Nucula (Palæonucula) cf. menkii Rœmer.

(Plate I, figs. 20*a*, *b*.)

The following are references to descriptions of *N. menkii*:—

Nucula menkii F. A. Rœmer, 1836, Versteinerungen des norddeutschen Oolithen-Gebirges, p. 98, Pl. VI, fig. 10.

Nucula menkei J. Thurmann and A Étallon, 1862, Lethea Bruntrutana, p. 208, Pl. XXVI, fig. 4.

Nucula menkii P. de Loriol, 1872, "Monographie paléontologique et géologique des étages supérieurs de la formation jurassique du département de la Haute-Marne," *Mém. Soc. Linn. Normandie*, vol. XVI, p. 322, Pl. XVIII, fig. 4.

Nucula menkii P. de Loriol, 1875, "Monographie paléontologique et géologique des étages supérieurs de la formation jurassique des environs de Boulogne-sur-Mer," *Mém. Soc. Phys. Hist. nat. Genève*, vol. XXIV, p. 137, Pl. XVII, figs. 8-10.

Nucula menkei H. A. Rœder, 1882, Beitrag zur Kenntniss des Terrain à Chailles, p. 70, Pl. III, figs. 7 *a-e*.

Nucula menkii P. Choffat, 1888, Faune jurassique du Portugal, Mollusques Lamellibranches, Asiphonida, p. 42, Pl. XI, figs. 4, 5.

Nucula pseudo-menkii P. de Loriol, 1901, "Étude sur les mollusques et brachiopodes de l'Oxfordien supérieur et moyen du jura bernois. Premier supplément," *Mém. Soc. pal. suisse*, vol. XXVIII, p. 89, Pl. V, figs. 22, 23.

Nucula menkii W. J. Arkell, 1929, "Monograph of British Corallian Lamellibranchia," *Pal. Soc. London*, p. 33, Pl. I, figs. 1, 1*a*.

The synonymy of the form now recorded is:—

Nucula aff. *fraasi* Nœtling; L. F. Spath, 1933, "Revision of the Jurassic Cephalopod Fauna of Kachh," *Pal. Ind.*, N. S., vol. IX, Mem. No. 2, p. 779.

Description.—The specimen (an internal cast) is of small-medium size and moderate inflation; its outline is subelliptical, with a length to height ratio of about 3 : 5. The umbones are opisthogyrous and placed at about the posterior third of the length; the umbonal profile is not very prominent. The antero-

[1] See L. F. Spath, 1933, p. 738.

dorsal profile is nearly straight, sloping at a very gentle angle; the anterior and ventral margins are both evenly convex, forming a continuous curve. The posterior end of the shell is rather pointed, with the sloping postero-dorsal and the ventral margins meeting in a rounded-off, acute angle, situated at about the middle of the height of the shell.

Dimensions.—The measurements of the specimen are as follows:—

Length	14·7 mm.
Height	9·0 ,,
Inflation	6·1 ,,

Remarks.—The outline of this specimen closely resembles that of *Nucula* (*Palæonucula*) *blanfordi* sp. nov., described above, the main difference being the even convexity of its ventral margin, at the posterior end of which there is no trace of a sinus. It is, however, much smaller than full-grown specimens of *N. blanfordi* and is less inflated than specimens of that species at a comparable stage of growth.

It agrees very well with the figures of *N. menkii* published by Rœmer and the other authors cited above in the synonymy, and most probably belongs to that species. Its horizon (Divesian), it is true, is considerably lower than that at which *N. menkii* is commonly found in Europe. Thus Rœmer's type was stated to come from the "Portlandkalk," that is, the Kimmeridgian, of northern Germany, and most authentic records of the species are from Argovian and Kimmeridgian horizons.[1] Rœder, however, has identified specimens from the "Terrain à Chailles" (Divesian) of Alsace as *N. menkii*, and I accept his determination as correct, although de Loriol has proposed to refer the specimens in question to a distinct species, *N. pseudo-menkii*.

Rœder himself, it is true, points out that his specimens appear to differ from the typical *N. menkii* in the lower profile of their umbonal region and in the presence of a slightly concave area between the anterior umbonal ridge and the antero-dorsal margin. De Loriol, also, states that in *N.* "*pseudo-menkii*" the umbo is lower and less inflated than in *N. menkii*, and adds that the buccal margin is straighter. Arkell, on the other hand, states that the umbones are more prominent in the former species than in the latter. A comparison of the figures of *N. menkii* cited above will indicate that the prominence of the umbones is rather variable and that there is no constant difference in this character between *N. menkii* and the Divesian *N.* "*pseudo-menkii.*" I have, moreover, examined specimens of *N. menkii* from the English Kimmeridge Clay, and find that a concave antero-dorsal area, as described by Rœder in *N.* "*pseudo-menkii*," is distinctly developed in them. The convexity of the buccal margin varies considerably in specimens from any one locality.

Thus the reference of the European Divesian form to *N. menkii* appears to be quite justifiable, and it would probably be unnecessary to qualify the

[1] An English Bathonian specimen figured as *N. menkei* by J. Lycett (1863, p. 44, Pl. XXXIX, fig. 2 and Pl. XL, fig. 12) is less elongate than the true *N. menkii*, with more prominent umbones, and is certainly wrongly determined. According to W. J. Arkell (1929, p. 34) it would be more correctly referred to the species *N. amata* d'Orbigny.

determination of the Indian fossil now recorded were it not for the fact that it is an internal cast. *Nucula fraasi* Nœtling (1887, p. 34, Pl. V, figs. 12, 12*a*, *b*), an Upper Divesian form from Syria to which this Indian specimen was provisionally referred in Dr. L. F. Spath's list, is most probably a synonym of *N. menkii*.

Dr. F. R. C. Reed (1927, p. 273, Pl. XIX, figs. 27, 27*a*) has recorded a specimen from the Kimmeridgian of Yun-nan as *Nucula* aff. *menkei*, but the fossil in question is very much less elongate than this species; there are, in fact, several other European species with which a much closer comparison could have been made. The true *N. menkii* has not been recorded from Asia previously.

Occurrence and Material.—Divesian, Middle or Upper *athleta* Beds, 3½ miles S. of Samatra—one specimen (G. S. I. No. K40/500, colld. J. H. Smith).

Nucula (Palæonucula) stoliczkai sp. nov.

(Plate I, figs. 21-23.)

Description.—The shell is of medium size and moderate inflation, subtrigonal, and pronouncedly inequilateral, with prominent, sharp, only slightly incurved, opisthogyrous umbones placed at the posterior third of the length; the umbonal angle approximates to 90°; the ratio of length to height is about 4 : 3. The antero-dorsal profile is straight or feebly convex, reaching very little above the margin, which is nearly straight, and sloping rather steeply to meet the short, oblique anterior margin in a well-defined but very obtuse angle. The anterior margin meets the strongly and somewhat asymmetrically convex, or at times obtusely subangular, ventral margin in a sharp curve. The postero-dorsal margin is straight and steeply sloping, making a slightly obtuse and usually well-defined angle with the ventral margin. A somewhat ill-defined ridge runs from the umbo to the postero-ventral corner; posterior to this, and separated from it by a shallow depression, a second ridge limits a narrow and scarcely impressed posterior area, the marginal region of which has no appreciable pout. Anterior to the umbones a narrow, scarcely impressed antero-dorsal area is limited by a ridge; a second ridge runs from the umbo to the antero-ventral corner of the shell. The surface is ornamented with fine concentric threads, while two or three of the later growth-stages are usually strongly accentuated.

The internal characters are not entirely exposed in any of the available specimens, but the teeth of the posterior series are seen to be large and somewhat irregular, numbering about ten; they are most closely spaced near the umbo.

Holotype.—G. S. I. type No. 16512.

Dimensions.—The measurements of the holotype are as follows:—

Length	15·7 mm.
Height	12·1 mm.
Inflation	9·7 mm.

Remarks.—This species is more trigonal in outline and shorter in proportion to its height than the more typical species of *Palæonucula*, and in these respects shows some approach to *Leionucula* W. Quenstedt (1930, p. 112), founded on the Cretaceous species *Nucula albensis* d'Orbigny. It differs, however, from the

latter species in its more strongly incurved umbones and in the absence of any pout of its postero-dorsal marginal region. Its reference to *Palæonucula* appears to be more appropriate.

No closely comparable species has been described from the Jurassic of Europe. *Nucula nina* Borissiak (1904, p. 34, Pl. I, figs. 4-9), from the Callovian and Divesian of Russia, shows some similarity in shape, but is smaller.

Occurrences and Material.—Upper Bathonian [*vel* Callovian], Lower Chari, *macrocephalus* Beds, of the following localities:—South of Deysulpur—the holotype and three paratypes (K 40/501, all colld. F. Stoliczka); north of Kumagoona—several specimens associated with *Nuculana* (*Dacryomya*) *lacryma* (J. de C. Sowerby) (G. S. I. No. K 40/513, colld. F. Stoliczka); Khera Hill, near Chari [" Bed No. 11 " of Blake, MS.[1]]—one specimen, associated with *Nucula* (*Palæonucula*) *blanfordi* sp. nov., *Nuculoma wynnei* sp. nov., *Nuculana* (*Dacryomya*) *lacryma* (J. de C. Sowerby), and "*Astarte*" *pisiformis* J. de C. Sowerby (Brit. Mus. L. 71422, colld. J. F. Blake); same locality—two specimens (G. S. I. No. K 40/503, colld. A. B. Wynne); Chari—five specimens (G. S. I. type No. 16513 and No. K 40/502, colld. W. T. Blanford[2]); N. W. of Jumara—one specimen (G. S. I. No. K 40/505, colld. F. Stoliczka); Juria hills, on road from Juria to Dhosa—one specimen (G. S. I. No. K 40/504, colld. A. B. Wynne); Kaora (Patchani) [" *Nucula* Flags " of Blake, MS.[3]]—one specimen (Brit. Mus. L. 71427, colld. J. F. Blake).

Subgenus incertum.

NUCULA sp.

Plate II, figs. 1*a*, *b*.

Description.—The shell, which is moderately large for the genus, is regularly ovate in outline, with very obtusely rounded, depressed, scarcely incurved, prosogyrous umbones placed at about the posterior fifth of its length; the ratio of length to height is about 3 : 2; the inflation is moderately strong. The antero-dorsal profile is feebly convex, rising very little above the well arched margin, which forms an uninterrupted curve with the symmetrically convex anterior margin; the evenly but rather feebly convex ventral margin merges in even curves with the anterior and posterior margins, the latter of which is also evenly convex. There is no impressed posterior area and no appreciable pout of the marginal region posterior to the umbones. The antero-dorsal area is narrow, shallow, and obscure; there are no umbonal ridges. The surface of the shell, which is rather eroded in the single available specimen, appears to have been smooth.

The internal characters are unobservable, but some broken-away shell reveals a few taxodont teeth, confirming the generic position of the species.

[1] *See* L. F. Spath, 1924, p. 22, and 1933, p. 743.

[2] Probably the specimens recorded by F. Stoliczka in T. Oldham's Appendix to W. T. Blanford (1867, p. 19) as *Nucula tenuistriata* J. de C. Sowerby.

[3] *See* L. F. Spath, 1933, p. 738.

Dimensions.—The following are the measurements of the specimen, allowing for a small portion of the shell which is missing :—

Length	20·7 mm.
Height	13·5 mm.
Inflation	11·0 mm.

Remarks.—This species is not closely comparable to any described previously, but the only available specimen is rather too damaged to name.

Its depressed umbonal region and regularly ovate outline suggest that it is not referable to the subgenus *Palæonucula.* It is quite unlike any of the Recent Nuculas.

Occurrence and Material.—Bathonian, Patcham Dolomite, Andhou—one specimen (Brit. Mus. L. 71428, colld. J. F. Blake).

Genus NUCULOMA, M. Cossmann, 1907.

"Note sur le Callovien de la Haute-Marne," *Bull. Soc. Agric., etc., Haute-Saône,* 1907, p. 124.

Genotype.—Nucula castor Cossmann (*ex* A. d'Orbigny[1]), Callovian, France.

Generic Characters.—Shell well inflated, ovately trapeziform or trapezoidal in outline, with dropping, terminal umbones which are very strongly opisthogyrous and incurved, reaching posteriorly beyond the valve-margins. The antero-dorsal margin is strongly and evenly arched, the anterior margin more or less evenly convex. The ventral margin may be evenly convex, but is sometimes straight or slightly sinuate along the posterior half of its length. A well-defined posterior area is present, and is usually well impressed, with the pout of its marginal region scarcely appreciable. The surface of the shell is ornamented with concentric threads ; the valve-margins are smooth internally.

The general arrangement of the hinge-teeth is as in *Nucula.* The teeth of the anterior series, however, are exceptionally large at the anterior end of the margin and very minute at the posterior end, where they do not reach as far as the umbo. The teeth of the posterior series are much reduced in number owing to the posterior position of the umbo, and are disposed more or less vertically, one above the other, their marginal ends sometimes bending up towards the umbo. At the anterior end of this series there are either one or two thick "chondrophore teeth" in both valves, lying below the end teeth of the anterior row, and leaving only a very narrow angle which is occupied by the subhorizontal chondrophore.[2]

Remarks.—Nuculoma comprises a well-defined group of Jurassic species differing from *Palæonucula* in the much more strongly opisthogyrous umbones. The twist of the umbones has led to the modifications in the arrangement of the hinge-teeth described above.

[1] For figures of *N. castor see* M. Cossmann, 1907, Pl. II, figs. 14, 15 ; O. Couffon, 1919, p. 80, Pl. V, figs. 14-14*i* ; M. Cossmann, 1924, p. 42, Pl. VI, figs. 32-35 ; M. Cossmann, 1925, p. 658, Pl. XXI, figs. 13-16 ; J. Cottreau, 1925, p. 153, Pl. XXXIX, figs. 23, 24 ; H. G. Schenck, 1934, p. 26, Pl. IV, figs. 5, 5 *a-c.* The original diagnosis of the species in d'Orbigny's 'Prodrome' was inadequate for its recognition.

[2] This description of the hinge of *Nuculoma* is based primarily on the species *N. blakei* sp. nov., described below (p. 24), but agrees with the figure of the hinge of the type-species given by H. G. Schenck (1934, Pl. IV, fig. 5*c*).

I am in agreement with H. G. Schenck (1934, pp. 27, 46) that this group is sufficiently distinct from typical *Nucula* to constitute a separate genus.

NUCULOMA WYNNEI sp. nov.

Plate I, figs. 29-31.

Nucula tenuistriata, H. Douvillé, 1916, "Les terrains secondaires dans le massif du Moghara à l'est de l'isthme de Suez," *Mém. Acad. Sci. Paris*, ser. 2, vol. LIV, p. 61, Pl. V, figs. 46-50 (*non* J. de C. Sowerby).

Description.—The shell, which attains a fairly large size for the genus, is strongly inflated, and trigonally ovate in outline, with very strongly incurved and opisthogyrous, dropping, terminal or sub-terminal umbones and a well inflated umbonal region: the ratio of length to height is about 4 : 3. The antero-dorsal profile is strongly convex, attaining its greatest height at a point considerably anterior to the umbones; the antero-dorsal margin is strongly and symmetrically arched. The anterior margin is strongly convex, meeting the antero-dorsal and ventral margin in even curves. The ventral margin is convex except at its posterior end, where it may become straight or slightly sinuate; it meets the flat or slightly concave, very steeply sloping posterior margin in a well-defined, obtuse angle. The posterior area is wide, cordiform, and deeply impressed, and is limited in each valve by a well-defined angulation corresponding to the umbonal ridge: frequently each half has a median sulcus, corresponding to the concavity of the posterior margin; its marginal region has a scarcely appreciable pout just below the umbones. Anterior to the umbones a very narrow and scarcely impressed antero-dorsal area is limited by an ill-defined ridge in each valve; there are no anterior umbonal ridges. The surface of the shell is ornamented with fine, raised concentric threads, which are absent from the dorsal areas.

The hinge-teeth of the anterior series are about 20 in number, and are fairly large and thick at the anterior end, decreasing regularly in size towards the umbones. The teeth of the posterior series number about 5, and are elongate and rather sinuous: it is impossible to observe if a chondrophore tooth is present. The chondrophore is not plainly visible in any of the specimens examined.

Holotype.—G. S. I. type No. 16514.

Dimensions.—The following are the measurements of the holotype and of a slightly larger paratype:—

Specimen.	*Length.*	*Height.*	*Inflation (single valve).*
Holotype (Khera Hill)	17·5 mm.	13·2 mm.	6·6 mm.
Brit. Mus. L. 71430 (Kaora) . . .	19·4 mm.	16·1 mm.	8·2 mm.

Remarks.—*Nuculoma wynnei* appears to be identical with the species from the Bathonian of Sinai recorded by H. Douvillé as *Nucula tenuistriata* J. de C. Sowerby. As already seen, however, the identity of Sowerby's species is problematical in view of the imperfect preservation of the specimens upon which it was founded.

Compared with the European Callovian species *Nuculoma castor* (Cossmann *ex* d'Orbigny),[1] *N. wynnei* differs in its larger size and less pronounced obliquity; it appears to be best regarded as a distinct species, although there is no doubt that the two forms are closely related. Its umbones are much more strongly incurved and opisthogyrous than in such species as *Nucula venusta* Terquem and Jourdy (1869, p. 107, Pl. XI, figs. 26-28) and *N. cottaldi* de Loriol (1875, p. 139, Pl. XVII, figs. 11-15), the former of which is placed by Douvillé (with a query) in the synonymy of the form from Sinai just mentioned.

Occurrences and Material.—Upper Bathonian [*vel* Callovian], Lower Chari, *macrocephalus* Beds, of the following localities:—Khera Hill, near Chari—the holotype and one paratype (G. S. I. No. K 40/506, both colld. A. B. Wynne); same locality ["Bed No. 11" of Blake, MS.[2]]—one specimen, on a slab with *Nucula* (*Palæonucula*) *blanfordi* sp. nov., *N.* (*P.*) *stoliczkai* sp. nov., *Nuculana* (*Dacryomya*) *lacryma* (J. de C. Sowerby) and "*Astarte*" *pisiformis* J. de C. Sowerby (Brit. Mus. L. 71422, colld. J. F. Blake); Kaora (Patcham) ["Nucula Flags" of Blake, MS.[3]]—several specimens (Brit. Mus. L. 71430-40, colld. J. F. Blake); east of Kaora—two specimens (G. S. I. type No. 16515 and No. K 40/507, colld. F. Stoliczka); north of Kumagoona—one specimen (G. S. I. No. K 40/508, colld. F. Stoliczka).

NUCULOMA BLAKEI sp. nov.

Plate I, figs. 24-28.

Description.—The shell, which attains a fairly large size for the genus, is strongly inflated, elongate, and trapeziform or trapezoidal in outline, with very strongly incurved and opisthogyrous, dropping, terminal umbones, and a well inflated umbonal region; the ratio of length to height well exceeds 3 : 2. The antero-dorsal profile is rather flattened, and more or less horizontal except at its anterior end, where it coincides with the margin; the antero-dorsal margin is strongly and nearly symmetrically arched, meeting the anterior margin in an even curve of variable obtuseness. The anterior margin is strongly and rather asymmetrically convex, meeting the ventral margin in an obtuse curve or angle. The ventral margin, which may be straight or may have a more or less well-defined sinus towards its posterior end, converges towards the antero-dorsal margin in a posterior direction; it meets the straight or slightly sinuate, sub-vertical or inward-inclined posterior margin in a well-defined, obtuse angle. The posterior area is wide, cordiform, and deeply impressed, and is limited in each valve by a well-defined angulation corresponding to the umbonal ridge; each half has a pronounced median sulcus, corresponding to the sinus in the margin; the marginal region pouts slightly just below the umbo. Anterior to the umbones is a shallow and ill-defined antero-dorsal area, but no umbonal ridges are present. The surface of the shell is ornamented with fine concentric threads, which are absent from the dorsal areas.

[1] For references to published descriptions of this species *see* p. 22.
[2] *See* L. F. Spath, 1924, p. 22, and 1933, p. 743.
[3] *See* L. F. Spath, 1933, p. 738.

The hinge-teeth of the anterior series number about 23, and are very large and prominent at the anterior end, but minute below the umbo. The teeth of the posterior series, which number up to 6, are long and rather irregular, and in some specimens bend up towards the umbo near the margin; in both valves either one or two of these teeth, nearest the chondrophore, are very thick and prominent; if two such teeth are present, they enclose a pit for the reception of a similar tooth of the other valve; if only one is present it adjoins the chondrophore in the right valve, but is separated from it in the left valve by a space which evidently received the corresponding tooth of the right. The chondrophore is narrow and sub-horizontal.

Holotype.—G. S. I. type No. 16516.

Dimensions.—The measurements of the holotype are as follows:—

Length	26·0 mm.
Height	16·0 mm.
Inflation	16·3 mm.

Remarks.—This species is distinguished from *Nuculoma wynnei* sp. nov., described above, by its more elongate form, by the obtuse angle between its posterior and ventral margins, and by its more pronouncedly sinuate ventral margin. The two forms do not appear to intergrade.

Occurrences and Material.—Upper Bathonian [*vel* Callovian], Lower Chari, *macrocephalus* Beds, of the following localities:—N. W. of Jumara—the holotype and numerous paratypes (G. S. I. type Nos. 16517-9 and No. K 40/509, all colld. F. Stoliczka); Jumara [" Bed No. 15*a*" of Blake, MS.]—one specimen (Brit. Mus. L. 71441, colld. J. F. Blake); east of Kaora (Patcham)—one specimen (G. S. I. No. K 40/512, colld. F. Stoliczka); Habo [" *Nucula* Flags " of Blake, MS.[1]]—one specimen (Brit. Mus. L. 71442, colld. J. F. Blake); Khera Hill, near Chari—four specimens (G. S. I. type No. 16520 and No. K 40/510, colld. A. B. Wynne; also No. K 40/511, colld. F. Stoliczka[2]).

Family: *NUCULANIDAE.*

This family includes genera of Nuculacea in which the shell is more or less elongate in outline, with the umbones either sub-median or anterior to median; the posterior end is frequently pointed or rostrate, and sometimes gapes. The mantle lobes are united to a varying extent, and definite siphons are developed posteriorly. The pallial line is sinuate in most of the Recent forms, but is entire in some of the earlier fossil forms of comparable shape. The hinge-teeth are interrupted by an internal resilium, but an external ligament is also present except in a few genera. The shell is porcellanous in most of the Recent forms, but certain fossil forms appear to have had an internal nacreous layer.

The Nuculanidæ arose, no doubt, from the Ctenodontidæ by partial submergence of the ligament. J. Barrande (1881, p. 97, Pls. CCLXIX, CCLXX, CCLXXIII) refers several species from the Ordovician and Silurian of Bohemia

[1] *See* L. F. Spath, 1933, p. 745.

[2] Stoliczka's specimen is recorded as coming from "above the Golden Oolite". This is probably the lower bed of Golden Oolite—*see* L. F. Spath, 1933, p. 743.

to "*Leda*", but states that, owing to the poor preservation of his material, the position of the ligament in these forms could not be observed. In external characters "*Leda*" *incola* Barrande (1881, Pl. CCLXX (iii), figs. 1-17), in particular, closely resembles a true *Nuculana*; L. Pfab (1934, p. 239), however, considers it to be indeterminate generically. Pfab shows that most of Barrande's species of "*Leda*" belong to *Ctenodonta*, but erects (p. 231) a genus *Præleda* for certain forms in which a pallial sinus is present. In this group, however, there is no evidence of the former presence of an internal resilium, although the ligament was partly internal in the same author's *Prænucula*.

Whether these and certain other early Palæozoic species described under the generic name "*Leda*" from other areas should be interpreted as primitive Nuculanidæ is at present conjectural. Undoubted representatives of the family appear in the Devonian (L. Beushausen, 1895, pp. 59-65, Pl. IV, figs. 26-39; J. Hall, 1885, pp. 329-332).

It will be necessary to study these Palæozoic representatives of the family more carefully before it can be decided if they belong to the same taxonomic groups as occur in later formations, or to distinct groups for which new generic or subgeneric names should be proposed. The Indian Jurassic species now described are considered to belong partly to the genus *Nuculana*, although to two subgenera, *Dacryomya* and *Præsaccella*, which are distinct from those existing at the present day, and partly to the extinct genus *Rollieria*.

Genus: NUCULANA H. F. Link, 1807.

Beschreibung der Naturalien-Sammlung der Universität zu Rostock, Pt. 3, p. 155.

Genotype.—*Arca rostrata* Chemnitz (1784, p. 206, Pl. LV, figs. 550, 551) [=*Arca pernula* O. F. Müller (1779, p. 57)], Recent, northern coasts of Europe and America.

Generic Characters.—Shell more or less elongate, posteriorly rostrate, the rostrate end traversed dorsally by a carina which bounds an escutcheon. Valve margins closed except at the extremity of the rostrum. Hinge-teeth interrupted, below the umbo, by a chondrophore for the support of an internal resilium; an external, amphidetic ligament may also be present. Pallial line sinuate in the Recent forms, but entire in many of the earlier fossil forms.

Remarks.—The genotype of *Nuculana* is a rather feebly inflated species with a bluntly rostrate posterior end; its umbones are obtuse, not at all incurved, and placed at about the anterior third of the length. An obtuse and slightly curved carina runs from the umbo to the postero-dorsal angle of the shell, but the escutcheon which it bounds is not at all impressed, so that the straight, gently sloping postero-dorsal margin is visible in the side-view of the shell. A second ridge, very ill-defined, runs from the umbo to the postero-ventral angle of the shell, which is obliquely truncated at its extremity. The ventral margin is nearly symmetrically convex except for a very shallow sinus which may be present below the rostrum. The surface is ornamented only with growth-lines which may stand out as fine threads in the earlier stages of growth.

The hinge consists of a feebly arched anterior row, and a slightly concave posterior row, of rather small, chevron-shaped taxodont teeth. The short, hollowed-out chondrophore which interrupts them slopes towards the posterior end of the shell, and is buttressed on its anterior side by a thickening of the shell-wall. The posterior part of the pallial line is obscure, but there are traces of a deep, ascending sinus.

The genus *Nuculana* is usually considered to include all species of the family which are characterized by a definite posterior rostrum, carinate above, and by valve margins which are closed except at the extremity of the rostrum. This genus may be divided into a number of subgenera or sections according to the general shape of the shell and rostrum and the surface ornamentation.[1]

Although many Jurassic species do not appear to be separable generically from *Nuculana*, it seems doubtful if any can be assigned to the Recent subgenera. Thus in many cases the Jurassic forms are distinguished from the various groups of living species by appreciable differences in the external characters of the shell. While the Recent forms, moreover, are characterized by the presence of a deep pallial sinus, more conspicuous in some groups than in others, many of the Jurassic forms have an entire pallial line. This feature is observable in at least two species of the subgenus *Dacryomya* L. Agassiz, in the well-known Upper Liassic species *Nuculana ovum* (J. de C. Sowerby), and in the Indian Jurassic species *Nuculana juriana* sp. nov., upon which the new subgenus *Præsaccella* is based in the present Monograph.[2] The species of the Liassic subgenus *Ryderia* C. P. N. Wilton (1830, p. 72) have a very wide, shallow pallial sinus, which is quite different from that of the Recent forms.

Another point of interest is that, while a nacreous shell-structure similar to that of the Nuculidæ is not developed in any of the Recent forms referable to the Nuculanidæ, a specimen of *Nuculana* (*Ryderia*) *graphica* (Tate), from the Lower Lias of Kingsthorpe (Northants.), in the British Museum collection (regd. 19560) has a very well preserved nacreous shell.

There seems to be no exception to the rule that all Tertiary and Recent species with the general external characters of *Nuculana*, as defined above, have the same essential hinge-structure. A. Bittner (1895, p. 145, Pl. XVIII) and A. Borissiak (1904, p. 46), however, have shown that certain Mesozoic forms which are indistinguishable from *Nuculana* in external characters prove to possess an uninterrupted series of taxodont hinge-teeth and a completely external ligament posterior to the umbones. For these forms Bittner proposes a genus *Phænodesmia*, to which it is possible that a number of Jurassic species in addition to those recognized by Borissiak will prove to be referable.

The Indian Jurassic fossils now described include two species which prove from their hinge-structure to belong to the genus *Nuculana*, as their external characters suggest. The first is considered to be identical with the well-known species *Nuculana lacryma* (J. de C. Sowerby), of the European Jurassic, which is

[1] For a modern classification of the Recent species, *see* J. Thiele, 1934, p. 782.

[2] *See* page 32.

the type of the subgenus *Dacryomya*. The second species belongs to another group for which the new subgeneric name *Præsaccella* is now proposed.

Subgenus : DACRYOMYA L. Agassiz, 1840.

"Mémoire sur les moules des mollusques vivans et fossiles," *Mém. Soc. Sci. nat. Neuchâtel*, vol. II, Mém. No. 4, p. 34.

Type.[1]—*Nucula lacryma* J. de C. Sowerby (1824, vol. V, p. 119, Pl. CCCCLXXVI, fig. 3), Middle Jurassic.

Subgeneric Characters.—Shell well inflated, inequilateral, with a moderately elongate, narrow, terminally truncated rostrum which is strongly concave in dorsal profile. Umbonal region rising prominently above the dorsal margins; umbones well incurved and opisthogyrous. Escutcheon deeply impressed, limited by sharp carinæ originating at the umbones and dividing into two ridges, which pass respectively to the two corners of the rostrum. Pallial line frequently entire.

Remarks.—I have examined the interior of a British specimen of *Nuculana lacryma*, the subgenotype of *Dacryomya*, and have ascertained that it is a form with a small internal chondrophore separating the two rows of hinge teeth, and therefore a true *Nuculana* and not a *Phœnodesmia*. The presence of an internal chondrophore is very clearly seen in an Indian specimen (Pl. II, fig. 3) referred to *N. lacryma* in the present Memoir. I have also ground down a French specimen of *N. rostralis*, the second genosyntype of *Dacryomya*, and have ascertained that this species has the internal structure of a true *Nuculana*.

These species differ, however, from any of the Tertiary and Recent representatives of the genus in certain characters which justify their reference to a distinct subgenus. In *Nuculana* s. str., the type-species of which has been discussed above,[2] the shell is more compressed, the umbones are less strongly opisthogyrous and not at all incurved, the escutcheon is not impressed, and the posterior rostrum is wider. In the subgenus *Jupiteria* L. Bellardi (1875, p. 20),[3] the outline of the shell is more closely comparable to that of some species of the group now under discussion, but the umbones are less strongly incurved, the escutcheon is shallower, and the rostrum shorter. The absence of a deep pallial sinus also distinguishes *Dacryomya* from any of the Recent groups. Thus an entire pallial line is clearly observable on pyritized casts of *N. rostralis* from the Upper Lias of Salins (Jura, France)[4], while it has also been illustrated by A. Borissiak (1904, p. 43, text-fig. 2 and Pl. III, figs. 2-4) and E. Krenkel (1915, p. 307, Pl. XXVII, figs. 12, 13) in specimens of the species *Nuculana medusa* (Borissiak), which clearly belongs to this subgenus. It is doubtful if the pallial line is entire or shallowly sinuate in the subgenotype, *N. lacryma* (J. de C. Sowerby).

[1] Selected by A. N. Herrmannsen (1846, p. 368) from the two original genosyntypes, *N. lacryma* J. de C. Sowerby, and *N. rostralis* Lamarck.

[2] *See* page 26.

[3] *See* also W. P. Woodring, 1925, p. 18.

[4] A figure of a specimen of *Nuculana rostralis* from the Aalenian of Prinzheim (Lower Alsace) published by E. W. Benecke (1905, p. 170, Pl. XIII, fig. 3) appears to show a shallow pallial sinus, but the author states that "Die Mantelbucht ist an diesem Stück nicht zu erkennen."

The group of Liassic species for which I have revived the subgeneric name *Ryderia* C. P. N. Wilton in a recent paper [1936 (1), p. 466] should probably be separated from *Dacryomya*, which I there considered to be a synonym. In the group in question the shell is more compressed, the rostrum is much more elongate, the umbones are less prominent and scarcely incurved, and the escutcheon is not impressed. Pyritized casts of the species *Nuculana* (*Ryderia*) *doris* (d'Orbigny), such as are found in the Lower Lias of Stonehouse (Glos.) and other localities, bear the impression of a wide and very shallow pallial sinus, which contrasts with the entire pallial line observable in at least some of the species of *Dacryomya*.

NUCULANA (DACRYOMYA) LACRYMA (J. de C. Sowerby).

Plate II, figs. 2-5.

Nucula lacryma J. de C. Sowerby, 1824, Mineral Conchology, vol. V, p. 119, Pl. CCCCLXXVI, fig. 3.

? *Nucula mucronata* J. de C. Sowerby, 1824, *loc. cit.*, p. 120, Pl. CCCCLXXVI, fig. 4.

? *Nucula lacryma* A. Goldfuss, 1837, Petrefacta Germaniæ, Pt. II, p. 156, Pl. CXXV, figs. 10 *a-c*.

Nucula caudata F. C. L. Koch and W. Dunker, 1837, Beiträge zur Kenntniss des norddeutschen Oolithgebildes, p. 31, Pl. II, figs. 7 *a-c*.

? *Leda acasta* A. d'Orbigny, 1850, Prodrome de paléontologie stratigraphique universelle, vol. I, p. 275.

Leda moreana A. d'Orbigny, 1850, *loc. cit.*, p. 336.

Nucula lacryma F. A. Quenstedt, 1852, Handbuch der Petrefaktenkunde, p. 529, Pl. XLIV, fig. 14.

Leda lachryma J. Morris and J. Lycett, 1853, Monograph of the Mollusca from the Great Oolite. Part II, Bivalves, *Pal. Soc. London*, p. 53, Pl. V, figs. 15, 15*a*.

Nucula lacryma F. A. Quenstedt, 1856, Der Jura, p. 505, Pl. LXVII, figs. 18-21.

Leda lacryma D. Brauns, 1869, Der mittlere Jura im nordwestlichen Deutschland p. 263 (*partim*).

Leda lachryma E. Witchell, 1882, Geology of Stroud, Pl. III, fig. 8.

Leda lacryma A. O. Schlippe, 1888, "Die Fauna des Bathonien im oberrheinischen Tieflande," *Abh. geol. Specialk. Elsass-Lothringen*, vol. IV, Pt. 4, p. 153.

? *Leda lacryma* E. Greppin, 1899, "Description des fossiles du Bajocien supérieur des environs de Bâle," *Mém. Soc. pal. suisse*, vol. XXVI, p. 97, Pl. IX, figs. 1, 1*a*.

Leda lacryma W. Wetzel, 1911, "Faunistische und stratigraphische Untersuchung der Parkinsonienschichten des Teutoburger Waldes bei Bielefeld," *Palæontographica*, vol. LVIII, p. 238.

Leda lacryma M. Cossmann, 1913, "Quelques pélécypodes jurassiques recueillis en France, 5me article," *C. R. Assoc. franc. Avancem. Sci., Mém. hors volume*, p. 7, Pl. III, figs. 11-13.

Leda moreana O. Couffon, 1919, Le Callovien du Chalet, p. 81, Pl. V, fig. 15.

Leda moreana M. Cossmann, 1924, "Extension dans les Deux-Sèvres de la Faune du Callovien de Montreuil-Bellay," *Mém. Soc. géol. min. Bretagne,* vol. I, p. 42, Pl. VI, figs. 24-27.

Leda moreana J. Cottreau, 1925, "Types du Prodrome de paléontologie stratigraphique universelle de d'Orbigny," *Ann. Paléont.*, vol. XIV, p. 144, Pl. XXXVIII, figs. 4, 5.

Description of the Specimens from Kachh.—The shell is of medium size and rather strongly inflated for the genus, pyriform, not greatly elongated, with a rapidly narrowing posterior rostrum. The umbonal profile is obtusely angular, the umbones well incurved, rather strongly opisthogyrous, and slightly anterior to median in position. The postero-dorsal profile is strongly concave. The antero-dorsal profile is convex and rather steeply sloping, forming, with the anterior and antero-ventral margins, a rather sharp, semi-elliptical curve. The ventral margin is strongly convex except at its posterior end, where there is a shallow sinus below the rostrum. Posterior to the umbones a deeply impressed escutcheon is limited by a well-defined umbonal ridge in each valve; towards the posterior extremity of the shell this ridge divides into two ill-defined ridges which pass respectively to the upper and lower angles at the extremity of the rostrum. The anterior umbonal ridges are ill-defined except near the umbones. A depression of the side of the shell may correspond to the posterior sinus in the ventral margin, but may be absent. The surface is ornamented with fine, regularly spaced concentric threads.

The hinge, which is very clearly preserved in one specimen, consists of a convex anterior row of 16, and a concave posterior row of 13, chevron-shaped teeth which meet below the umbo in a slightly obtuse angle; this angle is occupied by a triangular chondrophore whose median line is directed antero-ventrally. The adductor scars are small, orbicular, and placed below the end of each series of hinge-teeth. The pallial line is not clearly visible, so that it is impossible to say if a sinus was present.

Dimensions.—The measurements of the best preserved specimen (G. S. I. No. K 40/514) are as follows:—

Length	13·5 mm.
Height	8·1 mm.
Inflation	6·9 mm.

Remarks.—The specimens from Kachh agree in every detail with specimens from the Great Oolite of England, the type-occurrence of the species. Sowerby's holotype, which is preserved in the British Museum (Natural History), is a small specimen, only 7·5 mm. in length, but other English specimens which I have examined are of about the same size as those from India. The holotype is eroded and was, therefore, described by Sowerby as smooth. Uneroded English specimens, like those from India, are ornamented with regularly spaced concentric threads. It is probable that Sowerby's *Nucula mucronata*, which came from the same locality and horizon as the type of *N. lacryma*, and was stated to be characterized by well-defined concentric threads, belonged to the same species; Sowerby's specimen is no longer extant.

In England *N. lacryma* has been recorded from all horizons from the Inferior Oolite to the Oxford Clay, but I have seen specimens only from the Great Oolite, and think it probable that many of these records refer to other species. Thus the Yorkshire Dogger form figured by J. Phillips (1829, p. 156, Pl. XI, fig. 14) as this species appears to differ in its much shorter rostrum, and the form from the Bajocian Grey Limestone of the Yorkshire coast which the same author (1829, p. 151, Pl. IX, fig. 25) also refers to this species is a more ovate shell which is much less pointed at its posterior end. This latter form was given the new name *Leda anglica* by A. d'Orbigny (1850, vol. I, p. 275).

The specific identity of the specimen from the Bajocian (*humphriesianum* Zone) of Switzerland figured by E. Greppin (1899, p. 97, Pl. IX, figs. 1, 1*a*) as *Leda lacryma* also appears to me to be a little doubtful. Its rostrum is shorter and wider than in typical specimens of this species, while its surface is described as nearly smooth.

The identity of the species described by A. Goldfuss (1837, p. 156, Pl. CXXV, figs. 10 *a-c*) as *Nucula lacryma* and re-named *Leda acasta* by A. d'Orbigny (1850, vol. I, p. 275) is also rather doubtful. Its side-view is very similar to that of *N. lacryma*, but its escutcheon, as represented by fig. 10*c* of Goldfuss, is bounded by less pronounced carinæ than in that species. Goldfuss's form came from Rabenstein, in Franconia (northern Bavaria), and is said to have come from the Inferior Oolite.

The species *Nucula caudata* Koch and Dunker, from the Bathonian of Geerzen, in northern Germany,[1] appears to have been founded on quite a typical specimen of *N. lacryma*. *Leda moreana* d'Orbigny, from the French Callovian, also appears to me to be inseparable from *N. lacryma*, the specimens figured by Couffon and Cossmann, in particular, being very close to English specimens of this species.

H. Douvillé (1916, p. 61, Pl. V, figs. 56-62) has described a species *Leda decorata* from the Bathonian of Sinai. This is said to differ from *Nuculana lacryma* in its larger size, in the concentric threads which ornament its surface, and in certain peculiarities of ornamentation, notably the presence of a row of "pearls" adjacent to the antero-dorsal margin in each valve, bordered externally by a slightly defined costa, on the outer side of which is a shallow groove. The supposed larger size of *L. decorata* and the presence of concentric threads are certainly not valid points of distinction from *N. lacryma*, but the peculiar sculpture of the antero-dorsal region has not been observed by me in any specimens of this species. I suspect, however, that the "row of pearls" described by Douvillé is due to some abnormal development of the hinge-teeth, the positions of which are indicated by a series of projections on the exterior of the shell. *L. decorata* may, therefore, prove to be a synonym of *N. lacryma*.

I cannot agree with D. Brauns (1869, p. 264) in placing *Nucula claviformis* J. de C. Sowerby and *Nucula rostralis* Lamarck, as figured by A. Goldfuss (1837, Pl. CXXV, fig. 8), in the synonymy of *N. lacryma*. In these two forms, which

[1] From the *Ostrea knorri* beds, according to D. Brauns (1869, p. 265).

come from the Upper Lias and are probably synonymous, the shell is less inflated than in the Bathonian form and tapers more evenly towards its posterior end, while its escutcheon is much narrower.

In view of what has been said above[1] in the discussion of the characters of the subgenus *Dacryomya* it is unfortunate that the pallial line is not clearly visible in any specimens of *N. lacryma* (its type-species) whose interior I have been able to study. According to D. Brauns (1869, p. 264) the internal casts described by F. C. L. Koch and W. Dunker (1837, p. 32, Pl. II, figs. 12 *a*, *b*) as *Nucula musculosa* are referable to *Nuculana lacryma*, and on one of these specimens " die Mantelbucht ..... ist ganz flach, eben angedeutet, zu bemerken."

M. Cossmann (1924, p. 42), in describing *Leda moreana* d'Orbigny, which I regard as a synonym of *N. lacryma*, states that the pallial sinus is deep and acute, in so far as it is possible to distinguish it. It is, however, so easy to mistake accidental marks on a specimen for the pallial line that this statement should be accepted with some reservation.

Occurrences and Material.—Upper Bathonian [*vel* Callovian], Lower Chari, *macrocephalus* Beds, of the following localities:—Khera Hill, near Chari—two specimens (G. S. I. No. K 40/514, colld. A. B. Wynne), also one specimen (Brit. Mus. L. 71443, colld. J. F. Blake); the same [" Bed No. 11 " of Blake, MS.[2]]—one specimen, associated with *Nucula* (*Palæonucula*) *blanfordi* sp. nov., *N.* (*P.*) *stoliczkai* sp. nov., *Nuculoma wynnei* sp. nov., and " *Astarte* " *pisiformis* J. de C. Sowerby (Brit. Mus. L. 71422, colld. J. F. Blake); Kaora (Patcham)—one specimen (G. S. I. No. K 40/515, colld. A. B. Wynne); Andhou (Patcham)—one specimen on a slab with numerous specimens of *Nucula* (*Palæonucula*) *kaoraënsis* sp. nov. (G. S. I. type No. 16507, colld. A. B. Wynne); north of Kumagoona—one specimen, on a slab with *N.* (*P.*) *kaoraënsis* sp. nov., *N.* (*P.*) *stoliczkai* sp. nov., and *Nuculoma wynnei* sp. nov. (G. S. I. No. K 40/513, colld. F. Stoliczka). Jumara [" Bed No. 11, base " of Blake, MS.[3]]—one specimen, associated with *N.* (*P.*) *blanfordi* sp. nov. (Brit. Mus. L. 71420, colld. J. F. Blake). Gora Dongar (Patcham)—several specimens on a single slab (G. S. I. No. K 40/516, colld. J. H. Smith).

Subgenus: Præsaccella subgen. nov.

Type-species.—*Nuculana juriana* sp. nov., Divesian, Kachh.

Subgeneric Characters.—Shell small, of moderate inflation and elongation, subequilateral, tapering posteriorly to an acutely angular extremity which is situated well above the middle of its height. Postero-dorsal margin straight or slightly concave, gently sloping, not hidden (except near the umbo) by the carina which passes from the umbo to the posterior end of the shell. Ventral margin not at all sinuate. Surface smooth or ornamented with concentric threads. Pallial line entire.

[1] *See* page 28.
[2] *See* L. F. Spath, 1924, p. 22, and 1933, p. 743.
[3] *See* L. F. Spath, 1924, p. 22, and 1933, p. 740.

Remarks.—This subgenus has been founded on a shell whose general outline agrees fairly closely with that of Tertiary and Recent species belonging to the subgenus *Saccella* W. P. Woodring (1925, p. 15) [=*Ledina* F. Sacco (1898, p. 53), *non* W. H. Dall]. While, however, a pallial sinus is clearly visible in all species of *Saccella*, the Jurassic type-species of *Præsaccella* is characterized by an entire pallial line. Another difference lies in the fact that the hinge-teeth are larger (in proportion to the size of the shell) and less numerous in *Præsaccella* than in the Tertiary and Recent group.

The absence of a produced, attenuated, bicarinate rostrum distinguishes *Præsaccella* from the subgenus *Dacryomya*, already discussed.[1]

In addition to its type-species, it is probable that *Præsaccella* includes the French Liassic species *Nuculana heberti* (J. Martin) (1860, p. 79, Pl. III, figs. 1-4), the Swiss Oxfordian species *N. argoviensis* (C. Mœsch) (1867, p. 302, Pl. IV, figs. 12 *a-c*), and the Portuguese Jurassic species *N. sanctæ-crucis*, *N. favrei*, and *N. mœschi*, all described by P. Choffat (1888, pp. 46-7, Pl. XI, figs. 14-19).

Nuculana (Præsaccella) juriana sp. nov.

Plate II, figs. 6-9.

Description.—The shell is small, of moderate inflation and elongation, subequilateral, tapering posteriorly to an acutely angular extremity, the level of which is approximately two-thirds of the height of the shell above its lowest point. The umbonal profile is obtusely rounded and not very prominent, the umbo slightly incurved and opisthogyrous. The postero-dorsal margin, which is not hidden in the side-view of the shell, except near the umbo, is straight or very slightly concave, sloping gently to the posterior extremity of the shell. The antero-dorsal margin is feebly convex, sloping still more gently except at its extremity, where it curves down to join the evenly and strongly convex anterior margin in an uninterrupted curve which is continued by the very strongly convex ventral margin; the latter may be slightly flattened towards its posterior end, where it rises to the extremity of the shell, but is not at all sinuate. A narrow and scarcely impressed escutcheon is limited by a curved carina which passes from the umbo to the posterior extremity. The surface of the shell is ornamented with delicate concentric threads which fade away on the postero-dorsal region.

The hinge consists of a slightly curved anterior row, and a rather more strongly curved posterior row, of small chevron-shaped teeth. The posterior row, consisting of 11 teeth in the best-preserved specimen examined, is shorter than the anterior row, which in the same specimen consists of 14 teeth and terminates some distance from the extremity of the postero-dorsal margin. The two rows meet below the umbo in an obtuse angle which is occupied by a small internal chondrophore. The adductor scars are large, ovate, and deeply impressed, lying immediately below the extremities of the hinge-line. The pallial line is without a sinus.

[1] *See* page 28.

Holotype.—Brit. Mus. L. 71405*c*.

Dimensions.—The measurements of the holotype and of a paratype are as follows :—

	Length.	*Height.*	*Inflation (single valve).*
E. of Juria (holotype)	6·5 mm.	3·5 mm.	1·7 mm.
S. of Rataupur (L. 71444) . . .	7·7 mm.	4·3 mm.	1·7 mm.

Remarks.—Most of the specimens studied are preserved on a single slab of rock from east of Juria ; in one of these shells the internal characters are clearly exposed. A single left valve from south of Rataupur is rather larger than the other specimens, but closely resembles them in shape and ornamentation.

This species bears some resemblance to *Nuculana argoviensis* (Mœsch) (1867, p. 302, Pl. IV, figs. 12 *a-c*), from the Divesian of Switzerland, but is distinguished by its less prominent umbonal region. *N. sanctæ-crucis* (Choffat) (1888, p. 46, Pl. XI, figs. 14, 15), from the Lusitanian of Portugal, is distinguished by its more strongly concave postero-dorsal outline and by its more delicate surface-ornamentation.

Occurrences and Material.—Divesian, *athleta* Beds, of the following localities :—East of Juria [" Middle Zone " of Blake, MS.[1]]—the holotype and several other specimens on a single slab of rock associated with *Palæoneilo indicus* sp. nov., *Pteroperna blakei* sp. nov., and " *Astarte* " *pisiformis* J. de C. Sowerby (colld. J. F. Blake) ; south of Rataupur [" Habo Conglomerate " of Blake, MS.] —one specimen, associated with *Grammatodon* (*Indogrammatodon*) *virgatus* (J. de C. Sowerby) (Brit. Mus. L. 71444, colld. J. F. Blake). Horizon uncertain, probably the same, river at Jenane—several poorly preserved specimens in much weathered shale (G. S. I. No. K 40/518, colld. A. B. Wynne).

Genus : Rollieria M. Cossmann, 1920.

Revue critique de Paléozoologie, vol. XXIV, p. 82. *Nom. mut.* for *Nuculopsis* L. Rollier (1911, p. 64) [non *Nuculopsis* G. H. Girty (1911, p. 133)].[2]

Genotype.—*Nucula palmæ* auctt. (*non* J. de C. Sowerby),=*Nucula subovalis*, Goldfuss (*non* Rœmer),=*Leda bronni* Andler.[2]

Generic Characters.—Shell thin-walled, rather feebly inflated, evenly ovate in outline, with narrow, depressed, scarcely incurved umbones which are median or slightly anterior to median in position ; posterior end very slightly lower than anterior end. Surface smooth, evenly convex, devoid of dorsal areas or umbonal ridges. Valve margins closed. Hinge consisting of an anterior and a posterior row of numerous small taxodont teeth, meeting at a very obtuse angle below the umbo ; the posterior row is nearly twice as long as the anterior row. Position of ligament doubtful. Adductor scars dorsally placed, the anterior slightly larger than the posterior. Pallial line with a very small sinus.

[1] *See* L. F. Spath, 1924, p. 25.

[2] Rollier (1923, p. 67), overlooking Cossmann's note introducing the name *Rollieria*, himself proposed the new name *Isoleda* for this group ; and, as this proved to be a homonym of *Isoleda* de Ryckholt, 1853, the present writer (1925, p. 124) proposed to replace it by *Isonuculana*. Both names are, of course, synonyms of *Rollieria*.

[3] For the synonymy of this species, *see* L. R. Cox, 1936 (1), p. 464.

Remarks.—*Nuculopsis* Rollier was proposed, as a subgenus of *Leda*, for the species of the group of "*L. palmæ* (Sow.)", *L. delila* d'Orb., *L. compressa* d'Orb., *L. meriani* Rollier, and *L. oppeli* (Étallon). No type-species was originally designated, but Cossmann (1924, p. 42) in referring a second time to his substitution of the name *Rollieria* for *Nuculopsis*, cited the species *Nucula palmæ* Sow. as type. It is obvious that the *Nucula palmæ* to which Rollier and Cossmann refer is the Liassic species recorded under that name by A. Oppel, F. A. Quenstedt, E. Dumortier, and other authors. Sowerby's *Nucula palmæ* (1824, vol. V, p. 117, Pl. CCCCLXXV, fig. 1), however, is an entirely different species, from the Mountain, or Carboniferous, Limestone.[1] It is debatable whether, in these circumstances, the true *N. palmæ* or the Liassic species should be regarded as genotype of *Rollieria*; as, however, it was the Liassic species that Rollier had in mind when founding the genus, this, in my opinion, should be the species accepted as type.

Rollier's original diagnosis appears to have been based on the study of internal casts, and refers only to the general form of the shell and to the presence of the small pallial sinus. I have examined a number of well-preserved internal casts of the type-species, from the Lias of La Rivière, Aveyron (France), some of which show quite deep impressions of the two adductor scars and the pallial line. These also show the impressions of the small hinge-teeth quite clearly. So far, however, I have been unable to examine any specimen of the actual shell of a representative of this genus in which the hinge-structure is clearly visible. Hence I cannot say definitely if the ligament was internal or external.

Rollieria—a group long ago distinguished by F. A. Quenstedt (1843, p. 195) as his "Ovales" section of *Nucula*—has hitherto been considered as a subgenus of *Nuculana* [*Leda*]; whatever the position of its ligament, however, it must be separated from that genus if the latter is restricted to forms with a definite posterior rostrum. Long before a generic name was available for this group, its separation as a distinct genus was, in fact, suggested by A. Borrissiak (1904, p. 31), who pointed out that it is also represented in the Trias[2] and Cretaceous.[3]

In shape the species of this group closely resemble the Recent genus *Sarepta* A. Adams,[4] which, however, is distinguished by the absence of a pallial sinus and by the shortness of its two rows of hinge-teeth. The relationship of *Rollieria* to such Palæozoic groups of the Nuculacea as *Sluha* J. Barrande [1881, p. 159, Pl. CCLXVII (IV)] requires further investigation.

Rollieria cf. meriani (Rollier).

Plate II, figs. 10 *a-c*.

The synonymy of *R. meriani* is as follows:—

Nucula oppeli P. de Loriol, 1899, "Mollusques et brachiopodes de l'Oxfordien inférieur du Jura bernois," *Mém. Soc. pal. suisse*, vol. XXVI, p. 157, Pl. X, figs. 18-22 (*non* Étallon).

[1] The probable explanation of the misinterpretation of this species by the authors cited is that the abbreviation "M. L." by which its horizon is indicated in the Systematic Index to the 'Mineral Conchology' was taken to mean "Middle Lias" instead of "Mountain Limestone".

[2] By *Leda zelima* d'Orbigny, *L. distincta* Bittner, and (possibly) *L. dubia* Münster. (*See* A. Bittner, 1895, pp. 149-150.)

[3] "*Nucula*" *vibrayeana* d'Orbigny [H. Woods, 1899 (1), p. 10, Pl. II, figs. 4-9], of the Gault, is a Cretaceous representative of this genus. Woods's figures show the presence of a small pallial sinus, but do not indicate the nature of the hinge.

[4] The hinge of the genotype, *S. speciosa* A. Adams, is figured by J. Thiele (1934, p. 788).

Leda meriani L. Rollier, 1912, "Fossiles nouveaux ou peu connus des terrains secondaires du Jura," *Mém. Soc. pal. suisse*, vol. XXXVIII, p. 63.

The synonymy of the form now recorded is :—

Nucula aff. *oppeli* de Loriol ; L. F. Spath, 1933, "Revision of the Jurassic Cephalopod Fauna of Kachh," *Pal. Ind.*, N. S., vol. IX, Mem. no. 2, p. 779.

Description.—The single specimen examined is a small internal cast, ovate in outline and only slightly inequilateral, with a length to height ratio of 4 : 3 ; it attains its greatest length above the middle of its height ; its inflation is rather feeble. The umbones are small, obtuse, depressed, and slightly anterior to median ; umbonal ridges are absent. The antero-dorsal and postero-dorsal profiles are feebly concave and gently sloping, the former slightly more steeply than the latter. The anterior margin is evenly convex, the posterior obscurely subangular, with its lower half a little flattened. The ventral margin is strongly and symmetrically convex. The muscle scars and pallial line are not traceable.

Dimensions.—The measurements of this specimen are as follows :—

Length	10·8 mm.
Height	8·1 mm.
Inflation	5·0 mm.

Remarks.—"*Nucula*" *oppeli* Étallon (1864, p. 317), founded on F. A. Quenstedt's figure (1857, p. 582, Pl. LXXIII, fig. 52) of a specimen referred by him to *Nucula palmæ* J. de C. Sowerby, is, according to Rollier, a species of Argovian age. Hence the Divesian form referred to *N. oppeli* by de Loriol, and cited by several authors under Merian's MS. name *Nucula compressa* (at least twice pre-occupied), is re-named *Leda meriani* by Rollier.

As I have not had the opportunity of comparing specimens of the two forms I can express no opinion as to whether they should be considered specifically distinct. According to Rollier, *oppeli* is smaller and shorter than *meriani*, but Quenstedt's figured specimen of the former actually appears to be more elongate than de Loriol's figured specimens of the latter.

The horizon of the Indian specimen now recorded approximates the more closely to that of *meriani*, to which species it is therefore provisionally referred. Its subangular posterior end agrees with that of the Swiss specimens figured by de Loriol, but there is no trace of the shallow depression of the posterior slope observable in some of the specimens in question.

Occurrence and Material.—Divesian, middle or upper *athleta* Beds, 3½ miles S. of Samatra—one specimen (G. S. I. No. K 40/519, colld. J. H. Smith).

Order : ARCACEA.

Superfamily : *ARCACEA*.

Family : *PARALLELODONTIDAE*.

The Arcacea, formerly classified with the Nuculidæ and related families in an Order Taxodonta, have recently been advanced to the position of a distinct Order by Professor A. Morley Davies (1935, p. 171), who considers the group to

have diverged at a very early date from normal free-living lamellibranchs owing to an acquired tendency to lead a sedentary life, fixed by a byssus. The tendency to fixation is, however, slighter than in such families as the Pteriidæ and Mytilidæ, so that the forward rotation of the foot and the reduction of the anterior adductor observable in those families has not taken place. The shell is usually equivalve, but in some genera an appreciable difference in the ornamentation of the two valves is observable. The hinge-line is always long and straight, the ligament external and amphidetic, and situated on a triangular cardinal area of varying width. The test is porcellanous in structure. The mantle lobes of the animal are free, no siphons being developed.

A former theory that the Arcacea were derived from the Nuculacea was based on the purely superficial resemblance between the transverse, taxodont teeth of the Arcidæ and those of the Nuculidæ, and has now been abandoned. M. Neumayr's (1891, p. 55) genus *Prœarca*, whose two Bohemian Ordovician genosyntypes, recently re-described by L. Pfab (1934, p. 220, Pl. III, figs. 20, 21), belong to the Ctenodontidæ, cannot be accepted as a possible ancestor of the Arcacea.

The earliest representatives of the Arcacea proper to make their appearance are, in fact, forms in which the posterior teeth are elongate and parallel with the hinge-margin. Such forms are included in the family Parallelodontidæ, the earliest known genus of which (*Parallelodon*) appears in the Devonian.[1] This genus itself seems to have been most probably derived from the Lower Palæozoic family Cyrtodontidæ, whose several genera show much similarity to *Parallelodon* in hinge-structure, although they are more generalized in other shell-characters, showing some approach also to early members of the Pteriacea.

F. Bernard's [1896 (1), pp. 68-75] observations on the development of the hinge-teeth in various genera of the Arcacea shows that the ontogeny confirms the theory that the taxodont type of hinge was derived from the type characterized by elongate horizontal teeth. Thus in the Parallelodontidæ, as illustrated by the genus *Cucullæa*, all the teeth originate as horizontal lateral teeth at the ends of the hinge-line. During the growth of the shell successive new teeth are introduced horizontally, below the lateral teeth already present, while at the same time the teeth nearest the hinge-margin bend or curve down successively at their inner ends. The lateral, horizontal, part of each is then, as it were, pushed upwards out of the shell, leaving its bent-down inner extremity to form one of the transverse teeth of the middle of the hinge-line. In the Arcidæ the development is similar, although more accelerated. The earliest post-embryonic teeth to appear are situated at both ends of the hinge-line and are elongated in a direction parallel to the hinge-margin, lying one above the other. During the growth of the shell their inclination gradually changes until it becomes transverse to the hinge-margin, at both ends of which new teeth are introduced.

Dr. W. J. Arkell [1930 (2)] has shown that in the Jurassic there occurs a subgenus *Eonavicula* which is clearly ancestral to the genus *Navicula* of the

[1] The Ordovician "*Parallelodon*" *antiqua* Barrois (1891, p. 200, Pl. III, figs. 3 *a*, *b*) has been shown by H. Douvillé (1913, p. 440) to belong to an unrelated genus, *Actinodonta*.

Arcidæ; it differs only in the fact that the teeth towards each end of the hinge-line are more nearly parallel to the hinge-margin that perpendicular to it. Here, again, we have an indication than the taxodont type of dentition is a comparatively late development in the evolutionary history of the family.

Genus: PARALLELODON F. B. Meek and A. H. Worthen, 1866.

"Descriptions of Palæozoic fossils from the.....rocks of Illinois," *Proc. Chicago Acad. Sci.*, vol. I, p. 17. Proposed as a new name for *Macrodon* J. Buckman, 1844 (Appendix to R. I. Murchison, Outline of the Geology of Cheltenham, edit. 2, p. 98), *non* Müller, 1842 (genus of fishes).

Genotype.—Macrodon rugosus J. Buckman (1844, p. 99, Pl. V, fig. 5),[1] Inferior Oolite, England.

Generic Characters.—Shell rhomboidal, trapezoidal, or trapeziform, elongate, pronouncedly inequilateral, not greatly inflated; a posterior carina, if present, is seldom sharply defined. Ventral margin with a sinus near its anterior end, corresponding to a byssal gape. Cardinal area narrow, with numerous chevron-shaped ligamental grooves. Hinge asymmetrical, consisting of a posterior series of three or four greatly elongated teeth parallel or sub-parallel to the hinge-margin and an anterior series of shorter and mostly oblique teeth; these may be radially disposed, their inclination changing gradually from beneath the umbo, where they are perpendicular to the hinge-margin, to the anterior end of the hinge, where they are parallel to the margin; or they may consist of several oblique and sub-parallel teeth. No septum for the attachment of the posterior adductor is present. The ornamentation consists of radial threads crossed by irregularly spaced growth-lamellæ.

Remarks.—The genus *Parallelodon* originated in the Devonian and persisted till the Jurassic. Its Jurassic genotype is a somewhat abnormal representative, both in its large size and thick shell and in its dentition. Many of the Jurassic forms, however, are so closely similar to the Palæozoic ones in shape and ornamentation, as well as in dentition, that it is impossible to separate them even subgenerically.

Dr. W. J. Arkell [1930 (2), p. 303] considers it possible to distinguish between two subgenera, *Parallelodon* s. str., and *Beushausenia* Cossmann (1897, p. 93),[2] the former characterised by the presence of a postero-dorsal wing on the shell and the latter by its absence. This seems to me to be a highly unsatisfactory criterion. In the species *Grammatodon* (*Indogrammatodon*) *virgatus* (J. de C. Sowerby),[3] for instance, a comparable wing is well developed in some specimens and absent in others. This is also the case in the Recent *Navicula pacifica* (G. B. Sowerby) and *N. noæ* (Linné), and doubtless in many other species. It is highly improbable that what is merely a feature of individual variation in a single species of one genus should be considered a character of subgeneric importance in a related group.

[1] The following are further references to descriptions of this species:—*Macrodon hirsonensis* J. Morris and J. Lycett, 1853, p. 49, Pl. V, figs. 1, 1 *a*, *b* (*non* d'Archiac sp.). *Parallelodon rugosum* W. J. Arkell, 1930 (2), p. 338, Pl. XIV, figs. 1-4.

[2] Type, *Cucullæa hirsonensis* d'Archiac.

[3] *See* p. 47.

No doubt when all the species of *Parallelodon* are thoroughly studied it will be possible to distinguish between definite groups to which subgeneric names can be given, but this is a question which cannot be investigated in the present Memoir.

Parallelodon lerensis sp. nov.

Plate II, fig. 11.

Description.—The shell is small, elongate-trapezoidal in outline, with its length equal to about twice its height, and rather feebly inflated. The umbo is placed at about the anterior third of the length; the profile of the umbonal region is very obtusely rounded, and projects but little above the hinge-margin; the cardinal area, which must have been extremely narrow, cannot be distinguished in the present condition of the only available specimen. The whole of the postero-dorsal region of this specimen is broken away, but the hinge-margin appears to have been elongate; the ventral margin, which is sub-parallel to the hinge-margin in its general direction, is feebly convex posteriorly, but is slightly sinuate towards its anterior end, indicating a small byssal gape; it merges in a broad and somewhat truncated curve with the anterior margin, which curves round to meet the hinge-margin in an angle slightly exceeding 90°. A projecting carina appears to run from the umbo to the postero-ventral corner of the shell, but it is difficult to decide to what extent this carinate appearance has been accentuated by the broken condition of the shell. Only a minute portion of the surface of the shell posterior to the carina is preserved, but appears to indicate that the posterior area was well defined and sloped steeply from the carina towards the margins.

The radial component of the ornamentation is predominant, and consists of numerous fine threads on the median part of the surface, increasing in width and prominence both towards the carina and towards the anterior end of the shell, where there is a pronounced tendency for them to increase by bifurcation and to remain grouped in pairs. Concentric growth-lamellæ form a reticulate pattern with the radial threads on the middle of the shell and stand out as transverse squamæ on the wider ribs at each end.

The teeth at the anterior end of the hinge-line have a radial disposition; short and perpendicular below the umbo, their length and obliquity increase gradually anteriorly, until the very end tooth is nearly parallel to the hinge-margin.

Holotype.—Brit. Mus. L. 71445.

Dimensions.—The measurements of the holotype, which is the only known specimen of this species, are as follows:—

Length	23·2 mm.
Height	11·3 mm.
Inflation (single valve)	5·● mm.

Remarks.—It is unfortunate that the postero-dorsal region of this shell is broken away, as with no knowledge of the structure of the posterior part of the

hinge it is impossible to say definitely to what genus it should be referred. The general shape of the shell and the structure of the anterior half of its hinge suggest that it belongs either to *Parallelodon* or to *Navicula* (*Eonavicula*),[1] its posterior carina precluding the possibility of its belonging to *Barbatia*. The carina is usually sharper in *Navicula* than in *Parallelodon*, but the shell now described is less strongly inflated and its cardinal area is narrower than is normally the case in *Navicula*. Hence it is referred provisionally to *Parallelodon*.

No closely comparable species appears to have been described previously.

Occurrence and Material.—Divesian, *athleta* Beds, east of Ler ["Bed No. 8" of Blake, MS.[2]]—the holotype only (colld. J. F. Blake).

Genus: GRAMMATODON F. B. Meek and F. V. Hayden, 1860.

"Systematic Catalogue of Jurassic, Cretaceous and Tertiary Fossils collected in Nebraska," *Proc. Acad. Nat. Sci. Phila.* (for 1860),[3] p. 419.

Genotype.—*Arca* (*Cucullæa*) *inornata* Meek and Hayden (1858, p. 51),[4] Jurassic, North America.

Generic Characters.—Shell rhomboidal or trapezoidal, more or less inequilateral, well inflated, posteriorly carinate, with an even outline and without a byssal sinus of the ventral margin. Cardinal area of moderate width, and bearing chevron-shaped ligamental grooves. Hinge asymmetrical, consisting of a posterior series of 3 or 4 elongate teeth parallel to the hinge-margin and an anterior series of radially disposed teeth which are perpendicular to the margin, or nearly so, below the umbo, but become increasingly oblique towards the anterior end of the hinge-line; the obliquity of the most anterior teeth varies in different species, and in some cases these teeth are parallel to the hinge-margin. No posterior adductor septum is present.

Remarks.—The published figures of the genotype of *Grammatodon* represent the internal cast of the shell, and the only available specimen of this species in the British Museum (Natural History) is also an internal cast. The impressions of the hinge-teeth are, however, shown in the figure published by Meek and Hayden, and leave no doubt as to the characters of the hinge and the group of species to which the generic name *Grammatodon* should be applied.

This genus remained almost unnoticed, except in American literature, until it was pointed out by Mr. H. Woods [1899 (2), p. 47] that its hinge-characters are very similar to those of the genus *Parallelodon*.[5] The two genera were therefore considered by him to be synonymous and were united under the earlier name, *Grammatodon*.

Although the characters of the hinge are, generally speaking, of primary importance in the classification of the Lamellibranchia, in the discussion of generic

[1] For a description of the subgenus *Eonavicula* see W. J. Arkell, 1930 (2), p. 346.

[2] *See* L. F. Spath, 1924, p. 24.

[3] The title page of this volume for 1860 bears the date 1861, but, as the volume consulted by me does not include the original wrappers of its various parts, I have no means of ascertaining how much of the volume was published in that year.

[4] The following are further references to descriptions of this species:—*Grammatodon inornatus* Meek and Hayden, 1865, p. 90, Pl. III, figs. 9, 9 *a*, *b*. *Grammatodon inornatus* R. P. Whitfield, 1880, p. 359, Pl. V, figs. 16-18.

[5] *See* p. 38.

affinities some regard should also be paid to the general external characters of the shell. In the present instance the external characters of *Grammatodon*, which is confined to the Mesozoic, differ so appreciably from those of *Parallelodon*, which ranges from the Devonian to the Jurassic, that I cannot accept the two groups as synonymous.

The main differences, most of which were pointed out by Meek and Hayden in discussing *Grammatodon*, are that in this genus the shell is less elongate, inequilateral and compressed than in *Parallelodon*, and possesses a better defined posterior carina ; its growth-lines and ventral margin are more regular, and the latter has no sinus near its anterior end, corresponding to a byssal gape ; the hinge-line and the horizontal posterior teeth of the hinge are less elongate.

Dr. W. J. Arkell [1930 (2), p. 304], who also considers that a distinction should be drawn between the two groups, treats *Grammatodon* as a subgenus of *Parallelodon*, ignoring the fact that this procedure is contrary to the rules of nomenclature, as *Grammatodon* was the earlier name to be published.[6] In my opinion the differences between *Grammatodon* and *Parallelodon* are of sufficient importance to justify their treatment as distinct genera.

Subgenus : Grammatodon s. str.

Subgeneric Characters.—Shell of small-medium size (for the family), not greatly elongated, only slightly inequilateral, much resembling a small *Cucullæa* ; carina varying from obtusely rounded to sharp. Ligamental grooves on cardinal area usually not very closely spaced. Surface either smooth, reticulately ornamented, or with radial riblets which are often confined to, or strongest on, the posterior area and antero-dorsal region ; valves usually similarly ornamented, but, if dissimilar, with stronger ribbing on the left.

Hinge-characters as defined for the genus.

Remarks.—So far as its Jurassic representatives are concerned, *Grammatodon* s. str. comprises a group of species which do not show a great range of variation in size and outline, but differ to some extent in the sharpness of the posterior carina. Figures of a number of characteristic species have been assembled in a plate published by Dr. W. J. Arkell [1930 (2), Pl. XV]. The genotype is an almost completely smooth shell, but several species of this subgenus are radially ribbed anteriorly and posteriorly, although the median part of their surface is smooth. Three species characterised by ornamentation of this type, and so easily identifiable as representatives of *Grammatodon* although their hinge-structure is unknown, are met with in the Jurassic of Kachh and are described below.

Grammatodon andhouensis sp. nov.

Plate II, figs. 12-14.

Description.—The shell is of medium size for the subgenus, and subrectangular in outline, with a length to height ratio of about 3 : 2 ; it is rather strongly inflated,

[6] The fact that *Macrodon*, the name replaced by *Parallelodon*, was prior to *Grammatodon* is immaterial.

most so at about the anterior third of its length. The umbones, which are slightly posterior to the anterior third of the length, are pronouncedly prosogyrous; the profile of the umbonal region is broadly rounded and not very prominent. The cardinal area is narrow, attaining its greatest width just anterior to the umbones. The hinge-margin is elongate, its length being only slightly less than that of the shell. The ventral margin is moderately strongly convex, and merges in a broad curve with the anterior margin, which curves round to meet the hinge-margin in a slightly obtuse angle. The posterior margin is not preserved intact in the available specimens. The posterior carina is sharp and slightly projecting, delimiting a concave posterior area.

About five rather prominent radial riblets, which may be delicately serrated, ornament the antero-dorsal region of the shell; the posterior area bears about nine strong radial riblets, and several very faint threads are present on the umbonal region on the median part of the shell. The surface is also ornamented with rather conspicuous concentric riblets whose direction may be somewhat oblique to the growth stages on the postero-ventral part of the surface; this concentric ornamentation is absent from the posterior area.

The internal characters are not observable in the specimens studied.

Holotype.—Brit. Mus., L. 71446.

Dimensions.—The measurements of the most complete of the available specimens (Brit. Mus., L. 71447) are as follows:—

Length	19·2 mm.
Height	12·4 mm.
Inflation (single valve)	6·2 mm.

Remarks.—Three specimens of this species, including the holotype, are preserved on the surface of the same hand specimen of Patcham Dolomite, and show the ornamentation of the shell quite clearly. The outline of the shell is better shown in the specimen whose measurements are quoted, but its surface, unfortunately, is eroded.

In outline this species scarcely differs from *Grammatodon jurianus*, described below. The shell, however, attains its maximum inflation at a point which is more anterior in position than in that species. Its umbo, moreover, is more strongly prosogyrous than in *G. jurianus*, its posterior carina sharper, and its posterior area more strongly concave. Both the radial and the concentric elements of its ornamentation are more conspicuous than in *G. jurianus*.

Its more conspicuous ornamentation also serves to distinguish it from *G. concinnus* (Phillips)[1] and from the English Great Oolite species which Morris and Lycett identify with that species.[1]

Occurrence and Material.—Bathonian, Patcham Dolomite, Andhou—the holotype and three paratypes, preserved on the same slab of rock, and one isolated paratype (Brit. Mus., L. 71447) (all colld. J. F. Blake).

[1] These species are discussed below, in the remarks on *Grammatodon jurianus* sp. nov.

Grammatodon jurianus sp. nov.

Plate II, figs. 15-20.

Cucullæa (Grammatodon) concinna Phillips ; L. F. Spath, 1933, "Revision of the Jurassic Cephalopod Fauna of Kachh," *Pal. Ind.*, N. S., vol. IX, Mem. no. 2, p. 779 (listed) [*non* Phillips].

Cucullæa texta (Rœmer) Müller ; L. F. Spath, 1933, *loc. cit.*, p. 779 (listed) [*non* Rœmer sp.].

Description.—The shell is of medium size for the subgenus, and sub-rectangular in outline, with a length to height ratio of about 3 : 2 ; it is of somewhat variable but usually moderate inflation, the inflation attaining a maximum at about the posterior two-fifths of the length, well in front of the carina. The umbones, which are situated at about the anterior two-fifths of the length, are slightly prosogyrous and not greatly separated ; the profile of the umbonal region is obtusely rounded and not very prominent. The cardinal area is rather narrow, attaining its greatest width just anterior to the umbones ; it bears a few chevron-shaped ligamental grooves. The length of the hinge-margin is only slightly less than that of the shell. The posterior margin is flattened, meeting the hinge-margin in a slightly obtuse angle and the ventral margin in a fairly sharp curve. The ventral margin, which is of varying convexity, merges with the anterior margin in a broad curve. The anterior margin meets the hinge-margin in a right or slightly obtuse angle. The posterior carina is more pronounced in some specimens than in others ; sometimes it does not greatly modify the even convexity of the shell, but at other times the posterior area is appreciably concave.

About five well-defined radial threads ornament the antero-dorsal region of the shell, while several fainter radial threads are present on the posterior area, and a number of very faint ones on the umbonal region of the median part of the shell. There is also a concentric ornamentation of fine concentric threads, which may give rise to delicate serrations on the carina ; on two specimens the postero-ventral part of the surface bears a series of delicate oblique threads which cross the growth-lines at an acute angle.

The hinge and other internal characters are not observable in any of the specimens studied.

Holotype.—G. S. I. type No. 16521.

Dimensions.—The measurements of the holotype and of a larger paratype are as follows :—

	Length.	*Height.*	*Inflation.*
Holotype	16·8 mm.	11·3 mm.	9·4 mm.
Paratype (B. M.. L. 71448) . . .	23·6 mm.	16·3 mm.	11·0 mm.

Remarks.—Although its hinge-structure is unknown, this species is obviously related to the Oxford Clay species *Cucullæa concinna* Phillips (1829, p. 137, Pl. V, fig. 9),[1] which Dr. W. J. Arkell [1930 (2), p. 341, Pl. XV, figs. 2-4] has shown

[1] *See* also P. de Loriol, 1897, p. 109, Pl. XIV, figs. 5-9 (Swiss specimens), 10, 11 (English specimens).

to be a typical representative of the genus *Grammatodon*. The two forms agree closely in shape and ornamentation, but in *G. concinnus* the posterior carina has a more pronouncedly sigmoidal curve and is sharper than in the Indian species, and the posterior area is always concave. The same differences distinguish the Indian species from the species from the Great Oolite of England which J. Morris and J. Lycett (1853, p. 50, Pl. V, fig. 7)[1] identify with *G. concinnus* and which, indeed, scarcely differs from that species except in its smaller size (the largest available specimen attains a length of only 16·4 mm.).

The differences between *G. jurianus* and *G. andhouensis*, from the Bathonian of Kachh, are discussed under that species.

Occurrences and Material.—Divesian, Upper Chari, *athleta* Beds, of the following localities:—Valley north of Dhosa—the holotype (colld. A. B. Wynne); "Bowl" at Fakirwadi—several internal casts (G. S. I. type Nos. 16522-4 and No. K 40/520, colld. J. H. Smith); Fakirwadi[2]—6 specimens (G. S. I. No. K 40/521, colld. J. H. Smith); East of Juria ["Middle Zone" of Blake, MS.][3]—2 specimens (Brit. Mus. L. 71448-9, colld. J. F. Blake); Jikadi ["Beds No. 21 and 23" of Blake, MS.][4]—two specimens (Brit. Mus. L. 71450-1, colld. J. F. Blake); South Maujal ["Bed No. 2" of Blake, MS.][5]—2 specimens (Brit. Mus. L. 71460-1, colld. J. F. Blake); Charwar Range ["Bed No. 2" of Blake, MS.][6]—4 internal casts (Brit. Mus. L. 71452-5, colld. J. F. Blake); Samatra ["Bed No. 2" of Blake, MS.]—4 internal casts (Brit. Mus. L. 71456-9, colld. J. F. Blake); Wanda ["Bed No. 3" of Blake, MS.]—one specimen (Brit. Mus. L. 71465, colld. J. F. Blake).

Horizon uncertain; East of Ler—one specimen (Brit. Mus. L. 71464, colld. J. F. Blake); hills S. of Nurrha—2 specimens (G. S. I. No. K 40/522, colld. A. B. Wynne).

Grammatodon sp.

Plate II, figs. 21 *a*, *b*.

Description.—The shell is of medium size for the subgenus, and trapeziform in outline, the ventral margin diverging very slightly from the hinge-margin in a posterior direction; it is of moderately strong inflation, the inflation attaining a maximum just posterior to the middle of the length. The umbones, which lie at about the anterior third of the length, are pronouncedly prosogyrous; the profile of the umbonal region is rather sharply rounded and not at all prominent. The cardinal area is narrow, attaining its greatest width just anterior to the umbones. The hinge-margin, which is broken away at both extremities, appears to

[1] Judging by the specimens preserved in the Lycett Collection in the Geological Survey Museum, the figure cited appears to be composite, the outline of the shell having been drawn (natural size) from a specimen which is a *Cucullæa* referable to the species *C. goldfussi* Morris & Lycett (*non* Rœmer), while the ornamental details have been taken from some much smaller and proportionately more elongate specimens on one of which the green ticket signifying "figured specimen" has been stuck. These smaller specimens belong to the species of *Grammatodon* to which I now refer.

[2] Extracted by Dr. L. F. Spath from the matrix of a specimen of *Obtusicostites obtusicosta* (Waagen).

[3] *See* L. F. Spath, 1924, p. 25, and 1931, p. 373.

[4] *See* L. F. Spath, 1924, p. 23, and 1931, p. 310.

[5] *See* L. F. Spath, 1924, p. 24.

[6] *See* L. F. Spath, 1933, p. 753.

have been only slightly shorter than the length of the shell. The ventral margin is flat; it merges with the posterior margin in a moderately sharp curve and with the anterior margin in a somewhat more open curve. The posterior carina is very sharp and delimits a concave posterior area.

The surface of the shell is somewhat eroded, but bears traces of fine radial threads. There are three or four rather prominent radial ribs on the antero-dorsal part of the surface, and about eight on the posterior area. Possibly owing to the eroded state of the surface, there is no trace of concentric ornamentation, but growth-rugæ are rather prominent near the ventral margin.

Dimensions.—The measurements of this specimen are as follows :—

Length	15·2 mm.
Height	10·4 mm.
Inflation	9·5 mm.

Remarks.—Although this specimen comes from a horizon not far above that of *Grammatodon andhouensis*, described above, it does not seem to be referable to that species, as its flat ventral margin, which diverges from the hinge-margin in a posterior direction, gives it an appreciably different shape. The specimen, however, is somewhat eroded and crushed, so that it does not appear desirable to name it until further material is available.

Occurrence and Material.—Upper Bathonian, about base of *macrocephalus* Beds, N. W. of Jumara—one specimen (G. S. I. No. K 40/524, colld. F. Stoliczka), found at approximately the same horizon as *Nucula* (*Palæonucula*) *blanfordi* sp. nov., *Nuculoma blakei* sp. nov., *Eligmus rollandi* Douvillé, and other species.

Subgenus : INDOGRAMMATODON L. R. Cox, 1937.

"Notes on Jurassic Lamellibranchia. II. On *Indogrammatodon*, a new subgenus from the Jurassic of the Indo-African Province," *Proc. Malac. Soc. London*, vol. XXII, p. 194.

Type.—*Cucullæa virgata* J. de C. Sowerby, Jurassic, India and East Africa.

Subgeneric Characters.—Shell medium-sized to large (for the family), trapezoidal, rather elongate, inequilateral, with an obtuse and usually rounded-off posterior carina; umbonal region not very prominent. Cardinal area bearing numerous closely spaced, chevron-shaped ligament-grooves. Ornamentation consisting of irregularly arranged, narrow radial ribs which do not correspond in the two valves, but are rather weaker and more diversified or more closely spaced in the right valve than in the left; in the right valve the ribs tend to be weak or altogether absent in the neighbourhood of the carina. Hinge-characters as defined for the genus.

Remarks.—Besides the type-species, I include in this subgenus the Indian Jurassic species *Grammatodon egertonianus* (Stoliczka),[1] *G. blakei* sp. nov., *G. iddurghurensis* sp. nov., and *G. kantkotensis* sp. nov., together with *G. irritans* (Hennig)[2] and *G. stockleyi* Cox [1937 (2), p. 197, Pl. XVI, fig. 1], from the Jurassic of East Africa.

[1] *Macrodon egertonianum* F. Stoliczka, 1865, p. 89, Pl. VIII, fig. 7. *Cucullæa egertoniana* K. Holdhaus, 1913, p. 434, Pl. XCV, figs. 1-10. *Grammatodon* (*Indogrammatodon*) *egertonianus* L. R. Cox, 1937 (2), p. 196, Pl. XV, figs. 10, 11.

[2] *Cucullæa irritans* E. Hennig, 1914, p. 175, Pl. XIV, figs. 6 *a*, *b*. Also W. O. Dietrich, 1933, p. 26, Pl. II, figs. 23-32.

These species, which have a general similarity in shell-form and ornamentation and are all characterised by a distinct difference in the ornamentation of the two valves, appear to constitute a very natural group. The hinge-structure of the two species *G. virgatus* and *G. egertonianus* was figured in my previous paper [1937 (2), Pl. XV, figs. 9, 10], while that of *G. iddurghurensis* is figured in Pl. III, figs. 5, 6*a* of the present Memoir. The arrangement of the hinge-teeth agrees closely with that of the genera *Grammatodon* and *Parallelodon*. The latter genus, in which most authors have included *G. egertonianus*, differs in the more elongate and compressed form of the shell, in the absence of a pronounced carina and of strong radial ribs, and in the presence of a byssal sinus towards the anterior end of the ventral margin.

Grammatodon s. str. is normally less inequilateral than most of the species of the group now discussed, but resembles them in the strong posterior carination of the shell and the absence of a byssal sinus. Although founded on a species almost devoid of radial ornamentation it has been considered to include such species as *G. carinatus* (J. Sowerby)[1], from the Albian of Blackdown (Devon), in which radial ribbing is well developed. This radial ribbing, however, is of a different type from that which characterises the species now included in *Indogrammatodon*, the ribs being very closely spaced and much less prominent. It seems probably, moreover, that *G. carinatus* will ultimately be separated subgenerically from *Grammatodon* s. str. Usually the representatives of *Grammatodon* s. str. do not show the striking dissimilarity in the ribbing of the two valves which is so constant a feature in *Indogrammatodon*; and when they are differently ornamented the differences are not of a comparable type. *Grammatodon* s. str., moreover, comprises a group of comparatively small species none of which attains the size of *G. virgatus* and far less that of *G. iddurghurensis* sp. nov.

The differences between *Indogrammatodon* and *Grammatodon* s. str. appear to me to be of approximately the same importance as those which distinguish *Megacucullæa* from *Cucullæa* s. str. *Indogrammatodon* is therefore regarded as a subgenus of *Grammatodon*.

The most widely distributed species of *Indogrammatodon* is *Grammatodon egertonianus* (Stoliczka), which has been recorded from the Upper Jurassic of Arabia, Somaliland, East Africa, and New Zealand,[2] as well as from the Spiti Shales of northern India, its type-occurrence. So far, however, it has not been met with in Kachh.

In the Jurassic the most typical species of this subgenus are restricted to the Indo-African province. In the Toarcian of France, however, there occurs a species described by M. Cossmann (1915, p. 16, Pl. VI, figs. 6-12) under the name *Parallelodon guibali* which appears to belong to this group. It is ornamented with narrow radial ribs whose number and prominence appear to vary considerably in different specimens (Cossmann's specimens may, however, belong to

[1] *See* H. Woods, 1899 (1), p. 45, Pl. VIII, figs. 3-8.

[2] Dr. C. T. Trechmann's record (1923, p. 263, Pl. XIV, fig. 8) of this species from the Jurassic of New Zealand was based on a broken specimen, the specific identity of which must be regarded as somewhat doubtful. Even if not specifically identical with *G. egertonianus*, however, it appears to be referable to the same subgenus, *Indogrammatodon*.

more than one species). The dissimilarity in the ornamentation of its two valves is shown by Cossmann's figs. 7 and 8.

Dr. L. Picard has pointed out to me that the species *Grammatodon parallelus* (Conrad) (1852, p. 223, Pl. XVII, fig. 98 ; also L. Picard, 1930, p. 523, Pl. XXI, figs. 14*a*, *b*), from the Upper Cretaceous of Palestine, has the chief external characters of an *Indogrammatodon*. Its left valve has a few prominent ribs without interstitial ornamentation and its right valve a number of very weak primary ribs with numerous rather weaker riblets in their interspaces ; the two valves thus differ in ornamentation in precisely the same manner as in the Jurassic species of the subgenus. Its carina, however, is sharper than in the Jurassic forms and is not bordered by a smooth space in either valve. Probably this is a difference of only specific importance.

The species *Cucullæa robusta* Etheridge (1872, p. 340, Pl. XX, fig. 1 ; also R. L. Jack and R. Etheridge, 1892, p. 565, Pl. XXVI, figs. 1, 4), from the Cretaceous " Desert Sandstone " of Maryborough (Queensland), also shows much resemblance to *Indogrammatodon* in external characters, but its hinge-structure has not been described.

Grammatodon (Indogrammatodon) virgatus (J. de C. Sowerby).

Plate II, figs. 22-30.

Cucullæa virgata, J. de C. Sowerby, 1840, " Description of Fossils from the Upper Secondary Formation of Cutch," *Trans. Geol. Soc.*, ser. 2, vol. V, Pl. XXII, figs. 1, 2 and Explanation.

? *Cucullæa lasti*, G. Müller, 1900, " Versteinerungen des Jura und der Kreide." *Deutsch-Ostafrika*, vol. VII, p. 533 ; Pl. XVII, figs. 1, 2.

Grammatodon (*Indogrammatodon*) *virgatus*, L. R. Cox, 1937, " Notes on Jurassic Lamellibranchia. II. On *Indogrammatodon*," *Proc. Malac. Soc. London*, vol. XXII, p. 195 ; Pl. XV, figs. 8, 9.

Description.—The shell is of medium size for the genus, rhomboidal or trapezoidal in outline, rather elongate, with a ratio of length to total height of about 3 : 2, and of length to height between cardinal and ventral margins of about 2 : 1. The inflation is moderate, attaining a maximum at about the anterior third of the length. The umbones, which are rather feebly incurved and not closely proximate, are placed at about the anterior two-fifths of the length ; the profile of the umbonal region, which is usually very broadly rounded, but occasionally narrower and more angular, is not very prominent. The cardinal area is subhorizontal and rather narrow, attaining its greatest width just in front of the umbones ; it bears numerous closely spaced, well incised, chevron-shaped ligament grooves. The hinge-margin varies in elongation. The posterior margin is flattened or slightly sinuate, making an obtuse angle, varying from about 120° to 135°, with the hinge-margin and meeting the ventral margin in a sharp curve. The ventral margin, which is feebly convex, usually merges with the anterior margin in a broad curve, but may meet it in a somewhat ill-defined,

obtuse angle. The anterior margin is feebly convex or flat, and is usually sub-parallel to the posterior margin, often meeting the hinge-margin in an acute, projecting angle. The posterior carina is obtuse and usually rounded off; it delimits a concave posterior area.

The surface anterior to the carina is ornamented with irregularly distributed radial ribs, the number of which varies considerably in different specimens; these ribs are more numerous but usually less prominent on the right valve than on the left. On the left valve the number of ribs varies from 14 to 20 or more, and they usually become more wide-spaced in the neighbourhood of the carina. On the right valve, where the number of ribs may be considerable, and weaker ones may be irregularly intercalated between the stronger ones, there is a marked tendency for them to become weaker and more closely spaced near the carina. The posterior area in each valve bears a few faint radial threads. A concentric ornamentation of closely and regularly spaced growth-threads is well developed on some specimens, and frequently the growth-stages are strongly accentuated at irregular intervals.

In the hinge the posterior lateral teeth, which are strong, elongate, and parallel to the hinge-margin, number three in the right valve and four in the left. Anteriorly, the obliquity and length of the teeth increase regularly from below the umbo, where the teeth are short and perpendicular to the margin, to the anterior end of the hinge-line, where the three end ones in each valve are horizontal. The muscle-scars have not been observed.

Lectotype.—Brit. Mus., No. 9957 (Geol. Soc. register), fig. 1 of Sowerby's plate.

Dimensions.—The measurements of the lectotype (fig. 27) are as follows:—

Length	58·0 mm.
Height	39·0 mm.
Inflation (single valve)	15·7 mm.

Remarks.—The two syntypes of this species figured by Sowerby are right valves preserved in a very shelly fissile grey limestone which cannot be matched in any of the later collections examined. They have a very broadly rounded umbonal region and a well rounded posterior carina, while their sculpture, which is well preserved in the lectotype, is characterised by the highly irregular distribution of the closely spaced radial ribs.

At first sight many of the other specimens examined appear to differ so much from these types both in shape and in ornamentation as to be referable to distinct species. The umbones are often narrower and more elevated than in the types, while the posterior carina may be sharper. The antero-dorsal corner of the shell frequently forms a very acute projection, while in a few specimens the postero-dorsal corner projects in a similar manner, giving the shell a bialate appearance. The concentric ornamentation, like the radial ribbing, is very variable, and in some specimens occasional growth-rugæ stand out nearly as prominently as the radial ribs. The fine concentric threads are not observable in all the specimens, but this may be due to erosion. It does not appear to be possible to correlate these variations with differences in geological horizon.

Cucullæa lasti Müller, from East Africa, appears to be a synonym of *G. virgatus*. The presence of radial riblets on the posterior area, one of its supposed distinctive characters, is observable on uneroded specimens of the Indian species, and the hinge of the latter, which Müller believed to differ from that of *C. lasti*, was obviously known to him only from Sowerby's imperfect description. Although *C. lasti* was considered by Müller to come from beds of Kimmeridgian age, it is more probable that its horizon is Callovian.[1]

Occurrences and Material.—The type-locality of this species is recorded (J. de C. Sowerby, 1840, p. 328) as the Hubbye [Habo] Hills. Sowerby states that "a pass in the hills between Hubbye and Joorun is paved with these shells imbedded in a hard rock." This rock also contains numerous ill-preserved specimens of a *Nucula* described by Sowerby (1840, Pl. XXII, fig. 3) as *N. tenuistriata*; so imperfect are these specimens that it has not been possible for me to identify their species definitely with any of the representatives of the genus described in the present Memoir. Although *Nucula* is most abundant in the *macrocephalus* Beds it is probable that this rock came from a higher horizon, perhaps from the Divesian. Sowerby's two figured syntypes of *G. virgatus* are preserved in the British Museum (Natural History) (Nos. 9957 and 9958 of the register of the Geological Society collection).

The following are the occurrences of the remaining specimens examined:—

Upper Bathonian [*vel* Callovian], Lower Chari, *macrocephalus* Beds, of the following localities:—Between Kumagoona and Meera—one specimen (G. S. I. No. K 40/525, colld. F. Stoliczka)[2]; N. W. of Jumara ["*Scyphia* Limestone" of Stoliczka, MS.][3]—one specimen (G. S. I. No. K 40/526, colld. F. Stoliczka).

Callovian, Middle Chari, *rehmanni* or *anceps* Beds, of the following localities:—Khera Hill, near Chari ["Brown Oolite" of Stoliczka, MS.][4]—four specimens (G. S. I. No. K 40/528, colld. F. Stoliczka, and No. K 40/529, colld. A. B. Wynne); Juria Hills, on road from Juria to Dhosa—nine specimens (G. S. I. No. K 40/530, colld. A. B. Wynne); Badi ["Lower Zone" of Blake, MS.][5]—two specimens (Brit. Mus. L. 71469-70, colld. J. F. Blake).

Callovian, Middle Chari, *anceps* Beds, river east of Juria ["Lower Zone" of Blake, MS.][6]—one internal cast (Brit. Mus. L. 71471, colld. J. F. Blake).

Callovian or Divesian, upper *anceps* or lower *athleta* Beds, of the following localities:—River on road from Guddera to Jenane—numerous specimens, some associated with abundant specimens of a medium-sized, flat, ribbed *Astarte*

[1] *See* J. Weir, 1929, p. 32; also L. R. Cox, 1935 (1), pp. 188, 189. *Ceromya equatorialis* Müller, a very distinctive species which occurs in association with *Cucullæa lasti*, is considered in this latter work to be a synonym of *Ceratomya telluris* (Lamarck), a Bathonian species with Callovian mutations.

[2] This specimen is recorded from the *macrocephalus* Beds in Stoliczka's MS. list, but I suspect that it may have come from a slightly higher horizon.

[3] The "*Scyphia* Limestone" in which several of the specimens recorded by Stoliczka are stated to occur is mentioned by W. T. Blanford (in H. B. Medlicott and W. T. Blanford, 1879, p. 254). It occurs at the very base of the beds of the Chari group.

[4] The "Brown Oolite" of Khera Hill of Stoliczka's MS. list appears to have included both the upper horizons of the *macrocephalus* Beds and the overlying Callovian beds.

[5] *See* L. F. Spath, 1924, p. 33, and 1933, p. 743.

[6] *See* L. F. Spath, 1924, p. 25.

(G. S. I. No. K 40/531, colld. A. B. Wynne); river at Jenane—one specimen (G. S. I. No. K 40/527, colld. A. B. Wynne).

Divesian, *athleta* Beds, of the following localities:—South of Juria—a slab with several specimens associated with *Bakevellia* sp. and the ammonite *Hubertoceras* sp. (G. S. I. No. K 40/582, colld. A. B. Wynne); east of Juria [" Middle Zone " of Blake, MS.][1]—one specimen, associated with *Grammatodon jurianus* (Brit. Mus. L. 71448, colld. J. F. Blake). Samatra [" Bed No. 2 " of Blake, MS.]—one specimen (Brit. Mus. L. 71472, colld. J. F. Blake); south of Rataupur [" Habo Conglomerate " of Blake, MS.]—five specimens (Brit. Mus. L. 71444, 71473-6, colld. J. F. Blake); S. W. of Barasir [" *pseudobiplicata* and *pseudosella* Bed " of Stoliczka, MS.]—one specimen (G. S. I. No. K 40/532, colld. F. Stoliczka); Khera—one specimen (Brit. Mus. L. 71477, colld. J. F. Blake); east of Ler [" Bed No. 8 " of Blake, MS.][2]—one specimen (Brit. Mus. L. 71478, colld. J. F. Blake); south of Kotai—one specimen (Brit. Mus. L. 71479, colld. J. F. Blake); west of Kotai—one specimen (Brit. Mus. L. 71480, colld. J. F. Blake); western Katrol [" Bed No. 4 " of Blake, MS.]—two specimens (Brit. Mus. L. 71481-2, colld. J. F. Blake); Fakirwadi[3]—one specimen (G. S. I. No. K 40/533, colld. J. H. Smith).

Divesian, lower Dhosa Oolite, of the following localities:—West of Juria [" Upper Zone " of Blake, MS.][4]—one specimen (Brit. Mus. L. 71483, colld. J. F. Blake); Wanda [" Zone I " of Blake, MS.][5]—one specimen (Brit. Mus. L. 71484, colld. J. F. Blake); near Wanda [" *pseudobiplicata* Beds " of Stoliczka, MS.]—one specimen (G. S. I. No. K 40/534, colld. F. Stoliczka); south of Damburka [" *pseudobiplicata* Beds " of Stoliczka, MS.]—one specimen (G. S. I. No. K 40/535, colld. F. Stoliczka); valley north of Dhosa—two specimens (G. S. I. No. K 40/536, colld. A. B. Wynne).

Horizon uncertain, from the following localities:—hills south of Boojoori—one specimen (G. S. I. No. K 40/537, colld. F. Fedden); south of Drang—one specimen (G. S. I. No. K 40/538, colld. F. Stoliczka); west by south of Giri—one specimen (G. S. I. No. K 40/539, colld. F. Stoliczka).

Grammatodon (Indogrammatodon) blakei sp. nov.

Plate III, figs. 2 *a-c*.

Description.—The shell is of small-medium size for the subgenus, and ovate-rectangular in outline, with a ratio of length to height of about 4 : 3; its inflation, which is moderate, attains a maximum at about the middle of its length. The umbones, which are moderately incurved and not greatly separated, are placed at about the anterior two-fifths of the length; the profile of the umbonal region is broadly rounded and not very prominent. The cardinal area is rather narrow, but is somewhat obscured by matrix in the only available specimen. The hinge-margin (somewhat broken away at each extremity) appears to have been elongate.

[1] *See* L. F. Spath, 1924, p. 25.
[2] *See* L. F. Spath, 1924, p. 24.
[3] Extracted from the matrix of a specimen of the ammonite *Obtusicostites obtusicosta* (Waagen).
[4] *See* L. F. Spath, 1924, p. 25.
[5] *See* L. F. Spath, 1924, p. 23.

with a length only slightly less than that of the shell. The ventral margin is moderately and more or less symmetrically convex, merging with the anterior margin in a broad curve and meeting the posterior margin in a well-defined angle. The anterior margin appears to have been evenly rounded and the posterior margin flattened, but both are rather broken away. The posterior carina is obtuse, but sharp, and delimits a strongly concave posterior area on which there are traces of radial threads.

The surface anterior to the carina is ornamented with sharp, narrow, somewhat irregularly distributed radial ribs which are more prominent but less numerous on the left valve (where they number 13 on the holotype) than on the right (where they number about 20 on the holotype). On the right valve the ribs become weaker but more close-spaced in the neighbourhood of the carina, where weak radial threads may be intercalated in their interspaces. Fairly regularly spaced concentric threads are visible in the interspaces, and produce small denticulations where they cross the radial ribs near the ventral margin.

The internal characters are unobservable.

Holotype.—Brit. Mus. L. 71485.

Dimensions.—The measurements of the holotype are as follows :—

Length	26·4 mm.
Height	19·7 mm.
Inflation	16·9 mm.

Remarks.—This species has been founded on a single specimen which differs from *G. virgatus* (J. de C. Sowerby), described above, in its more rectangular shape and much sharper carina.

It bears some resemblance to "*Cucullæa*" *irritans* E. Hennig (1914, p. 175, Pl. XIV, figs. 6 *a*, *b*; also W. O. Dietrich, 1933, p. 26, Pl. II, figs. 23-32), from the Kimmeridgian of Tendaguru, East Africa. In that species, however, the umbonal region is somewhat broader and the posterior carina more rounded-off.

Occurrence and Material.—Horizon uncertain, probably Callovian, *anceps* Beds, east of Juria[1]—the holotype only (colld. J. F. Blake).

Grammatodon (Indogrammatodon) kantkotensis sp. nov.

Plate III, figs. 1 *a-c*.

Description.—The shell is of small-medium size for the subgenus, and subrectangular in outline, with a ratio of length to height of about 6 : 5; it is strongly inflated, most so at about its middle. The umbones, which are moderately incurved and not greatly separated, are slightly anterior to median; the profile of the umbonal region is broadly rounded and not very prominent. The cardinal area is rather narrow, attaining its greatest width just anterior to the umbones; the surface of this area is largely obscured in the only available specimen, but traces of chevron-shaped ligament grooves are visible. The hinge-margin is elongate, its length being only slightly less than that of the shell. The posterior

[1] Blake's label is, unfortunately, faded, and the horizon cannot be deciphered with certainty. It appears to be "Lower Zone", *i.e.*, the *anceps* Zone of the Middle Chari (*See* L. F. Spath, 1924, p. 25).

margin is flattened, meeting the hinge-margin in an angle which only slightly exceeds 90°, and the ventral margin in a well-defined and slightly more obtuse angle. The ventral margin is asymmetrically convex, sweeping up anteriorly in a broad curve, and meeting the anterior margin in an obtuse angle. The anterior margin is flattened, making a projecting angle of about 80° with the hinge-margin; the anterior and posterior margins thus converge slightly in a ventral direction. The posterior carina is obtuse, but sharp, and delimits a concave posterior area on the dorsal part of which there are traces of radial threads.

The surface anterior to the carina is ornamented with sharp, narrow, irregularly distributed radial ribs, which are more prominent but less numerous on the left valve (where they number 12 on the holotype) than on the right (where they number about 24 on the holotype). On the left valve the ribs become more wide-spaced, and on the right valve much weaker but more close-spaced, in the neighbourhood of the carina; weak radial threads are occasionally intercalated between them on both valves. Fairly regularly spaced concentric threads are faintly visible and produce small denticulations where they cross the radial ribs.

The internal characters are unobservable.

Holotype.—Brit. Mus. L. 71493.

Dimensions.—The measurements of the holotype are as follows:—

Length	28·2 mm.
Height	23·6 mm.
Inflation	22·0 mm.

Remarks.—This species, like *G. blakei*, has been founded on a single specimen. It differs from *G. virgatus* (J. de C. Sowerby) in its more rectangular and less elongate shape, its relatively stronger inflation, and its sharper carina. From the East African Kimmeridgian species *G. irritans* (Hennig), mentioned in connexion with *G. blakei*, it is distinguished by its less elongate shape and its stronger inflation.

Occurrence and Material.—Argovian (?), Kantkote [" lowest bed " according to Blake, MS.][1]—the holotype only (colld. J. F. Blake).

Grammatodon (Indogrammatodon) iddurghurensis sp. nov.

Plate III, figs. 3-6, and Plate IV, figs. 1, 2.

Description.—The shell, which attains a large size for its genus, is trapezoidal in outline and somewhat variable in elongation, with a ratio of length to height ranging from about 3 : 2 to 6 : 5. It is strongly inflated, its inflation being greatest at about the anterior third or two-fifths of its length, between which point and the carina its surface is rather flattened; the test is very thick. The umbones, which are moderately incurved, are well separated in the full-grown shell, and are situated between the middle and the anterior third of the length; the umbonal region is of moderate prominence. The cardinal area, which attains

[1] L. F. Spath (1933, p. 755) refers to Argovian fossils from Kantkote marked " Zone I " by Blake, but there do not appear to be any ammonites from Blake's " lowest bed ".

its maximum width just anterior to the umbones, is wide, slightly concave, and inclined to a varying extent; its chevron-shaped ligamental grooves are closely spaced and deeply incised. The hinge-margin occupies from about two-thirds to four-fifths of the total length of the shell. The posterior margin is flattened, forming an obtuse angle, of about 120° or 130°, with the hinge-margin. The ventral margin, which in its general direction is parallel to the hinge-margin, is very feebly convex, meeting the posterior margin in a rounded-off angle, and merging with the anterior margin in an even curve. The anterior margin is straight or feebly convex, and meets the hinge-margin in an angle slightly exceeding 90°. The posterior carina is obtuse and rounded off, disappearing before it reaches the postero-ventral corner of the shell. The posterior area is slightly concave, sloping rather gradually to the margins.

The surface anterior to the carina is ornamented with a variable number (11 to about 19) of narrow, weak, rounded or sub-angular radial ribs, which are absent from the vicinity of the carina in the right valve and are only weakly developed near the carina in the left; the ribs do not correspond in the two valves. Up to four radial threads of unequal strength, which sometimes fade away towards the ventral margin, may be present in the interspaces in the right valve, but not in the left. The posterior area has a few radial riblets near the umbo, but these fade away before reaching the ventral margin. The rather coarse growth-lamellæ of the shell are accentuated at irregular intervals to form conspicuous rugæ.

In the full-grown shell the teeth of the posterior series, five in number, are narrow, elongate, and exactly parallel, sloping downwards in a posterior direction, and forming an angle of about 20° with the hinge-margin; anteriorly, the five end teeth are radially arranged and slightly curved, the uppermost one being elongated and sub-parallel to the hinge-margin; the teeth of the median portion of the hinge have been obliterated in the only full-grown specimen. In an immature specimen the posterior teeth, three in number, are horizontal, while the remaining teeth have a radial arrangement, their inclination changing gradually from under the umbo, where they are transverse, to the anterior end of the hinge-line, where the last four are almost horizontal.

Holotype.—G. S. I. type No. 16525.

Dimensions.—The measurements of the holotype and of two paratypes, the second a relatively short shell, are as follows:—

Specimen.	*Length.*	*Height.*	*Inflation.*
Holotype	101·0 mm.	65·0[1] mm.	62·0 mm.
Brit. Mus. L. 71488 .	105·0 mm.	70·0 mm.	35·0 mm. (single valve).
G. S. I. type No. 16526 . .	84·4 mm.	55·5 mm.	28·0 mm. ,,

The largest specimen, the anterior end of which is broken away, must originally have been over 120 mm. in length.

Remarks.—As the details of the structure of the middle part of the hinge are not visible in the only full-grown specimen whose interior is exposed, it would

[1] Estimated, as the umbonal region is partly broken away.

be easy to mistake the hinge for that of a *Cucullæa*. An immature specimen, however, clearly shows that the arrangement of the teeth of the whole anterior half of the hinge agrees with that of the genus *Grammatodon*. The general character of the ornamentation, namely, the presence of radial ribs in both valves and their more diversified character in the right, indicates that the species should be referred to the subgenus *Indogrammatodon*.

This species appears to be closely related to *Grammatodon* (*Indogrammatodon*) *stockleyi* Cox [1937 (2), p. 197, Pl. XVI, fig. 1], recently described by me from the Jurassic (probably Callovian) of Tanganyika Territory. Its size, however, is even larger than that of that species, while the ribs on its right valve are less numerous and more regularly distributed. In *G. stockleyi*, moreover, the ventral margin diverges from the hinge-margin in a posterior direction, so that the shell is highest at its posterior end.

Occurences and Material.—Argovian of the following localities:—Iddurghur [" *Astarte* Beds A and B " of J. H. Smith, MS.][1]—the holotype and ten paratypes (G. S. I. type No. 16526 and No. K 40/543, colld. J. H. Smith, type No. 16528, colld. F. Stoliczka, and type No. 16527 and No. K 40/544, colld. A. B. Wynne; also Brit. Mus. L. 71486-8, colld. J. F. Blake). Wamka [" *Astarte* Bed " of Blake, MS.]—three specimens (G. S. I. No. K 40/545, colld. F. Fedden; also Brit. Mus. L. 71489, colld. J. F. Blake). Adooe—two specimens (G. S. I. No. K 40/546, colld. A. B. Wynne). Burooria—one specimen (G. S. I. No. K 40/547, colld. A. B. Wynne). Kantkote [" Zone 1 " of Blake, MS.][2]—one internal cast (Brit. Mus. L. 71490, colld. J. F. Blake).

GRAMMATODON (INDOGRAMMATODON) sp. indet.

(Plate III, fig. 7.)

Description.—The specimen, which is broken away at both extremities, is a poorly preserved left valve belonging to a large-medium and somewhat feebly inflated representative of the subgenus. It appears to have been ovate in outline and of moderate elongation. The umbonal region, which is not very prominent, is sub-median in position and very broadly rounded. The posterior carina is ill-defined, and the posterior area convex. There are about 19 radial ribs, but the surface is too much eroded for the finer details of the ornamentation to be observable.

Dimensions.—The original measurements of the specimen may be estimated, very approximately, as follows:—

Length	50 mm.
Height	43 mm.
Inflation (single valve)	20 mm.

Remarks.—This specimen is distinguished from *G. virgatus* (J. de C. Sowerby), which ranges from the Bathonian to the Divesian, by its broader umbonal region and less well-defined carina. From *G. iddurghurensis* sp. nov., described

[1] *See* L. F. Spath, 1935, p. 185.
[2] *See* L. F. Spath, 1933, p. 755.

above, it is distinguished by its more equilateral shape and its less pronounced carina, while its dimensions are much less than those normally attained by that species.

There is a distinct similarity between this specimen and some of the specimens from the Kimmeridgian of East Africa figured by W. O. Dietrich (1933, p. 26, Pl. II, figs. 23-32) as "*Cucullæa*" *irritans* Hennig. Its size, however, is slightly larger than that of any of Dietrich's specimens and its posterior carina is not so well-defined.

Occurrence and Material.—Argovian, Kantkote Sandstone, north of Wamka ["Crimson Bed" of Blake, MS.[1]]—one specimen (Brit. Mus. L. 71494, colld. J. F. Blake).

Genus : CUCULLÆA J. B. de Lamarck, 1801.

Système des Animaux sans Vertèbres, p. 116.

Genotype.—Arca concamera Bruguière (1789, p. 102) [*C. auriculifera* Lamarck], Recent, Indo-Pacific.

Generic Characters.—Shell trapezoidal or sub-quadrangular, never pronouncedly inequilateral, posteriorly carinate, well inflated; valve-margins closed (byssus vestigial). Cardinal area of moderate width and bearing a variable number of chevron-shaped ligamental grooves. Dentition consisting, in the adult shell, of a median series of short teeth perpendicular to the hinge-margin, and of two lateral series each formed by from two to five elongate teeth which are more or less parallel to the hinge-margin. Posterior adductor usually, but not invariably, attached in front to a thin, raised septum.

Remarks.—Some authors, including, fairly recently, Mlle S. Gillet [1924(1), p. 16], R. B. Stewart (1930, p. 75), and J. V. L. Rennie (1936, p. 304), have considered that *Cucullæa* s. str. should include only post-Mesozoic species and that earlier forms should be referred to *Idonearca* Conrad (1862, p. 289)[2], regarded either as a subgenus of *Cucullæa* or as a distinct genus.

Except in its thicker shell, however, *Cucullæa vulgaris* Morton (*C. tippana* Conrad)[3], the type-species of *Idonearca*, does not differ in any character of importance from the Recent genotype of *Cucullæa*, since it is of the same general shape, possesses the same type of reticulate ornamentation, has similar internal ribbing, is similar in hinge-structure (except that the perpendicular teeth of its median series are rather fewer and coarser), and has a similar myophorous septum. Stewart's statement that grooves are absent on the ligamental area of the genotype shows that he had insufficient material at his disposal, since they are present in the majority of specimens. P. Fischer's figure of the genotype (1887, Pl. XVII, fig. 14), cited by Rennie (1936, p. 307), represents an immature specimen in which the hinge-teeth have a less differentiated, more radial, arrangement than

[1] See L. F. Spath, 1933, p. 755.

[2] H. A. Pilsbry (1929, p. 113) has attempted to revive the name *Cyphoxis* Rafinesque (1819, p. 427) in place of *Idonearca*, but since it was based on internal casts at whose identity it is only possible to guess, this name appears to be best ignored.

[3] Well figured by S. Weller [1907, p. 394, Pl. XXXI, figs. 5-10, and Pl. XXXII, figs. 1, 2 (*C. tippana*); p. 397, Pl. XXXII, figs. 5, 6 (*C. vulgaris*)], J. A. Gardner (1916, p. 529, Pl. XX, figs. 8, 9, and Pl. XXI, figs. 1, 2), and B. Wade (1926, p. 43, Pl. IX, figs. 3, 4, 6, 7).

in the full-grown shell. The development of the dentition follows exactly the same course in the Cretaceous species *Cucullæa glabra* Parkinson, early stages of which have been figured by H. Woods [1899(1), Pl. XI, figs. 10-12]. The comparatively thin shell of the genotype serves to distinguish it from most of the Tertiary species as well as from the Mesozoic ones, and does not justify its separation in a distinct subgenus.

Cucullæa s. str. may, in fact, be regarded as a group which has persisted from early Jurassic times to the present day. Its external characters are a rectangular or trapezoidal outline, strong inflation, a well-defined although usually rounded-off posterior carina, and a smooth or reticulately ornamented surface. Its ligamental grooves are usually rather widely separated. One interesting feature of the genotype lies in the slight difference in the ornamentation of its two valves. The grooves which form the radial component of this ornamentation are shallower and further apart in the left valve than in the right, so that the former has a smoother appearance.

No representative of *Cucullæa* s. str. has yet been found in the Jurassic of Kachh; two species have, however, been found which agree with *Cucullæa* in the general arrangement of the hinge-teeth, but are ornamented with prominent radial ribs. These are included in a distinct subgenus which has recently been described by Dr. J. V. L. Rennie under the name *Megacucullæa*.

Subgenus: MEGACUCULLÆA J. V. L. Rennie, 1936.

"Lower Cretaceous Lamellibranchia from Northern Zululand," *Ann. S. African Mus.*, vol. LXXI, p. 305.

Type.—Cucullæa kraussii Tate (Tithonian, India; Neocomian, South and East Africa and Madagascar).

Subgeneric Characters.—Shell large, strongly inflated, high in proportion to its length, with a very prominent umbonal region and a strongly incurved umbo; cardinal area wide, concave, and sloping; posterior carina sharp, posterior area concave, sloping steeply to the margins. Ornamentation consisting of prominent radial ribs which correspond in the two valves; fine radial threads in the interspaces are more conspicuous in the right valve than in the left.

Remarks.—Besides the genotype and *C. eminens* sp. nov., described below, this subgenus includes certain specifically unnamed forms from the Neocomian of Zululand recently described by Rennie (1936, p. 308, Pl. XXXVII, figs. 1-3), and, probably, the somewhat imperfectly known species *C. neuquensis* C. E. Weaver (1931, p. 186, Pl. XIII, figs. 45, 46), from the Neocomian of the Argentine.

While the hinge-characters of the subgenotype are those of a normal *Cucullæa*, *C. eminens* is remarkable for its curved, radiating lateral teeth, and for the smallness of the number of transverse teeth occupying the middle of the hinge-line. *C. kraussii* lacks the internal septum for the attachment of the posterior adductor which is present in most species of *Cucullæa* s. str., but it is unknown if this plate is present in the other species referred to *Megacucullæa*.

CUCULLÆA (MEGACUCULLÆA) KRAUSSII Tate.

(Plate IV, figs. 3, 4.)

Cucullæa cancellata F. Krauss, 1850, "Über einige Petrefacten aus der untern Kreide des Kaplandes," *Verh. k. Leopold.-Carol. Akad. Naturforscher*, vol. XXII, Pt. 2, p. 452; Pl. XLVIII, figs. 2*a*, *b* (*non* Phillips).

Cucullæa kraussii R. Tate, 1867, "On some Secondary Fossils from South Africa," *Quart. Journ. Geol. Soc.*, vol. XXIII, p. 161.

Cucullæa kraussi E. Holub and M. Neumayr, 1882, "Über einige Fossilien aus der Uitenhage-Formation in Süd-Afrika," *Denkschr. k. Akad. Wiss. Wien*, vol. XLIV, p. 275, Pl. II, fig 2.

Cucullæa kraussi F. H. Hatch and G. S. Corstorphine, 1905, Geology of South Africa, p. 251, text-fig. 69*f*.

Cucullæa kraussi E. Krenkel, 1910, "Die untere Kreide von Deutsch-Ostafrika," *Beitr. Pal. Österr.-Ungarns*, vol. XXIII, p. 208.

Cucullæa kraussi E. Lange, 1914, "Die Brachiopoden, Lamellibranchiaten und Anneliden der *Trigonia Schwarzi*-Schicht," *Archiv f. Biontologie*, vol. III, Pt. 4, p. 223.

Cucullæa kraussi L. Barrabé, 1929, "Contribution à l'étude.... de la Partie médiane du Pays Sakalave (Madagascar)," *Mém. Soc. géol. France*, N. S., No. 12, p. 147, Pl. VIII, fig. 13.

Cucullæa kraussi W. O. Dietrich, 1933, "Zur Stratigraphie und Palæontologie der Tendaguruschichten," *Palæontographica*, Supp. VII, ser. 2, Pt. 2, p. 28.

Cucullæa (*Megacucullæa*) *kraussi* J. V. L. Rennie, 1936, "Lower Cretaceous Lamellibranchia from Northern Zululand," *Ann. S. African Mus.*, vol. XXXI, p. 305, Pl. XLIV, fig. 2.

Description of the Specimens from Kachh.—The shell, which attains a fairly large size for the genus, is subrhomboidal or subovate in outline and rather short in proportion to its height. It is evenly and rather strongly inflated, the inflation attaining a maximum at about its middle; the thickness of the test is considerable. The umbones, which are submedian, are well incurved, and were evidently not closely proximate in the full-grown shell; the profile of the umbonal region is rather prominent and of moderate width. The cardinal area, which is somewhat obscured in the available specimens, is gently inclined and fairly wide, apparently attaining its maximum width just anterior to the umbones; its ligamental grooves are rather wide-spaced and not very deeply incised. The hinge-margin is elongate, its length being only slightly less than that of the shell. The posterior margin is flattened, meeting the hinge-margin in an angle which slightly exceeds 90°. The ventral margin (apart from the scalloping between the radial ribs) is symmetrically convex, meeting the posterior margin in a well-marked angle and merging with the anterior margin in a broad curve. The anterior margin is feebly convex, its general direction forming an angle of slightly less than 90° with the hinge-margin. The posterior carina is sharp and somewhat projecting, although less conspicuous than in most other species of *Cucullæa* owing to the prominence of the radial ribs; it delimits a slightly concave and rather narrow posterior area.

The surface anterior to the carina is ornamented with about eight unevenly spaced, narrow radial ribs, of which the five on the inflated part of the valve are very sharp and prominent, while the remainder, on the anterior region, are sharp and conspicuous in one specimen but only faintly developed in the other; between the ribs the ventral margin is fairly deeply scalloped. In the smaller specimen a minor radial riblet occupies one of the interspaces, while in both specimens (right valves) there are traces of fine radial threads (now partly obliterated by erosion) in the interspaces. The posterior area bears about three weakly developed radial riblets. The whole surface is also crossed by rather conspicuous, irregularly spaced growth-lamellæ, which produce small denticulations where they cross the ribs and are arched upwards in each interspace.

In the hinge, which has been crudely developed in the larger specimen, three elongate horizontal lateral teeth are discernible at each end of the margin, but the intermediate teeth are obscured.

Dimensions.—The measurements of the two available specimens from Kachh are as follows :—

Specimen.	*Length.*	*Height.*	*Inflation (single valve).*
G. S. I. No. K40/551	77·0 mm.	60·0[1] mm.	35·0 mm.
Brit. Mus. L. 71495	33·0 ,,	28·3 ,,	10·0 ,,

Remarks.—I have examined several specimens of this species from the Uitenhage Beds of South Africa, its type-occurrence, and also a number from the Neocomian of the Tendaguru district of Tanganyika Territory. South African specimens have recently been described in some detail by Dr. J. V. L. Rennie (1936, p. 305). The specimen figured by Rennie differs from those figured by Krauss and by Holub and Neumayr in the presence of numerous strong radial threads in the broad interspaces between the costæ—a difference commented upon by Rennie himself. It may, however, be noted that Rennie's specimen is a right valve, while the two figured by the older authors were left valves. It is probably more than a coincidence that, among the specimens examined by me, the right valves possess this fine radial ornamentation while the left valves do not. A tendency for the right valve to be more ornamented than the left is, in fact, observable to a varying degree in nearly all species of *Cucullæa.*

The African specimens vary to some extent in the number and closeness of their ribs, and among them it is possible to match the Indian specimens now recorded very closely, so that there seems to be no reason to qualify the specific determination of the latter. The late Dr. F. L. Kitchin (1908, p. 43) was the first to place the occurrence of this species in Kachh on record, while, more recently, Dr. L. F. Spath (1933, p. 798)[2] has referred to the presence of a "*Cucullæa* indistinguishable from *C. kraussii* Tate" in the beds of this region. In view

[1] Estimated, as the specimen is broken away ventrally.

[2] Dr. Spath informs me that the specimens to which he refers are in the collection of Dr. Raj Nath, of Benares University.

of the occurrence of this species in the Neocomian of South Africa and Madagascar it is of importance to note that the exact horizon of a specimen in the J. F. Blake Collection, as well as of those recorded by Dr. Spath, is known from associated ammonites. These belong, according to Dr. Spath, to the *densiplicatus* assemblage of the Tithonian.

Occurrences and Material.—Tithonian, Umia Group, of the following localities :—N. E. Umia (queried)—one specimen (G. S. I. No. K40/551, colld. F. Stoliczka) ; north of Moondan ["Small bed" of Blake, MS.[1]]—one specimen (Brit. Mus. L. 71495, colld. J. F. Blake).

Cucullæa (Megacucullæa) eminens sp. nov.

(Plate IV, figs. 5-7.)

Description.—The shell is of large-medium size for its genus and, although rather variable in shape, is always characterised by its elevated form, its height being sometimes nearly equal to, and never falling far short of, its length. It is fairly strongly and rather unevenly inflated ; its most inflated region is usually situated at about the anterior third of its length, while between this region and the carina its surface is somewhat flattened. The umbonal region is rather sharply rounded in profile, and is very elevated and steep-sided, rising, in the tallest specimens, as high above the hinge-margin as the ventral margin lies below it ; its prominence, however, varies considerably. The umbones are sub-median and very strongly incurved over the cardinal area, so as to be rather closely proximate when the two valves are in juxtaposition. The cardinal area, the outer margins of which are strongly curved, attains its greatest width just anterior to the umbones, and is wide, transversely concave, and inclined to a varying degree, according to the elevation of the umbones ; it is ornamented with conspicuous but closely spaced, chevron-shaped ligamental grooves. The hinge-margin is of moderate elongation, usually occupying about five-sixths of the length of the shell. The posterior margin is flattened, forming with the hinge-margin a well-marked angle of about 120°. The ventral margin is asymmetrically convex, tending to be somewhat flattened and to converge slightly towards the hinge-margin posteriorly ; it meets the posterior margin in a fairly well-defined, rounded-off angle, and merges with the anterior margin in a broad curve. The anterior margin may curve inwards slightly to meet the hinge-margin, or may meet it in an angle of slightly less than 90°. The posterior carina is well pronounced although rather blunt, delimiting a strongly concave posterior area which falls away steeply to the margin.

The surface anterior to the carina is ornamented, in each valve, with about 16 somewhat irregularly distributed, narrow radial ribs which are only weakly developed in the immediate vicinity of the carina, but are rather sharp and prominent on the remainder of the surface ; the interspaces are considerably wider than the ribs, and in the right valve those between the middle of the shell and the carina bear weak radial threads. The posterior area is smooth except for three or four weak radial threads which may be present near the umbo. The

[1] See L. F. Spath, 1933, p. 757.

growth-rugæ are irregular and often rather conspicuous, producing denticulations on the radial ribs; finer and more regular growth-threads are also developed in places.

The hinge-teeth are thick and comparatively wide-spaced, numbering (in the right valve) only about 12 in all. Of these, a single tooth in the middle is straight and vertical, while those on each side of it have a more or less symmetrically radial arrangement. There is no discontinuity between the shorter, oblique teeth nearer the middle and the elongate, subhorizontal teeth at each end of the hinge-line. Of the oblique teeth, the inner ones have a pronounced bend, and consist of a short, vertical lower limb and of an oblique upper limb which is truncated by the hinge-margin. The outer, or lateral, teeth, consisting of the three at each end which are not truncated in this manner, are curved and slightly divergent; these lateral teeth have a pronounced transverse striation. The muscle-scars are unobservable.

Holotype.—Brit. Mus. L. 71496.

Dimensions.—The following are the measurements of the holotype and two paratypes, illustrating the variation in the proportions of the shell:—

Specimen.	*Length.*	*Height.*	*Inflation (single valve).*
Holotype	60·5 mm.	53·5 mm.	25·0 mm.
Paratype (L. 71497)	66·0[1] ,,	53·0 ,,	31·0 ,,
Paratype (L. 71498)	66·0[1] ,,	57·5 ,,	28·5 ,,

Remarks.—The two specimens of this species in the G. S. I. collections are poorly preserved, so that the description has been based mainly on the seven specimens in the J. F. Blake collection, which all come from the same locality and bed, and enable one to form some idea of the variability of the species. Except for the radial threads which are present in some of the intercostal spaces of the right valve but have not been observed in the left valve, the two valves do not differ in ornamentation.

C. eminens does not closely resemble any species previously described.

Occurrences and Material.—Tithonian, Umia Group, west of Soorkha ["Moondan Group" of Blake, MS.]—the holotype and six paratypes (Brit. Mus. L.71496-502, colld. J. F. Blake); also one paratype localized as "valley west of Soorkha Hill" (G. S. I. No. K40/549, colld. A. B. Wynne).[2]

Order: DYSODONTA.

Super-family: *MYTILACEA.*

Family: *MYTILIDAE.*

The more typical representatives of this family are characterized by the obliquely elongated, sub-rhomboidal shape of the shell and by the very anteriorly placed umbones. This peculiar shape and the corresponding reduction or

[1] Estimated original measurement, where the specimen is broken.

[2] A second specimen in the G. S. I. material (No. K40/550), collected by F. Stoliczka, is said to come from Iddurghur, but is probably wrongly localized.

complete disappearance of the anterior adductor muscle have resulted from the mode of growth of the shell, freely suspended from other objects by a byssus protruding between the antero-ventral margins. The mantle lobes of the animal are united below the anal siphon, but are otherwise free. The surface of insertion of the ligament, which is usually considerably extended along the postero-dorsal margin, is essentially internal.

That shells of mytiliform shape may have arisen from unrelated stocks by convergence is shown by the living genus *Dreissena* [*Dreissensia*], which, although conchologically very similar to *Mytilus*, differs fundamentally in anatomical characters. It cannot be assumed, therefore, that all fossil shells which resemble *Mytilus* in shape are related to the Mytilidæ. In a recent paper [1937(4)] I have suggested that the detailed structure of the dorsal region of the shell, in particular the relation of the ligament to the margins, affords the most satisfactory criterion for the recognition of members of this family.

The earliest undoubted representative of the Mytilidæ known to us is *Modiolus*, which appears in the Devonian. According to F. Frech (1891, p. 184) the internal characters of specimens from this horizon leave no doubt as to the correctness of the generic determination. A species *Mytilus patriarchalis* Waagen (1887, p. 272, Pl. XX, figs. 12 *a-c*) has been described from the Permian of India, but its hinge-characters need careful study before its generic reference can be considered established. At least some of the Triassic species which have been referred to *Mytilus* appear to be survivors of the Palæozoic family Myalinidæ, and it is not until the Jurassic that undouted Mytilidæ with terminal umbones appear.

The ontogeny of the shell in this family has been investigated by R. T. Jackson (1890, pp. 363-4) and F. Bernard [1896(2), pp. 415-422; 1898, pp. 68-85]. Bernard's work, in particular, is of interest as explaining the development of the "dysodont" teeth which occur in certain genera. In *Modiolus* and all comparable genera these teeth begin to appear in the earliest post-nepionic stage, on either side of a transversely crenulated band which represents the hinge of the prodissoconch and nepionic shell. The ligament, however, originally small and internal, begins to extend rapidly in a posterior direction as the shell becomes increasingly inequilateral during growth, and, in the case of *Modiolus* and *Mytilus*, obliterates the teeth from that portion of the hinge-margin which it ultimately occupies. In *Brachidontes*, however, these teeth may remain visible above the ligament, while a few usually extend along the posterior end of the hinge-margin, beyond the ligament. Of the dysodont teeth of the anterior series, a small number, situated in the neighbourhood of the umbonal angle of the adult shell, become much intensified in some groups of *Mytilus* and *Brachidontes*. In *Modiolus*, on the other hand, these teeth undergo complete atrophy.

If, as one would imagine, these interesting facts of ontogeny are to be interpreted as a recapitulation of gradual changes in dentition during the phylogeny of the group, it is remarkable that *Modiolus*, and not some denticulate genus, is, so far as we know, the earliest representative of the family to make

its appearance. Further, as shown in the present Memoir, in the genera *Mytilus* and *Brachidontes* the denticulate groups of the Cainozoic are preceded, in the Jurassic, by edentulous forms.

Some authors (for example, F. Frech, 1891, table facing p. 206; E. O. Ulrich, 1897, p. 501) have considered that the Mytilidæ were derived from the Palæozoic family Myalinidæ, in which the umbones are terminal, as in *Mytilus*. In view of the external position of the ligament in that family and the fact that *Modiolus*, in which the umbones are not terminal, appears before *Mytilus*, it seems doubtful if this view is correct. Some Mesozoic forms which have hitherto been referred to *Mytilus* (for example, those which I now include in the genus *Lycettia*) may, however, be true descendants of the Myalinidæ.

Other authors have suggested that the Mytilidæ were derived from the Modiolopsidæ, in which the shell frequently approaches *Modiolus* in shape, but in which the anterior adductor is less reduced than in that genus. In that family the position of the ligament seems to have varied to some extent, but frequently (as in *Modiolopsis* and *Modiomorpha*) it appears to have been subexternal and situated along a thickened, grooved hinge-margin—an arrangement rather different from that of *Modiolus*.

If, however, the ontogeny of the shell in this family in any way recapitulates its phylogeny, an alternative suggestion may be made. F. Bernard (1898, p. 71) has shown that the small deep-sea genus *Dacrydium* of the present day is characterized by a hinge-structure almost identical with that of the nepionic stage of the larger and more familiar genera of the family. It is, therefore, possible that the Mytilidæ may have sprung from some inconspicuous Lower Palæozoic genus yet to be recognized, and of which *Dacrydium* is a but little modified descendant.

The classification of the Recent Mytilidæ has been considered in an interesting paper by A. J. Jukes-Browne (1905), which has been largely followed by J. Thiele in his recent Handbook (1934, pp. 797-801). A few of the Jurassic forms have already been discussed by me in a preliminary paper [1937(4)].

Genus: Modiolus J. B. de Lamarck, 1799.

"Prodrome d'une nouvelle classification des coquilles," *Mém. Soc. Hist. nat. Paris*, vol. I, p. 87.

Genotype.—Mytilus modiolus Linné (1758, p. 706), Recent, European seas.

Generic Characters.—Shell more or less trapeziform in outline, elongated either in a direction parallel to the hinge-margin or, more frequently, in a transverse direction, but with its obliquity (measured by the angle between the hinge-margin and a line joining the umbo to the most remote point of the postero-ventral margin) seldom exceeding 45°. Anterior margin usually projecting beyond the umbo; antero-ventral region usually expanded, with a pronounced bulge of its margin. A rounded, but more or less distinct, ridge usually crosses the shell diagonally from the umbo to the posterior end of the ventral margin.

Lysodont teeth are absent both from the hinge-margin and from the antero-dorsal margin. Ligament internal or sub-external, occupying from about two-thirds to three-quarters of the hinge-margin, and underlain by a usually rather conspicuous internal ridge which originates at the termination of the antero-dorsal margin. Anterior adductor well developed. Exterior of shell usually unornamented, but occasionally with oblique undulations on its dorsal region, or with weak radial riblets.

Remarks.—*Modiolus*, which first appears in the Devonian, and is represented by a number of Upper Palæozoic species, is widespread at all geological horizons from the early Mesozoic onwards. In addition to *Modiolus* s. str., certain relatively unimportant groups of Recent species (*Adipicola* Dautzenberg and *Amygdalum* Megerle von Mühlfeld) are usually considered as subgenera of *Modiolus*, but little is known of their geological history. The fossil species, notwithstanding their great number and the variation in form which they show, do not readily lend themselves to subgeneric classification, and few distinct groups have so far been recognized. One fairly well defined group, *Inoperna*, occurs, however, in the Jurassic and Cretaceous, and is discussed later in the present Memoir.[1] Most of the remaining fossil forms must still be retained in *Modiolus* s. str.

Subgenus : MODIOLUS s. str.

Subgeneric Characters.—Shell transversely elongated, well inflated, with the umbonal region frequently somewhat inflated and prominent, and the diagonal ridge usually well defined. Periostracum hirsute in the Recent species.

MODIOLUS PATCHAMENSIS sp. nov.

(Plate IV, fig 8.)

Description.—The shell is of medium size for the genus, strongly inflated, subtrigonal, narrow anteriorly and somewhat expanded postero-dorsally, with an obliquity of about 35°. The anterior margin projects slightly beyond the umbo. The hinge-margin is straight and elongate, occupying more than two-thirds of the total length ; it joins the strongly convex and only slightly oblique posterior margin in an even curve. The ventral margin is straight except for a slight anterior bulge, and meets the posterior margin in a rather sharp curve. A prominent, rounded, sigmoidally curved ridge, which rises slightly above the level of the hinge-margin, and coincides with the line of maximum inflation of the shell, passes from the umbo to the posterior end of the ventral margin, and divides the surface of the shell into two areas, of which the ventral is narrow and the dorsal wide. The antero-ventral region is well inflated and separated from the diagonal ridge by a shallow depression. The surface of the shell is smooth except for occasional inconspicuous concentric striæ.

Holotype.—G. S. I. type No. 16529.

Dimensions.—The measurements of the holotype are as follows :—

Length	49·0 mm.
Height	32·0 mm.
Inflation (single valve)	11·0 mm.

[1] See page 70.

Remarks.—In general outline this species closely resembles some specimens of *Modiola explanata* J. Morris (1857, p. 103, Pl. I, fig. 1) from the Inferior Oolite of Cheltenham, but that species attains a much larger size, while its diagonal ridge is less prominent and its antero-dorsal region less inflated. *M. patchamensis* shows some resemblance to a specimen from the Bajocian of Sinai figured by H. Douvillé (1916, p. 34, Pl. IV, fig. 10) as *Modiola solenoides* Morris and Lycett, but is less elongate.

Occurrences and Material.—Bathonian, Patcham Beds, of the following localities :—Kuari Bet (N. of Patcham)—the holotype and one paratype (G. S. I. No. K40/552, colld. A. B. Wynne); Dhorawar (Patcham)—two specimens (G. S. I. No. K40/553, colld. A. B. Wynne).

Modiolus imbricatus J. Sowerby.

(Plate V, figs. 1-7.)

Modiola imbricata J. Sowerby, 1818, Mineral Conchology of Great Britain, vol. III, p. 21, Pl. CCXII, figs. 1, 3.

Modiola imbricata F. A. Rœmer, 1836, Versteinerungen des norddeutschen Oolithen-Gebirges, p. 92, Pl. V, figs. 8*a-c*.

Mytilus compressus A. Goldfuss, 1837, Petrefacta Germaniæ, Pt. II, p. 178, Pl. CXXXI, fig. 11.

Mytilus imbricatus J. Morris and J. Lycett, 1853, "A Monograph of the Mollusca from the Great Oolite. Part II, Bivalves," *Pal. Soc. London*, p. 41, Pl. IV, fig. 2.

Mytilus compressus J. Morris and J. Lycett, 1853, *loc. cit.*, p. 40, Pl. IV, fig. 7.

Modiola imbricata G. C. Laube, 1867, "Bivalven des braunen Jura von Balin," *Denkschr. k. Akad. Wiss. Wien*, vol. XXVII, Pt. 2, p. 29, Pl. II, fig. 3.

Modiola imbricaria [sic] var., W. T. Blanford, 1870, Observations on the Geology and Zoology of Abyssinia, p. 201, Pl. VIII, fig. 2.

Modiola imbricata P. de Loriol, 1883, "Étude paléontologique des Couches à *Mytilus* des Alpes vaudoises," *Mém. Soc. pal. suisse*, vol. X, p. 60, Pl. IX, figs. 1-8.

Modiola angustissima R. B. Newton, 1895, "On a Collection of Fossils from Madagascar," *Quart. Journ. Geol. Soc.*, vol. LI, p. 83, Pl. III, fig. 4.

Modiola imbricata B. Semenov, 1896, "Faune des dépôts jurassiques de Mangychlak et de Touar Kyr," *Trav. Soc. Nat. St. Pétersb.* (*Sect. Géol. et Min.*), vol. XXIV, p. 58, Pl. I, fig. 13.

Modiola imbricata M. Clerc, 1904, "Fossiles du Dogger de quelques gisements classiques du Jura neuchâtelois et vaudois," *Mém. Soc. pal. suisse*, vol. XXXI, p. 56.

Mytilus (*Modiola*) *blanfordi* J. Weir, 1929, "Jurassic Fossils from Jubaland.... and the Jurassic Geology of Somaliland," *Mon. Geol. Dept. Hunterian Museum Glasgow Univ.*, No. 3, p. 30, Pl. II, figs. 15, 16 (*non* fig. 17).

Mytilus (*Modiolus*) *imbricatus* L. R. Cox, 1935, Mesozoic Palæontology of British Somaliland, p. 162 (with further synonymy), Pl. XVI, figs. 3-5.

Description of the Specimens from Kachh.—The specimens which I refer to this species vary to some extent in size and shape, and several have been crushed or otherwise distorted. The smaller specimens are rather narrowly trapeziform in outline, with sub-terminal umbones, an only moderately bulging antero-ventral region, and an obliquity of about 30°. Several larger but rather crushed specimens are wider and more reniform in shape, with a strongly bulging antero-ventral region which projects well to the anterior side of the umbones and is delimited above by a pronounced sulcus; their obliquity is approximately the same as that of the smaller specimens. In one fairly large specimen the shell is more trigonal in outline, with an obliquity of nearly 45°; in this specimen the antero-ventral region bulges only slightly, but the ventral margin has a strong median concavity. In these specimens the posterior margin varies from flattened-convex to moderately strongly convex, and meets the hinge-margin, which occupies from about one-half to three-quarters of the total length of the shell, in a rounded-off, obtuse angle, usually of about 135°. In most of the specimens a slightly curved, rounded ridge passes diagonally across the shell from the umbo towards the postero-ventral corner, but usually broadens out and fades away before reaching the latter. This ridge coincides with the line of maximum inflation of the shell, and divides the surface into two areas of which the antero-ventral is much the narrower in specimens of trapeziform or sub-trigonal outline, but nearly as wide as the postero-dorsal area in the more reniform specimens.

In uneroded specimens the surface of the shell is ornamented with fine concentric threads; the growth-lamellæ are pronounced, and imbricate at rather irregular intervals.

Dimensions.—The length and height of four specimens are given below. Owing to their more or less crushed condition, their original inflation, which appears to have been moderately strong, cannot be measured.

Locality.	*Length.*	*Height.*
Lodranee (G. S. I. No. K40/554)	25·0 mm.	15·0 mm.
Mooanna (G. S. I. No. K40/557)	55·0 mm.	38·0 mm.
do. (do.)	68·0 mm.	44·0 mm.
Khera (Brit. Mus. L. 71509)	59·0 mm.	45·0 mm.

Remarks.—The synonymy of this species has been discussed by me when describing specimens from British Somaliland, and I have shown that it may be considered to range from the Bathonian to the Argovian, or even higher. Its variability is well illustrated by the figures of specimens from the *Mytilus*-beds of the Alps of Vaud (Switzerland) published by P. de Loriol (1883). The smaller and uncrushed specimens from India appear to differ from the majority of specimens from the British Bathonian in the less pronounced bulge of the antero-ventral margin and in the consequently more pointed anterior end of the shell. In this character, however, they agree with occasional British specimens and with numerous specimens in the material from British Somaliland described by me previously, as well as with specimens from the Swiss *Mytilus*-beds.

The large, crushed, reniform specimens, which come from Mooanna Hill, compare very closely with the similarly crushed *Modiolus* described by A Goldfuss (*see* synonymy) under the name *Mytilus compressus*. Goldfuss records this species from the Coral Rag of Linden, near Hanover, and from the "Forest Marble" (Stonesfield Slate) of Stonesfield, near Oxford, but does not mention from which locality his figured specimen came. Crushed specimens which undoubtedly belong to the species *Modiolus imbricatus* occur commonly in the Stonesfield Slate, and many agree very well with Goldfuss's figure. Morris and Lycett treat *M. compressus* as a species distinct from *M. imbricatus*, differing in its more expanded antero-ventral region, but there appears to me to be complete intergradation between the two forms.

Another *Modiola compressa* was described by F. C. L. Koch and W. Dunker (1837, p. 44, Pl. V, figs. 5*a*, *b*) from the Upper Jurassic of the Weser hills, in northern Germany, and D. Brauns (1874, p. 302) places both this and Goldfuss's form in the synonymy of *Modiola æquiplicata* Strombeck. I have elsewhere [1935(1), p. 162] expressed the opinion that the Upper Jurassic species referred to by Brauns (although possibly not Strombeck's original *M. æquiplicata*) should be included in the synonymy of *Modiolus imbricatus*. Whatever the horizon of his figured specimen there seems, therefore, to be every justification for including Goldfuss's *Mytilus compressus* in the synonymy of *M. imbricatus*.

Modiolus maitlandi Etheridge (1910, p. 33, Pl. V, figs. 1, 2), from the Bajocian of Western Australia, is very closely comparable to *M. imbricatus*. Although stated to differ in its larger size, its dimensions are no greater than those of many specimens of *M. imbricatus* found in the English Cornbrash and of the larger specimens from India now recorded. It may, therefore, be eventually relegated to the synonymy of Sowerby's species.

Occurrences and Material.—Bathonian, Patcham Beds, of the following localities:—Flanks of Mooanna Hill (Bela)—several crushed specimens (G. S. I. No. K40/557, colld. F. Fedden)[1]; north of Lodranee (Bela)—a slab with several poorly preserved specimens (G. S. I. No. K40/555, colld. A. B. Wynne); cliff north of Lodranee (Bela) [from *Corbula lyrata* Beds]—four specimens (G. S. I. No. K40/554, colld. F. Stoliczka); north of Gudjeuva (Karrir) [from *Corbula lyrata* Beds]—two specimens (G. S. I. No. K40/556, colld. F. Stoliczka); Karrir [same horizon, "Kuari Bet Bed" of Blake, MS.]—one specimen (Brit. Mus. L. 71508, colld. J. F. Blake); Kuari Bet (north of Patcham)—five specimens (Brit. Mus. L. 71503-7, colld. J. F. Blake).

Upper Bathonian [*vel* Callovian], Lower Chari, *macrocephalus* Beds, of the following localities:—Khera Hill, near Chari ["Bed No. 12" of Blake, MS.[2]]—one specimen (Brit. Mus. L. 71509, colld. J. F. Blake); summit of "Moani" (? Mooanna hill, Bela) ["*Nucula* Flags" of Blake, MS.]—one specimen (Brit. Mus. L. 71510, colld. J. F. Blake).

[1] Reference is made to these specimens by A. B. Wynne, 1872, p. 116.

[2] Upper *macrocephalus* Beds—see L. F. Spath, 1924, p. 22, and 1933, p. 743.

Modiolus cf. bipartitus J. Sowerby.

Plate V, figs. 11, 12.

The following synonymy refers to the typical *M. bipartitus* :—

Modiola bipartita J. Sowerby, 1818, Mineral Conchology, vol. III, p. 17, Pl. CCX, fig. 4 (*non* fig. 3).

Modiola tulipœa J. B. de Lamarck, 1819, Histoire naturelle des animaux sans vertèbres, vol, VI, Pt. 1, p. 117.

Modiola bipartita J. Phillips, 1829, Geology of Yorkshire, p. 134, Pl. IV, fig. 30.

Modiola bipartita F. A. Rœmer, 1836, Versteinerungen des norddeutschen Oolithen-Gebirges, p. 92, Pl. XIV, fig. 14.

Mytilus bipartitus A. Goldfuss, 1837, Petrefacta Germaniæ, Pt. II, p. 176, Pl. CXXXI, fig. 3.

Mytilus villersensis A. Oppel, 1858, "Die Juraformation," *Württemb. naturw. Jahresh.*, Jahrg. XIII, p. 309 (p. 607 of reprint) (*nom. nud.*).

Modiola bipartita R. Damon, 1860, Geology of Weymouth, Suppl., Pl. II, fig. 12.

Modiola cuneata R. Damon, 1860, *loc. cit.*, Pl. II, fig. 13 (*non* J. Sowerby).

Modiola bipartita J. Phillips, 1871, Geology of Oxford, Pl. XIII, fig. 25.

Modiola bipartita D. Brauns, 1874, Der obere Jura im nordwestlichen Deutschland, p. 301.

Modiola bipartita H. A. Rœder, 1882, Beitrag zur Kenntniss des Terrain à Chailles und seiner Zweischaler, p. 62, Pl. IV, fig. 12.

Modiola tulipœa P. de Loriol, 1897, "Mollusques et Brachiopodes de l'Oxfordien supérieur et moyen du Jura bernois," *Mém. Soc. pal. suisse*, vol. XXIV, p. 118, Pl. XV, figs. 1, 2.

Modiola tulipœa P. de Loriol, 1901, *op. cit.* (Suppl.), *ibid.*, vol. XXVIII, p. 90.

Modiola villersensis J. Raspail, 1901, "Contribution à l'étude de la falaise jurassique de Villers-sur-Mer," *Feuille des jeunes Naturalistes*, Ann. XXXI, Pl. XII, fig. 10.

Modiola tulipœa P. de Loriol, 1902, "Mollusques et Brachiopodes de l'Oxfordien supérieur et moyen du Jura lédonien." *Mém Soc. pal. suisse*, vol. XXIX, p. 209.

Modiola tulipœa A. Borissiak, 1906, "Die Pelecypoden der Jura-Ablagerungen im europæischen Russland. III. Mytilidæ," *Mém. Com. géol.*, N. S., Livr. 29, p. 24, Pl. I, figs. 3-6.

Modiola tulipœa M. Cossmann, 1915, Description de quelques pélécypodes jurassiques recueillis en France (6me Article), *C. R. Assoc. franc. Avancem. Sci.* (Mém. hors volume), p. 10, Pl. V, fig. 10.

Modiola bipartita J. A. Douglas and W. J. Arkell, 1928, "The Stratigraphical Distribution of the Cornbrash. I. The South-Western Area," *Quart. Journ. Geol. Soc.*, vol. LXXXIV, p. 174, Pl. XII, figs. 8, 9.

Modiola bipartita W. J. Arkell, 1929, A Monograph of British Corallian Lamellibranchia (*Pal. Soc. London*), p. 55, Pl. II, figs. 1-4, and text-fig. 8.

Modiola tulipea V. Diaz-Romero, 1931, "Contributo allo studio della fauna guirese della Dancalia centrale," *Pal. Ital.*, vol. XXXI, p. 32, Pl. II, figs. 14, 15.

Description.—The shell is moderately large for the genus, well inflated, trapezoidal in outline, and of moderate width; its obliquity is about 25°. The umbo is almost terminal. The hinge-margin, which is very feebly convex, occupies about one-half of the total length of the shell, and meets the slightly concave, oblique posterior margin in a rounded-off angle of about 150°. The ventral margin, which bulges strongly at its anterior end, is sub-parallel to the posterior margin, which it joins in a wide, slightly asymmetrical, and somewhat flattened curve, the dorsal half of which is the more projecting. A rounded ridge which coincides with the line of maximum inflation of the shell, curves round from the umbo to the posterior end of the ventral margin (a point considerably anterior to the posterior end of the shell), and divides the surface into two areas, the dorsal of which is much larger than the ventral. The antero-ventral region is moderately well inflated and is separated from the diagonal ridge by a shallow depression of the surface.

In the most complete specimen the surface of the shell is smooth except for a few irregular accentuations of the growth-stages, but in another specimen, which is broken, there is a series of irregular plications parallel to the growth-lines.

Dimensions.—The measurements of the best preserved specimen, on which the above description has been mainly based, are as follows:—

Length	77·8 mm.
Height	47·5 mm.
Inflation (single valve)	16·5 mm.

Remarks.—The most complete of the three specimens now recorded agrees very well with *M. bipartitus* in the general outline of the shell. English specimens of the species, however, are characterized by the very even inflation of the body of the shell, which is separated from the well inflated antero-ventral lobe by a well-marked sulcus. Thus the line of maximum inflation does not coincide with the rounded ridge which passes from the umbo towards the posterior end of the ventral margin, but occupies a much more dorsal position, passing mid-way along the body of the shell to meet the posterior margin at a point which coincides approximately with the posterior extremity of the shell. In the most complete of the Indian specimens now recorded, on the other hand, the line of maximum inflation of the shell coincides with the diagonal ridge. The specimen, however, is slightly crushed, and it is possible that the difference may be due to this cause.

The lectotype of *M. bipartitus*[1] came from the Oxford Clay, but Dr. W. J. Arkell records that specimens undoubtedly referable to the same species occur in both the lower and upper Cornbrash. Hence the Indian specimens do not occur at a lower horizon than any of the known occurrences of the species in Europe.

Largely owing to Sowerby's ambiguity as to the provenance of his figured specimen (some authors have understood him to say that it came from the Lias),

[1] Sowerby figured two specimens as *Modiola bipartita*. His fig. 4, which I take as lectotype of the species, came from the Oxford Clay of Osmington, near Weymouth, and his fig. 3 from the Lower Greensand. Dr. W. J. Arkell (1929, p. 56) thinks that the inclusion of fig. 3 was due to a misprint, but the specimen is referred to in Sowerby's text.

de Loriol and others have preferred to use Lamarck's name *Modiola tulipæa* for the Oxford Clay species. As Dr. Arkell has shown, the Lamarckian species is indistinguishable from *M. bipartitus*, which was described the year previously.

Occurrences and Material.—Upper Bathonian [*vel* Callovian], Lower Chari, *macrocephalus* Beds, of the following localities:—Khera Hill, near Chari ["Bed No. 13" of Blake, MS.[1]]—one specimen (Brit. Mus. L. 71511, colld. J. F. Blake); same locality (bed unrecorded)—one broken specimen (G. S. I. No. K40/558, colld. A. B. Wynne); Gaduada (Karrir) ["*Nucula* Flags, upper bed" of Blake, MS.[2]]—one rather doubtful specimen (Brit. Mus. L. 71512, colld. J. F. Blake).

Modiolus glendayi (Weir).

Plate V, figs. 8-10.

Mytilus (*Pharomytilus*) *glendayi* J. Weir, 1929, "Jurassic Fossils from Jubaland .... and the Jurassic Geology of Somaliland," *Mon. Geol. Dept. Hunterian Mus. Glasgow Univ.*, No. 3, p. 29, Pl. II, fig. 14.

Description.—The shell is of medium size for the genus, strongly inflated, reniform, of moderate width, with an obliquity of about 30° or rather less. The umbones are terminal or sub-terminal, and pronouncedly prosogyrous. The hinge-margin is short, occupying slightly less than one-half of the total length of the shell; it meets the feebly convex, oblique posterior margin in a rounded-off angle. The antero-ventral margin is strongly bulging; at its posterior end the ventral margin is sub-parallel to the posterior margin, which it joins in a rather wide curve. The line of maximum inflation of the shell, which is not represented by a definite ridge, passes diagonally across the surface to about the middle of the postero-ventral margin. The antero-ventral lobe is strongly inflated and is separated from the rest of the shell by a well-defined sulcus, limited above by an ill-defined ridge which curves round from the umbo to a point near the posterior end of the ventral margin. The whole surface of the shell dorsal to the sulcus is ornamented with strong and fairly regularly spaced oblique corrugations which are parallel to the growth-stages; the antero-ventral lobe is smooth except for growth-rugæ.

Dimensions.—The measurements of a typical specimen (fig. 8) are as follows:—

Length	38·0 mm.
Height	27·5 mm.
Inflation	18·2 mm.

Remarks.—The specimens now described agree so closely with Weir's figured type of *M. glendayi* that there could be no doubt as to their specific identity. The holotype was collected by V. G. Glenday at Dakatch (Jubaland), where it was found associated with a number of other shells, mainly lamellibranchs and brachiopods. The whole assemblage was considered by Weir to be probably of Corallian age, but the evidence appears inconclusive and the horizon could well be lower. *M. glendayi* is also represented in the British Museum collection

[1] See L. F. Spath, 1924, p. 22, and 1933, p. 743.
[2] See L. F. Spath, 1933, p. 738.

by a single specimen (L. 63724) from an unknown horizon of the Jurassic at Bihendula, in British Somaliland. The Indian specimens come partly from the Upper Bathonian-Callovian and partly from the Divesian, but the specimens from the different horizons appear to agree in every detail.

On account of its concentrically corrugated surface *M. glendayi* was referred by Weir to the subgenus *Pharomytilus* Rollier, which is shown below to be synonymous with *Inoperna* Conrad, but I consider this subgenus to be best restricted to the group of elongate ensiform species of which *Modiolus plicatus* J. Sowerby is the best known Jurassic representative. I therefore include *M. glendayi* in *Modiolus* s. str.

In shape *M. glendayi* bears much resemblance to the European Bathonian species *M. lonsdalei* Morris and Lycett (1853, p. 40, Pl. IV, fig. 3; A. O. Schlippe, 1888, p. 142, Pl. II, fig. 12). A slight corrugation of the dorsal half of the surface of the shell which is observable in some specimens of that species is never, however, so regular or so pronounced as in the form from Africa and India. J. A. Douglas and W. J. Arkell (1928, p. 175) regard *M. lonsdalei* as a synonym of *M. bipartitus* J. Sowerby.

Occurrences and Material.—Upper Bathonian [*vel* Callovian], Lower Chari, *macrocephalus* Beds, of the following localities:—Jumara—one specimen (G. S. I. No. K40/563, colld. A. B. Wynne); same locality ["Bed No. 12" of Blake, MS. [1]]—one specimen (Brit. Mus. L. 71515, colld. J. F. Blake); N. W. of Jumara ["*Scyphia* Limestone" of Stoliczka, MS., apparently the same matrix as Blake's "Bed 12"]—three specimens (G. S. I. No. K40/559, colld. F. Stoliczka); Khera Hill, near Chari—one specimen (G. S. I. No. K40/561, colld. A. B. Wynne); same locality ["below Oxfordian" according to Blake, MS.[2]]—one specimen (Brit. Mus. L. 71516, colld. J. F. Blake); Habo ["*Nucula* Flags" of Blake, MS.[3]]—one specimen (Brit. Mus. L. 71517, colld. J. F. Blake).

Callovian, Middle Chari, *rehmanni* or *anceps* Beds, of the following localities:—Khera Hill ["Brown Oolite" of Stoliczka, MS.]—one specimen (G. S. I. No. K40/560, colld. F. Stoliczka); N. W. of Jumara ["Brown Oolite" of Stoliczka, MS.]—two specimens (G. S. I. No. K40/602, colld. F. Stoliczka).

Divesian, *athleta* Beds, of Fakirwadi—two specimens (G. S. I. No. K40/564, colld. J. H. Smith).

Divesian, lower Dhosa Oolite, of Fakirwadi-Samatra range—one specimen (G. S. I. No. K22/293, colld. J. H. Smith).

Horizon uncertain, perhaps Dhosa Oolite, valley north of Dhosa—one specimen (G. S. I. No. K40/562, colld. A. B. Wynne).

Subgenus: Inoperna T. A. Conrad, 1875.

"Descriptions of New Genera and Species of Fossil Shells of North Carolina," Appendix A to W. C. Kerr, Report of the Geological Survey of North Carolina, p. 5.

[1] See L. F. Spath, 1924, p. 22, and 1933, p. 749.
[2] See L. F. Spath, 1924, p. 22.
[3] See L. F. Spath, 1933, p. 745.

Type[1].—*I. carolinensis* Conrad (*loc. cit.*, p. 5, Pl. I, fig. 22), Cretaceous, North America.

Synonym.—*Pharomytilus* L. Rollier (1914, p. 338), type, *Modiola plicata* J. Sowerby (see below).

Subgeneric Characters.—Shell ensiform, narrow and elongated, slightly curved, with the ventral margin almost parallel to the hinge-margin ; anterior margin projecting slightly beyond the umbones. A diagonal ridge divides the surface into two areas, the dorsal of which bears strong oblique corrugations parallel to the growth-stages on its dorsal region, splitting up into much finer riblets about half-way between the margin and the diagonal ridge. The area ventral to this ridge is smooth except for growth-lines.

Remarks.—Most authors have overlooked the fact that this group of species was separated generically by Conrad so early as 1875, and it is only recently that his name *Inoperna* has been revived by two American authors, B. Wade (1926, p. 53, Pl. XIII, fig. 10) and W. P. Popenoe (1937, p. 382, Pl. XLV, figs. 6, 7), the former of whom figures specimens referred to the genotype, while the latter describes a new Cretaceous species, ***I. bellarugosa.***

Inoperna is a group well characterized by the ensiform shape of the shell and by the peculiar ornamentation of the dorsal part of the surface ; it is represented by several species which are widely distributed in Jurassic and Cretaceous rocks. It was probably derived from the smooth-shelled, ensiform group of *Modiolus* of which the well-known Liassic species *M. scalprum* J. Sowerby (1821, vol. III, p. 186, Pl. CCXLVIII, fig. 2) is a typical example.

Conrad considered this group to be closely related to *Inoceramus*, and Wade regards it as a "generic group different from *Modiola.*" There can be no doubt, however, that the species of this group have all the essential characters of the genus *Modiolus*, of which I therefore regard *Inoperna* merely as a subgenus.

Modiolus (Inoperna) plicatus J. Sowerby.

Plate V, figs. 13, 14.

Modiola plicata J. Sowerby, 1819, Mineral Conchology of Great Britain, vol. III, p. 87, Pl. CCXLVIII, fig. 1.

Modiola plicata K. von Zieten, 1833, Die Versteinerungen Württembergs, p. 79, Pl. LIX, fig. 7.

Mytilus plicatus A. Goldfuss, 1837, Petrefacta Germaniæ, Pt. II, p. 175 (*partim*), Pl. CXXX, fig. 12*a* (*non* fig. 12*b*).

Mytilus sowerbianus A. d'Orbigny, 1850, Prodrome, vol. I, p. 282.

Mytilus sowerbyanus J. Morris and J. Lycett, 1853, "A Monograph of the Mollusca from the Great Oolite. Part II, Bivalves," *Pal. Soc. London*, p. 36 ; Pl. IV, fig. 1.

Modiola plicata F. A. Quenstedt, 1856, Der Jura, p. 357, Pl. XLIX, fig. 4.

Modiola sowerbyana G. C. Laube, 1867, "Bivalven des braunen Jura von Balin," *Denkschr. k. Akad. Wiss. Wien*, vol. XXVII, Pt. 2, p. 28.

[1] Selected from the four genosyntypes, *I. carolinensis*, *Modiola plicata* J. Sowerby, *Modiola flagellifera* Forbes, and *Inoceramus siliqua* Matheron, by W. P. Popenoe (1937, p. 382).

Modiola sowerbyana P. de Loriol, 1883, "Etude paléontologique des Couches à *Mytilus* des Alpes vaudoises," *Mém. Soc. pal. suisse*, vol. X, p. 62, Pl. IX, figs. 9-12.

Modiola sowerbyana E. Greppin, 1899, "Fossiles du Bajocien supérieur des environs de Bâle," *Mém. Soc. pal. suisse*, vol. XXVI, p. 106, Pl. IX, fig. 9.

Modiola sowerbyana L. Richardson, 1904, Handbook to the Geology of Cheltenham, p. 240, Pl. XVIII, fig. 6.

Modiola plicata E. W. Benecke, 1905, "Versteinerungen der Eisenerzformation von Deutsch-Lothringen und Luxemburg," *Abh. geol. Spezialk. Elsass-Lothringen*, N. S., Pt. VI, p. 168, Pl. IX, fig. 6.

Modiola plicata E. Dacqué, 1910, "Dogger und Malm aus Ostafrika," *Beitr. Pal. u. Geol. Österr.-Ungarns*, vol. XXIII, p. 30, Pl. V, fig. 10.

Modiola plicata K. Staesche, 1932, "Uber einige Trias- und Jura-Fossilien aus Nordkaschmir," Wissensch. Ergebn. der Dr. Trinklerschen Zentralasien-Exped., vol. II, p. 148, Pl. XXII, fig. 36.

Modiolus (*Pharomytilus*) *plicatus* L. R. Cox, 1936, "Fossil Mollusca from Southern Persia (Iran) and Bahrein Island," *Pal. Ind.*, N. S., vol. XXII, Mem. No. 2, p. 13, Pl. I, fig. 21.

Description of the Specimens from Kachh.—The specimens now recorded are incomplete and eroded, but may be seen to be characterized by their narrow, elongate, parallel-sided and slightly curved outline; the diagonal ridge is rather obscure in the two smaller specimens, but is well marked in the largest, a fragment consisting of the posterior end of the shell. The region adjacent to the dorsal margin is ornamented with coarse oblique folds which fade away about half-way between the margin and the diagonal ridge, and are replaced by numerous inconspicuous and irregularly spaced growth-ridges; the area ventral to the diagonal ridge is ornamented only with growth-lines.

Dimensions.—The two most complete specimens are broken shells originally about 70 mm. in length and 15 mm. in width. A third specimen is a fragment of a larger shell, 23 mm. in width; its original length cannot be estimated accurately.

Remarks.—The specimens now recorded have the characteristic shape and ornamentation of *Modiolus plicatus*, which in England ranges from the uppermost Lias to the Cornbrash. The Corallian-Kimmeridgian species *M. perplicatus* (Étallon) is stated by P. de Loriol (1872, p. 349) to differ from *M. plicatus* in the fact that the coarse folds of the dorsal region of the shell bifurcate half-way between the margin and the diagonal ridge, instead of being replaced by numerous small ridges, as in the typical *M. plicatus*. A specimen from the Bajocian of Iran described by me recently [1936(2), p. 13, Pl. I, fig. 21] has proved, however, to have the type of ribbing characteristic of *M. perplicatus*, notwithstanding its low stratigraphical horizon. I have, consequently, cast doubt on the validity of the distinction drawn between these two forms. In a specimen of probably Divesian age now recorded the ribbing is of the type characteristic of *M. plicatus*.

Occurrences and Material.—Upper Bathonian [*vel* Callovian], Lower Chari, *macrocephalus* Beds, of the following localities:—N. W. of Jumara ["*Scyphia*

Limestone" of Stoliczka, MS.]—one specimen (G. S. I. No. K40/565, colld. F. Stoliczka); Gaduada (Karrir) ["Upper bed, *Nucula* Flags" of Blake, MS.] —one specimen (Brit. Mus. L. 71518, colld. J. F. Blake).

Divesian, *athleta* Beds, east of Ler ["Bed No. 8" of Blake, MS.[1]]—one specimen (Brit. Mus. L. 71519, colld. J. F. Blake).

Genus: LITHOPHAGA P. F. Röding (*ex* J. F. Bolten, MS.), 1798.

Museum Boltenianum, Pt. 2, p. 156.

Genotype.—*Mytilus lithophagus* Linné (1758, p. 705), Recent, seas of Europe.

Generic Characters.—Shell sub-cylindrical, strongly inflated, elongate, not very oblique; umbones obtusely rounded, placed near or at the anterior end. Anterior end evenly rounded and inflated, posterior end rounded or tapering. Valve margins closed, without a byssal gape. Dysodont teeth absent. Ligament elongate, narrow, sub-external, supported, as in *Modiolus* and *Mytilus*, by an internal ridge which continues the antero-dorsal margin. Anterior adductor rather ventrally placed, nearly as large as the posterior one. Surface either smooth, or with fine transverse striations, or with coarse transverse ridges confined to the posterior end, or with radial ribs at the posterior end; or, in some species, partly coated with a calcareous incrustation. Habitat rock-boring.

Remarks.—*Lithophaga* is undoubtedly an offshoot from *Modiolus* adapted to a boring habitat, particularly in coral rock. Several Carboniferous species resemble this genus in shape, but there is no evidence that these were rock-boring forms. F. Frech (1891, p. 217) states that he has observed *Lithophaga* borings in the Upper Trias. Undoubted representatives of *Lithophaga* occur commonly in the Jurassic, especially in coral formations. Frequently only the club-shaped natural casts of its borings are now preserved, the enclosing coral rock having disappeared by solution; sometimes, however, these casts enclose the actual shell of the mollusc. An impression of the coral structure of the wall of the cavity may be preserved on their surface.

LITHOPHAGA sp. indet. A.

Plate V, fig. 23.

Description.—The specimen consists of a fragment of a hard limestone nodule riddled with numerous small, sub-cylindrical *Lithophaga* borings, some of which are infilled with fine-grained yellowish sandstone. The largest cavity attains a diameter of 7·8 mm. No traces of the actual shell of the mollusc are preserved.

Occurrence and Material.—Upper Bathonian [*vel* Callovian], Lower Chari, *macrocephalus* Beds, Habo ["*Nucula* Flags" of Blake, MS.[2]]—one specimen (Brit. Mus. L. 71520, colld. J. F. Blake).

[1] See L. F. Spath, 1924, p. 24.
[2] See L. F. Spath, 1933, p. 745.

LITHOPHAGA sp. indet. B.

Plate V, fig. 21.

Description.—The specimens now recorded are the club-shaped natural casts of *Lithophaga* borings, preserved in a hard yellow limestone. The larger of the two attains a length of 20 mm. and a diameter of 12 mm. They are stout in proportion to their length, bluntly rounded at their extremity, and strongly convex-sided. Their stouter and less cylindrical shape distinguishes them from *Lithophaga* sp. indet. A, recorded above.

Occurrence and Material.—Callovian, Middle Chari, *anceps* Beds, Khera Hill, near Chari ["Bed No. 3" of Blake, MS.[1]]—two specimens (Brit. Mus. L. 71521-2, colld. J. F. Blake).

LITHOPHAGA sp. indet. C.

Plate V, fig. 22.

Description.—Like those described above, the specimen now recorded is the club-shaped natural cast of the boring of a *Lithophaga* shell; it is preserved in a yellowish oolitic limestone. The specimen is 35 mm. in length, its maximum diameter being 17 mm. and the diameter at its narrower end 8 mm. Its extremity is evenly rounded and not at all pointed; its sides are flattened, so that it tapers regularly towards its narrower end. This latter feature distinguishes it from the borings recorded above as *Lithophaga* spp. indet. A. and B.

Remarks.—Comparable natural casts, from the Tithonian of Stramberg (Moravia), have been figured by G. Boehm (1883, Pl. LXVI of Atlas, figs. 10, 11). Of these, the one (fig. 10) referred to *L. avellana* (d'Orbigny) is more pointed at its extremity, while the one (fig. 11) not named specifically is more globose.

Occurrence and Material.—Tithonian, Umia Group, N. of Moondan ["Small bed" of Blake MS.[2]]—one specimen (Brit. Mus. L. 71523, colld. J. F. Blake).

Genus: MYTILUS Linné, 1758.

Systema Naturæ, edit. 10, p. 704.

Genotype.—Mytilus edulis Linné (1758, p. 705), Recent, European seas.

Generic Characters.—Shell trapezoidal or trapeziform, transversely elongated, with its obliquity (measured by the angle between the hinge-margin and a line joining the umbo to the most remote point on the postero-ventral margin) usually exceeding 45°. Umbo terminal or sub-terminal; umbonal region not inflated or prominent. Antero-ventral margin seldom with a pronounced bulge. In the Cainozoic forms a small number of dysodont teeth, sometimes borne by a septum-like infilling of the umbonal angle, are present below the umbo, and are represented by grooves on the exterior of the shell, radiating from below the umbo to the anterior margin. In the earlier forms, however, the teeth and external grooves are absent. Dysodont teeth are absent from the postero-

[1] See L. F. Spath, 1924, p. 21, and 1933, p. 743.
[2] See L. F. Spath, 1933, p. 757.

dorsal margin. Ligament sub-external, usually narrower and more extended than in *Modiolus*, occupying more than three-quarters, and sometimes nearly the whole, of the total length of the hinge-margin; it is usually attached to a cavernous, shelly platform which is borne by the internal ridge which originates at the end of the antero-dorsal margin; this ridge itself is usually less conspicuous than in *Modiolus*. Anterior adductor small or absent. Exterior without radial ornamentation.

Remarks.—Both conchological and anatomical characters clearly show that *Mytilus* and *Modiolus* are very closely related, and from our knowledge of their geological history it would appear that the former was descended from the latter.

Most species of *Mytilus* are clearly distinguishable from *Modiolus* by the terminal position of the umbones and by their more transversely elongated shells, but, if only external characters are considered, a number of forms seem to lie on the border-line between the two groups. Hence *Modiolus* has frequently been considered by palæontologists to be a subgenus of *Mytilus*. In the Recent forms the most reliable basis of distinction lies in the sub-umbonal denticles, which are well developed in *Mytilus* and absent in *Modiolus*. They are absent, for example, in the species *M. barbatus* (Linné) and *M. auriculatus* (Krauss), and, although these forms approach *Mytilus* in shape, they are clearly referable to *Modiolus*. On the other hand, denticles are present in certain other border-line species, such as *M. falcatus* d'Orbigny and *M. strigatus* Hanley, and these species are referable to *Mytilus*.

W. H. Dall (1898, p. 791) points out that the Recent species of *Modiolus* are characterized by a tendency to hirsuteness of the epidermis and by the "habit of nestling in a mass of byssal fibres with extraneous entangled [illegible]". The criterion of hirsuteness would necessitate the reference to *Modiolus* of the most "mytiliform" Recent species, *Mytilus horridus* Dunker, in which the umbones are absolutely terminal. It is of interest, therefore, to note that this conclusion is supported by the absence of subumbonal denticles in the species.

When, however, we consider the earlier fossil species, the problem of discriminating between the two genera becomes more difficult. It seems preferable to include such border-line species as *Mytilus jurensis* Rœmer, whose variations have been discussed by me in a recent paper [1935(1), p. 161, Pl. XV, figs. 15-17] in *Modiolus* rather than in *Mytilus*. On the other hand, it seems undesirable to break with convention to the extent of transferring [illegible] other Jurassic species, characterized by quite terminal umbones and a regular [illegible] antero-ventral margin, from *Mytilus* to *Modiolus*, although it is known that these forms are edentulous.

The Recent species of *Mytilus* are clearly divisible, according to the character of their sub-umbonal teeth and the presence or absence of an anterior adductor muscle, into two subgenera, *Mytilus* s. str. (type, *M. edulis* Linné) and *Chloromya* Mörch [type, *M. perna* (Linné)][1]; in addition, the radially ribbed group

[1] A strict application of the Rules of Nomenclature would apparently result in the replacement of the name *Chloromya* by *Perna* Retzius (1788, p. 20), the type of which, by tautonymy, is *Mya perna* Linné, re-named *Perna magellanica* by Retzius

Aulacomya Mörch (type, *M.* "*magellanicus* Chemnitz") has frequently been included in the genus, but I consider it preferable to treat it as a subgenus of *Brachidontes*.

The geological history of these groups is at present incompletely known. Several Lower Tertiary species which I have examined (for example, *Mytilus affinis* J. de C. Sowerby, from the Oligocene of England, and *M. acutangulus* Deshayes, from the Eocene of the Paris Basin) seem to be referable to *Chloromya*.

The toothless Jurassic species which it has been decided to retain in *Mytilus* clearly cannot be referred to any of these Recent groups, and have recently been distinguished by me under the subgeneric name *Falcimytilus*. This group may, of course, be an offshoot from *Modiolus* not directly ancestral to the toothed groups of *Mytilus*, but this is a question upon which no definite conclusion can yet be reached. With the exception of the species transferred to the genus *Lycettia* and considered to be possible descendants of the Myalinidæ I know of no Jurassic species described under *Mytilus* in which the presence of teeth has been observed.

Subgenus: FALCIMYTILUS L. R. Cox, 1937.

"Notes on Jurassic Lamellibranchia. V. On a new Subgenus of *Mytilus* and a new *Mytilus*-like Genus," *Proc. Malac. Soc. London*, vol. XXII, p. 343.

Type.—*Mytilus suprajurensis* Cox (1925, p. 142, Pl. I, fig. 9, and Pl. III, fig. 2[1]), Kimmeridgian and Portlandian, England.

Subgeneric Characters.—Shell smooth, sickle-shaped, with pointed, terminal umbones, and a more or less pronounced carina which curves round from the umbo to the postero-ventral corner. Expansion of antero-ventral region very slight. Sub-umbonal teeth and external grooves absent. Ligament occupying about four-fifths of the hinge-line, and supported, as in *Mytilus* s. str., by an internal ridge which underlies the margin. Anterior adductor scar small, situated on the shell-wall in the umbonal angle.

Remarks.—In addition to the type-species, this subgenus includes *Mytilus sublævis* J. de C. Sowerby (1823, vol. V, p. 56, Pl. CCCCXXXIX, fig. 3; also J. Morris and J. Lycett, 1853, p. 41, Pl. IV, fig. 19), from the Bathonian of England. It also most probably includes *Mytilus falcatus* Goldfuss (1837, p. 169, Pl. CXXVIII, figs. 8*a*, *b*), from the Jurassic of Bavaria, and several forms, *M. mirabilis* (Lepsius), *M. bittneri* Tausch, *M. transalpinus* Tausch, and *M. lepsii* Tausch,[2] possibly synonymous with one another, from the Liassic limestones of northern Italy; and also the species from the Lias of Timor described by L. Krumbeck (1923, p. 82, Pl. CLXXIV, figs. 1-13) under the name *Mytilus mirabilis* (Lepsius) var. *timorensis*.

The pointed, terminal umbones and scarcely expanded antero-ventral region clearly distinguish these species from *Modiolus* and indicate their reference to *Mytilus*, according to the criteria by which fossil species of the two genera are usually distinguished. Nevertheless, while Recent representatives of *Mytilus*

[1] See also L. R. Cox, 1929, p. 168, Pl. IV, fig. 1, and 1937 (4), p. 344, Pl. XVII, figs. 1-3.

[2] See L. Tausch, 1890, pp. 15, 16, Pls. VII, VIII.

are distinguishable from *Modiolus* by the presence of sub-umbonal teeth, such teeth are absent in the group now discussed.[1] It appears, therefore, that these Jurassic forms should be distinguished subgenerically from *Mytilus* s. str. and *Chloromya* Mörch, to which groups nearly all the smooth-shelled Recent forms belong. The pronounced carina and the falciform shape of the shell also distinguish *Falcimytilus* from all Recent forms with the exception of the two or three which are referable to *Sinomytilus* Thiele (1934, p. 801), founded on the species *Dreissensia crosseana* Morlet (1884, p. 402, Pl. XIII, fig. 3). In this latter group, the transference of which to the Mytilidæ is unexplained by Thiele, there is an umbonal septum similar to that present in *Dreissena* [*Dreissensia*].

L. Rollier (1914, p. 356) has erected a sub-genus *Pernomytilus* in which he includes certain "*Perna*"-like species which appear to be without serial ligamental pits, and are therefore assumed by him to belong to *Mytilus*. This is an unsatisfactory subgenus, as we have no knowledge of the internal characters of its type-species, *Mytilus pernoides* Rœmer (1836, p. 89, Pl. V, figs. 2*a*, *b*). Some of the species which Rollier refers to it probably belong to *Inoceramus*.[2] Whatever its affinities, it is improbable that *M. pernoides* belongs to *Falcimytilus*, as it lacks the carina which is so characteristic of that subgenus.

Mytilus (Falcimytilus ?) tramauensis sp. nov.

Pl. V, fig. 18.

Description.—The shell is of medium size for the genus, well inflated, and rather narrowly falciform, widening very gradually towards its postero-ventral extremity; its obliquity is about 45°. The umbo is terminal and sharply pointed. The hinge-margin is short, occupying less than one-half of the total length of the shell, and slightly convex, meeting the rather strongly convex postero-dorsal margin in an even curve. The ventral margin, which is evenly concave except for an ill-defined anterior bulge, meets the posterior margin in a rounded-off angle of about 90°. The antero-ventral profile coincides with a sharp carina which passes in a gentle curve from the umbo to the angle in question, and marks the most inflated region of the shell. On the ventral side of this carina the surface is flattened and falls away nearly perpendicularly to the margin. On the dorsal side of the carina the surface is evenly convex and slopes gradually to the margins.

Holotype.—Brit. Mus. L. 71524.

Dimensions.—The measurements of the holotype are as follows:—

Length (parallel to hinge-margin)	32·0 mm.
Height (perpendicular to hinge-margin)	28·0 mm.
Inflation	13·2 mm.

[1] See L. R. Cox, 1937 (4), Pl. XVII, fig. 3, for an illustration of the interior of the umbonal region of *Mytilus suprajurensis* Cox, showing the complete absence of teeth. Their absence has also been observed in specimens of *Mytilus sublævis* J. de C. Sowerby.

[2] One of the species which Rollier refers to *Pernomytilus* is *Mytulites gryphoides* Schlotheim, a specimen of which is figured under the name *Inoceramus gryphoides* by Goldfuss (1836, p. 109, Pl. CXV, figs. 2*a-c*). Rollier overlooks the fact that serial ligamental pits are clearly depicted in Goldfuss's fig. 2*c*, which shows the hinge-line of the shell.

Remarks.—The holotype, unfortunately the only available specimen of this species, is an internal cast, but is complete enough for description.

The presence of a slight antero-ventral bulge justifies the provisional reference of this species to *Falcimytilus* rather than to *Lycettia*, described below, although its carina is almost as sharp as in that genus. In shape it is comparable to narrow specimens of the English Upper Jurassic species *Mytilus* (*Falcimytilus*) *suprajurensis* Cox, such as occur in the Kimmeridge Clay of Devizes [L. R. Cox, 1937(4), Pl. XVII, fig. 1] and in the Lower Portland Beds. In that species, however, the diagonal carina is more strongly curved.

Occurrence and Material.—Argovian, Tramau River [" Zone 1 " of Blake, MS.[1]]—the holotype only (colld. J. F. Blake).

Genus : BRACHIDONTES W. Swainson, 1840.

A Treatise on Malacology, p. 384.

Genotype.—*Modiola sulcata* Lamarck (1819, p. 113) [=*Arca modiolus* Linné (1767, p. 1141)[2]], Recent, West Indies.

Generic Characters.—Shell mytiliform or modioliform, but always more or less oblique, with terminal or sub-terminal umbones; expansion of antero-ventral region and prominence of diagonal carina variable. Surface ornamented with occasionally divaricating riblets. In the Recent forms dysodont teeth are present in the umbonal angle and also, frequently, along either the whole length or only the posterior end of the hinge-margin; in the earlier fossil forms such teeth are absent. Ligament of variable length, internal to sub-external, supported, as in *Modiolus* and *Mytilus*, by an internal ridge which approximately continues the antero-dorsal margin. Anterior adductor present or absent.

Remarks.—The genotype of *Brachidontes* is an oblique, modioliform species with a well-marked, rounded diagonal ridge and a well expanded antero-ventral region; its umbones are sub-terminal. Its ligament is comparatively short, occupying only about two-thirds of the hinge-margin, and is almost completely internal. In these characters the species agrees more closely with *Modiolus* than with *Mytilus*. Short but very prominent teeth, however, are present in the umbonal angle, where they are borne by a narrow expansion of the marginal region. Small teeth are also present along the hinge-margin, both above and beyond the ligament. The surface of the shell bears rather depressed, divaricating radial riblets which are weak but very numerous on the antero-ventral region.

The presence of sub-umbonal teeth justifies the generic separation of this species from *Modiolus*, while its radial ribbing distinguishes it from *Mytilus*. A. J. Jukes-Browne (1905, p. 222) regards the presence of posterior dysodont teeth as an important generic character, but these are not developed in all the groups of species which I include in *Brachidontes*.

[1] See L. F. Spath, 1924, p. 25, and 1933, p. 756.

[2] Not to be rejected as a homonym of *Mytilus modiolus* Linné (1758), genotype of *Modiolus*, if *Brachidontes* and *Modiolus* are separated generically. S. Hanley (1855, p. 92) records the identity of *Arca modiolus* with *Modiola sulcata*, which is a homonym of the Eocene species *M. sulcata* Lamarck (1805).

In this genus I would also include the radially ribbed Recent groups *Hormomya* Mörch (type, *Mytilus exustus* Linné), *Ischadium* Jukes-Browne (type, *Mytilus hamatus* Say), and *Aulacomya* Mörch (type, *Mytilus* "*magellanicus* Chemnitz"), in all of which, however, the shell is more mytiliform than in *Brachidontes* s. str. These groups are all characterized by the presence of sub-umbonal teeth. In *Hormomya* a few teeth are also present at the posterior end of the hinge-margin, beyond the ligament, but such teeth are absent in *Ischadium* and *Aulacomya*. *Septifer* Recluz, characterized by the presence of an umbonal septum for the attachment of the anterior adductor, appears best regarded as a distinct genus.

The geological antiquity of these toothed radially ribbed groups is at present uncertain. In the Jurassic a number of species occur which are closely comparable to some of these Recent forms in external characters, but lack hinge-teeth. Most of these forms are referable to the subgenus *Arcomytilus*.

Subgenus: ARCOMYTILUS L. Agassiz, 1842.

Annotation to 'James Sowerby's Mineral-Conchologie Grossbritanniens (deutsch bearbeitet von E. Desor)', p. 318.

Type.—*Mytilus pectinatus* J. Sowerby (1821, vol. III, p. 147, Pl. CCLXXXII) [*subpectinatus* d'Orbigny (1850, vol. I, p. 340[1])], Upper Jurassic, Europe, etc.

Subgeneric Characters.—Shell pyriform or trapezoidal, with slightly outcurved and separated, and usually rather hamate, terminal umbones, and a short and more or less arched hinge-margin. Dysodont teeth are absent from the hinge-margin and also from below the umbo, where there occur only weak marginal crenulations produced by the radial ribbing; the umbonal angle may be somewhat infilled by a thickening of the margin. Ligament probably completely internal. Surface-ornamentation consisting of occasionally divaricating radial riblets which tend to be absent from the part of the antero-ventral region which adjoins the byssal gape.

Remarks.—*Arcomytilus* was separated from *Mytilus* by Agassiz on account of differences in the shape of the shell and of the presence along the hinge-margin of small teeth which he considered analogous to the taxodont teeth of the Arcidæ. The teeth referred to are, of course, the posterior dysodont teeth developed in many of the radially ribbed Recent species of the Mytilidæ. The name *Arcomytilus* was, however, introduced by him in a note appended to the description of the Corallian species *Mytilus pectinatus* J. Sowerby, [*subpectinatus* d'Orbigny] and, since no other species was mentioned by name, this must be accepted as the type-species of *Arcomytilus*.

I have developed the interior of the hinge-region of a specimen of *M. subpectinatus* from the Corallian of Weymouth, its type-locality, and have also examined a specimen (Brit. Mus. 66033) from the German "White Jura" in

[1] Re-named *M. subpectinatus* by d'Orbigny on account of its being a homonym of *Modiola pectinata* J. B. de Lamarck (1805, p. 123) if both species are referred to *Mytilus*. *M. pectinata* Lamarck is a species from the Eocene of the Paris Basin which is also referable to *Brachidontes*, so that d'Orbigny's name must be adopted for the Jurassic species.

which the hinge is very clearly exposed. There can be no doubt that in these specimens teeth are completely absent from the hinge-margin (which is thick and not at all crenulated by the radial riblets), as well as from the anterior margin, below the umbo. It therefore seems most improbable that the teeth referred to by Agassiz were observed by him in specimens of this species; his text suggests, in fact, that *Arcomytilus* was based primarily on certain other species which he does not cite by name, while his statement that the hinge-margin is "gerade gestreckt" certainly does not apply to *M. subpectinatus*, in which it is short and arched.

I have also developed the hinge-region of an English Bathonian specimen which I refer to *M. laitmairensis* de Loriol[1], a species which undoubtedly belongs to the same group as *M. subpectinatus*; in this specimen, also, teeth are completely absent. A figure showing the internal characters of a specimen from the Bathonian-Callovian of Balin (Poland) referable to *M. laitmairensis*, published by G. C. Laube (1867, p. 30, Pl. II, fig. 5) under the name *Mytilus* (*Septifer*) *asper* (J. Sowerby), and one of a specimen of *M. asper* (J. Sowerby), from the Great Oolite of Langrune (Calvados), published by K. von Zittel (1881, p. 41, text-fig. 51) also indicate the absence of teeth.

It thus appears that one of the main diagnostic characters originally given for *Arcomytilus* must be excluded from its diagnosis, and that the main difference between it and *Brachidontes* s. str. lies in the absence of dysodont teeth. The relationship between these groups is thus very similar to that which exists between *Falcimytilus* and *Mytilus* s. str.[2]

It should be mentioned that the diagnostic characters of *Arcomytilus* have been discussed by L. Rollier (1914, pp. 368-370), who makes no reference to the interior of the shell; he appears to consider the most important feature of this subgenus to lie in the flattening of the postero-ventral margin, which is so pronounced in most specimens of the type-species. Hence he would exclude "*Modiola*" *aspera* J. Sowerby from this group. The convexity of this margin, however, is a feature which varies considerably in specimens of one and the same species, and is of no significance in classification.

Arcomytilus, as here defined, may be considered to rank as a subgenus of *Brachidontes*—a name which has priority by two years. In general shape its more typical species are remarkably similar to the Recent species *Mytilus hamatus* Say, which A. J. Jukes-Browne (1905, p. 223) has separated from *Brachidontes* as a distinct subgenus, *Ischadium*. This Recent group differs, however, in the presence of strong sub-umbonal teeth.

Arcomytilus first makes its appearance in the Bajocian, and occurs commonly in the Middle and Upper Jurassic. It is at present uncertain if any of the radially ribbed Cretaceous Mytilidæ belong to this group. Neither in the Lias nor in the Trias are any comparable representatives of the family with strong radial ribbing known.

[1] See page 81.
[2] See page 77.

BRACHIDONTES (ARCOMYTILUS) LAITMAIRENSIS (de Loriol).

Pl. V, figs. 15-17.

Mytilus asper J. Morris and J. Lycett, 1853, "A Monograph of the Mollusca from the Great Oolite. Part II, Bivalves," *Pal. Soc. London*, p. 39, Pl. IV, fig. 8 (*non* J. Sowerby sp.).

Mytilus (*Septifer*) *asper* G. C. Laube, 1867, "Bivalven des braunen Jura von Balin," *Denkschr. k. Akad. Wiss. Wien*, vol. XXVII, Part 2, p. 30, Pl. II, fig. 5.

Mytilus laitmairensis de Loriol, 1883, "Étude paléontologique des Couches à *Mytilus* des Alpes vaudoises," *Mém. Soc. pal. suisse*, vol. X, p. 57, Pl. VIII, figs. 6-12.

Mytilus autissiodorensis J. Weir, 1929, "Jurassic Fossils from Jubaland, East Africa..and the Jurassic Geology of Somaliland," *Mon. Geol. Dept. Hunterian Mus. Glasgow Univ.*, No. 3, p. 29, Pl. II, figs. 12, 13 (*non* Cotteau).

Mytilus laitmairensis V. Diaz-Romero, 1931, "Contributo allo studio della fauna giurese della Dancalia centrale," *Pal. Italica*, vol. XXXI, p. 29, Pl. II, figs. 11, 12.

Mytilus (*Arcomytilus*) *laitmairensis* H. H. Renz, 1935, "Zur Stratigraphie und Paläontologie der *Mytilus*-Schichten im östlichen Teil der Préalpes romandes," *Eclog. Geol. Helvet.*, vol. XXVIII, p. 210.

Mytilus (*Arcomytilus*) *laitmairensis* L. R. Cox, 1935, Mesozoic Palæontology of British Somaliland, p. 164, Pl. XV, figs. 13, 14.

Mytilus (*Arcomytilus*) *laitmairensis* W. J. Arkell, 1936, "A Monograph of British Corallian Lamellibranchia," *Pal. Soc. London*, p. 359, Pl. LIII, fig. 2.

Description of the Specimens from Kachh.—The shell, which attains a fairly large size for the genus, is well inflated, and pyriform in shape, widening gradually towards its postero-ventral extremity; its umbonal region is rather produced and hamate, and rises at first well above the level of the hinge-margin; the umbo is terminal. The hinge-margin is short and arched, occupying about one-half of the total length of the shell; it meets the steeply sloping and only slightly convex posterior margin in an even curve. The postero-ventral margin, whose general direction makes only a slight angle with the horizontal, is usually moderately convex, meeting the posterior and ventral margins in even curves; in one specimen, however, this margin is flattened, meeting the adjacent margins in rounded-off angles. The ventral margin is strongly concave. The surface of the shell is evenly inflated except in the single specimen with a flattened postero-ventral margin; in that specimen ill-defined ridges run from the extremities of that margin towards the umbo. The ornamentation consists of fine, occasionally divaricating, radiating riblets which are absent from the part of the antero-ventral region adjoining the byssal gape. The internal characters are unobservable.

Dimensions.—The largest specimens are crushed and broken, and so cannot be accurately measured. One such specimen measures 65 mm. from the umbo to the postero-ventral margin.

Remarks.—The specimens now described seem undoubtedly to belong to the species from the *Mytilus*-beds[1] of the Alps of Vaud (Switzerland) described by de Loriol as *Mytilus laitmairensis*. Specimens from the Callovian of British Somaliland referred to this species have been described recently by myself.

It now appears, however, somewhat uncertain if this species is distinct from *Brachidontes* (*Arcomytilus*) *asper* (J. Sowerby) (1818, vol. III, p. 22, Pl. CCXII, fig. 4, sub *Modiola*), described originally from the Bathonian of England. The type-specimens of *B. asper*, from the Cornbrash of Felmersham, near Bedford, are characterized by their strong inflation and their parallel-sided outline; the hinge-margin is short and the umbones blunt and not at all pointed or hamate. A specimen from the Great Oolite of Langrune (Calvados), agreeing closely with the typical *B. asper*, has been figured by K. von Zittel (1881, p. 41, text-fig. 51), while a similar specimen, from Abyssinia, has been figured by H. Douvillé (1886, p. 228, Pl. XII, fig. 11).

Specimens of the typical *B. asper* occur in the Great Oolite of Minchinhampton (Gloucestershire), but are associated with less strongly inflated, broader, and much more pyriform specimens with a produced, hamate umbonal region and acute, terminal umbones. This form, which is figured by Morris and Lycett as *Mytilus asper*, appears to me to be identical with *B. laitmairensis*; the English specimens, it is true, are smaller than those from the type-locality, but other species (for example, *Modiolus imbricatus* J. Sowerby) commonly attain larger dimensions in the Alpine *Mytilus*-beds than in the English Great Oolite.

It appears, therefore, that we must either recognize two distinct species as occurring in the Bathonian of England, or else conceive *B. asper* as a highly variable species with which *B. laitmairensis* should be united in synonymy. For the present it seems preferable to adopt the former alternative, and to refer certain specimens which have been figured as *B. asper* to the species *B. laitmairensis*.

Whatever the type-horizon of this species, specimens indistinguishable from *B. laitmairensis* undoubtedly occur in the Argovian-Kimmeridgian of northern Africa (Diaz-Romero) and in the Argovian of England (Arkell). The further question thus arises whether this species should be separated from the Argovian form, *B. subpectinatus* (d'Orbigny) [*pectinatus* (J. Sowerby)], which is characterized by its flattened postero-ventral margin and by the pronounced ridges which run from the extremities of that margin towards the umbo; for, as mentioned above, a similar tendency is observable in at least one of the Indian specimens now described (fig. 17). Since, however, it is only in the Argovian that there is any general tendency for specimens to acquire this shape, it seems preferable to regard *B. subpectinatus* as a distinct species of limited range, and

[1] The age of the *Mytilus*-beds is still a subject for dispute among Swiss geologists. According to H. H. Renz (1935, p. 241) the great majority of the mollusca described by de Loriol come from an Oxfordian-Argovian horizon. I fully agree, however, with de Loriol that the evidence of the fossils themselves suggests that their age is Bathonian or, at least, not later than Callovian. The occurrence of the genus *Eligmus*, elsewhere so characteristic of the Bathonian-Callovian, strongly supports this view. F. Rabowski (1919, pp. 77-82) records the discovery of Upper Oxfordian-Argovian ammonites in beds which, according to Renz, belong to the upper part of the main molluscan horizon ("Niveau III"). A. Heim (1921, pp. 616-9) records the discovery by A. Jeannet and others of Callovian and Lower Oxfordian ammonites in beds overlying the *Mytilus*-beds, but Renz considers this ammonite horizon to underlie "Niveau III".

to conceive *B. laitmairensis* as a long-ranging and variable species from which *B. subpectinatus*, and perhaps also the Bathonian *B. asper*, arose as offshoots.

Occurrences and Material.—Upper Bathonian [*vel* Callovian], Lower Chari, *macrocephalus* Beds, of the following localities :—N. W. of Jumara—three specimens (G. S. I. No. K 40/566, colld. F. Stoliczka) ; south flank of Bela hills—one specimen (G. S. I. No. K 40/569, colld. A. B. Wynne) ; Khera Hill, near Chari ("Brown Oolite" of Stoliczka, MS.[1])—two specimens (G. S. I. No. K 40/567, colld. F. Stoliczka). Same horizon ?, Chari—one specimen (G. S. I. No. K 40/568, colld. W. T. Blanford[2]).

Also one specimen of unknown provenance, associated with the brachiopod "*Terebratula*" *aurata* Kitchin.

Genus : LYCETTIA L. R. Cox, 1937.

"Notes on Jurassic Lamellibranchia. IV. On a new Genus of Mytilidæ and a new *Mytilus*-like Genus," *Proc. Malac. Soc. London*, vol. XXII, p. 345.

Genotype.—*Mytilus lunularis* Lycett (1857, p. 128 ; also L. R. Cox, *loc. cit.*, p. 346, Pl. XVII, figs. 4-6), Inferior Oolite, England.

Generic Characters.—Shell smooth, sickle-shaped, with acutely pointed, terminal umbones and a very sharp carina which runs from the umbo to the postero-ventral corner. Antero-ventral region not at all expanded. Umbonal angle occupied by a septum which is not at all, or very little, depressed below the plane of the valve margins and bears a weak, sub-median, radially disposed tooth. Dorsal margin bordered by a flattened ligamental area, which (except near the umbo) is inclined outwards to a slight extent so as to be sub-external, and bears one or more longitudinal ridges, the most conspicuous of which originates at the umbo, where the area tapers to a point. Location of anterior adductor scar unknown.

Remarks.—This genus was proposed by me for the reception of the previously unfigured species *Mytilus lunularis* Lycett, which, although very similar in general shape to some species of *Mytilus*, differs in certain important respects in the structure of its hinge-region.

As already seen[3], in *Mytilus*, *Modiolus*, and related genera the ligament occupies the space between the postero-dorsal margin, which is not at all thickened, and an internal ridge borne by the wall of the shell. In *Lycettia* there is a comparatively wide, flattened cardinal area which is constituted, at its posterior end, by a considerable thickening of the shell along its dorsal margin, and towards its anterior end appears to be slightly undercut. The ligament thus appears to have been more completely external than in *Mytilus*. The principal ridge for its support is sometimes well separated from the lower edge of the cardinal area, and in one specimen of the genotype which has been examined [L. R. Cox, 1937(4), Pl. XVII, fig. 5*b*] occupies a median position on that area. Other

[1] Stoliczka's "Brown Oolite" appears to have been a somewhat indefinite term embracing the greater part of the *macrocephalus* Beds and the overlying Callovian.

[2] This is most probably the specimen recorded as *Mytilus furcatus* Goldfuss by F. Stoliczka in T. Oldham's Appendix to W. T. Blanford (1867, p. 19).

[3] See pages 63, 75.

longitudinal ridges besides the principal one are, moreover, present on the area in some specimens [L. R. Cox, 1937(4), Pl. XVII, figs. 6*a*, *b*]. In one specimen examined two oblique ridges are present at the junction of the cardinal area and the posterior margin; these, however, may be merely of the nature of growth-rugæ.

The internal characters of the umbonal region also differ from those observable in *Mytilus*: for whereas in that genus the antero-dorsal margin is continued back below the umbo and underlies the hinge-margin for a short distance, in *Lycettia* the corresponding margin terminates at the umbo.

Externally, *Lycettia* differs from the more typical species of *Mytilus* in the extreme sharpness of the carina which runs from the acute, terminal umbo to the postero-ventral corner of the shell, and in the complete absence of any expansion of the antero-ventral region.

The septum which occupies the umbonal angle does not appear to have served for the attachment of the anterior adductor muscle, as in *Septifer* and *Dreissena*, but to have constituted a hinge-plate for the support of the tooth, as in the *Chloromya* subgenus of *Mytilus*. The weak tooth which this septum bears does not, however, closely resemble the teeth developed in any group of *Mytilus*; for in that genus the teeth are not radially disposed, but originate at the anterior margin just below the umbo, their position being usually indicated by grooves on the exterior of the shell.

It must, perhaps, remain a matter for conjecture whether *Lycettia* should be regarded as a derivative of *Mytilus* in which a thickened, sub-external cardinal area has developed, or if, on the other hand, it is a descendant of the Palæozoic families Ambonichiidæ and Myalinidæ. In shape *Lycettia* closely resembles many species of certain genera referable to these families—in particular *Myalina* de Koninck (1842, p. 125), *Mytilarca* Hall (1869, p. 19; also 1884, pp. xiv, 253), and *Gosseletia* Barrois (1882, p. 273). These genera, however, are characterized by a fine, regular longitudinal striation of the whole of the cardinal area, and it is difficult to decide whether the fewer and less regular, but much more pronounced, longitudinal ridges which are present in *Lycettia* should be regarded as a modification of this structure.

Externally, there is also much resemblance to the Devonian genus *Hoplomytilus* G. and F. Sandberger (1856, p. 281; also G. F. Whidborne, 1892, p. 44), which has three ridges, presumably for the support of the ligament, adjacent to its dorsal margin.[1] In *Hoplomytilus*, however, the affinity of which with the Myalinidæ (in which it is usually included) appears somewhat doubtful, there is no external cardinal area, the ridges being borne by the wall of the shell, like the single ridge in *Mytilus*.

In general shape *Lycettia* is also not unlike a widespread group of Cretaceous species, which include *Mytilus lanceolatus* J. de C. Sowerby (*see* H. Woods, 1900, p. 110, Pl. XIX, figs. 1-11), from the Aptian and Albian of England, *M. tegulatus* J. Müller (*see* E. Holzapfel, 1889, p. 218, Pl. XXV, figs. 1-9), from the Senonian

[1] Whidborne interprets these ridges as teeth, and considers the septum with a free ventral edge, which occupies the umbonal angle, to be an internal ligamental area.

Greensand of Aachen, *M. uitenhagensis* Kitchin (1908, p. 82, Pl. II, figs. 10, 11), from the Lower Cretaceous Uitenhage Beds of South Africa, and *Dreissena tippana* Conrad (*see* J. A. Gardner, 1916, p. 628, Pl. XXXVII, figs. 8-11; also B. Wade, 1926, p. 72, Pl. XXIII, figs. 11, 12), from the Upper Cretaceous of North America. In those forms, however, the structure of the hinge-region agrees with that of normal representatives of the Mytilidæ, and it is probable that a new subgenus of *Mytilus* should be erected for their reception. I do not consider them to be related to *Dreissena*, which probably evolved in Tertiary times from some genus of the Eulamellibranchiata which was not at all mytiliform in shape.

Lycettia indica sp. nov.

Plate V, figs. 19, 20.

Description.—The shell is of medium size and moderate inflation, trapezoidal in outline and of moderate breadth, with an obliquity (measured by the angle between the hinge-margin and a line joining the umbo to the most remote point of the posterior margin) of about 45°. The umbo is acutely pointed and slightly hamate. The hinge-margin is straight, occupying about one-half of the total length of the shell. The posterior margin, which meets the hinge-margin in an obtuse angle of about 150°, is only feebly convex dorsally, but sweeps round in a broad, asymmetrical curve to the well-defined antero-ventral corner of the shell. The antero-ventral margin is slightly concave and without an anterior bulge; it may or may not be obscured, in the side-view of the shell, by the straight or slightly curved, sharp carina, which runs from the umbo to the postero-ventral corner and coincides with the most inflated region of the shell. On the ventral side of the carina the surface is flattened and falls away abruptly to the margin; on its dorsal side the surface is very feebly convex, sloping gradually to the margins. The byssal gape is inconspicuous. The surface of the shell is smooth except for growth-imbrications which are present at irregular intervals.

Internally, the umbonal angle is occupied by a slightly concave septum which is level with the shell-margin on its anterior side; in the extreme umbonal angle this septum bears a short, weak, radially disposed tooth which is slightly dorsal to median in position. A conspicuous ridge for the support of the ligament originates at the umbo and diverges from the hinge-margin at a very acute angle. The internal structure of the greater part of the hinge-line has not, however, been observed.

Holotype.—G. S. I. type No. 16530.

Dimensions.—The measurements of the holotype, the more complete of the two specimens examined, are as follows:—

Length (parallel to hinge-margin)	42·5 mm.
Height (perpendicular to hinge-margin)	38·0 mm.
Inflation (single valve)	6·5 mm.

Remarks.—In external characters and in the internal structure of its umbonal region this species closely resembles the English Inferior Oolite species *Mytilus*

lunularis Lycett, upon which the genus *Lycettia* was founded by me. Unfortunately, the interior of the hinge-region is not exposed in the only specimen (the holotype) in which this part of the shell is complete, so that it has not been possible to observe the thickened cardinal area which is the chief characteristic of the genus. The Indian species may, however, be confidently assumed to be congeneric with the genotype. It differs from that species in its more rounded postero-ventral extremity, in its narrower umbonal septum, and in its shorter and less conspicuous tooth.

Its sharper carina, more pointed umbo, and more compressed form serve to distinguish this species externally from *Mytilus* (*Falcimytilus*) *tramauensis*, described above.[1]

Occurrence and Material.—Locality and horizon unfortunately unrecorded—the holotype and a fragment of one paratype, preserved in a hard, fine-grained, brown, ferruginous sandstone.

Superfamily : *PTERIACEA.*

Family : *PTERIIDAE.*

Apart from the Malletiidæ (if that family be considered inseparable from the Ctenodontidæ), the Pteriidæ were the earliest to appear of those lamellibranch families which have persisted to the present day.[2] This family is first met with in the Ordovician, is of preponderating importance in the Upper Palæozoic, and is well represented in the Mesozoic, where, however, its derivatives, the Pectinidae and related families and the Isognomonidæ, have become more abundant. At the present day it is represented only by a comparatively small number of species which occur in certain tropical faunas. Although the family is so long-ranged, well characterized genera of more restricted range occur at various geological horizons and form a useful index to horizon.

The main features of the shell in this family result from its mode of growth, attached by a byssus, usually to objects on the sea-floor, and resting on the right valve. The two valves are frequently pronouncedly unequal, the left being the more strongly inflated. The shell is usually very inequilateral, with its body obliquely elongated in a postero-ventral direction ; it is most commonly bialate, with the posterior wing the larger. In many genera the right anterior auricle is separated from the body of the shell by a deep notch for the passage of the byssus. The umbones are separated by a narrow, obtusely triangular cardinal area. In many of the early forms this area was longitudinally striated and without a ligamental pit, but in the later forms, including those from the Jurassic described in the present Memoir, the fibrous ligament is confined to a definite triangular pit below the umbo. Forms with serial ligamental pits, now usually grouped together in the family Isognomonidæ [Pernidæ], were, no doubt, derived independently from the Pteriidæ at various geological epochs. Some of the

[1] See page 77.

[2] The family name Pteriidæ is here employed in a wide sense. Since this was written, several of the Palæozoic genera previously referred to this family have been discussed in an important work by N. D. Newell (1937), who classifies them in different families (some new) according to the structure of the ligamental area and (p. 24) " suspects, but cannot yet demonstrate, that the modern Pteriidæ are not closely related to many of the " pterioids " of the Palæozoic."

earlier genera of the Pteriidæ, notably *Pterinea*,[1] are dimyarian, but in the later forms the anterior adductor is usually obsolete in the full-grown shell. Well-developed hinge-teeth are present in several genera; such genera (*e.g. Pterinea* of the Lower Palæozoic and *Pteroperna* of the Jurassic) may occur at widely separated geological epochs. In many genera, however, such teeth are undeveloped. In the Recent species of *Pteria* there is usually a single posterior lateral tooth, and a tuberculiform "cardinal" tooth just anterior to the umbo. F. Bernard's work [1896(2), pp. 427-432; 1898, pp. 119-123] on the ontogeny of the shell has shown that these teeth are essentially homologous with the teeth of the Parallelodontidæ and Mytilidæ, which have already been discussed.[2]

In the Recent and in many fossil representatives of the family the shell-structure consists of an outer prismatic calcitic layer and an inner nacreous aragonitic layer. O. B. Böggild (1930, pp. 260-1), however, records that the shells of a number of Mesozoic representatives of the family consist entirely of calcite with a peculiar crossed-lamellar structure.

The Pteriidæ and related families form the subject of a classical paper by R. T. Jackson (1890), but the conclusions regarding the phylogeny of these groups at which he arrives from his observations on the ontogeny of the shell are open to dispute, as Bernard's work has shown. A discussion of the history of the Pteriidæ is also given by F. Frech (1891) in his monograph on the Rhenish Devonian species of the family.

Genus: PTEROPERNA J. Morris and J. Lycett, 1853

(*ex* J. Lycett, 1850, *n. nud.*)

J. Lycett, 1850, "Tabular View of Fossil Shells from the Middle Division of the Inferior Oolite in Gloucestershire," *Ann. Mag. Nat. Hist.*, ser. 2, vol. VI, pp. 413, 421 (*n. nud.*). J. Morris and J. Lycett, 1853, "A Monograph of the Mollusca from the Great Oolite, Part II, Bivalves," *Pal. Soc. London*, p. 16.

Genotype[3].—*Gervillia costatula* J. A. Eudes-Deslongchamps (1824, p. 131, Pl. V, figs. 3-5), Bathonian, Europe.

Generic Characters.—Shell very inequilateral, oblique, bialate, with a long, pointed posterior wing and a short anterior auricle; in general outline closely resembling *Pteria*. Usually slightly inequivalve, with the right valve less convex than the left. A wide, flattened, triangular ligamental area is present in each valve, sloping outwards from the hinge-margin and separating the umbones, as in *Gervillia*; this area bears a moderately wide, oblique, triangular ligamental pit, sloping backwards from the umbo to meet the hinge-margin within the anterior half of its length. The hinge-margin is thickened anteriorly so as

[1] *Pterinea* and a few other early Palæozoic genera are separated by W. H. Dall (1895, p. 518) as a distinct family, the Pterineidæ. Apart from the presence of a small anterior adductor, however, these forms differ from typical genera of the Pteriidæ only in the structure of their cardinal area.

[2] See pages 37, 61.

[3] Designated by Morris and Lycett (1853). *Pteroperna gibbosa*, the sole species listed under the genus by Lycett in 1850, remained a *nomen nudum*.

to simulate a hinge-plate, and bears a number of oblique tooth-like crenulations, to which there may correspond a series of grooves radiating from the umbo on the cardinal area. The inner side of the posterior wing is flattened and bears either one (left valve) or two (right valve) elongate ridges parallel to the hinge-margin, constituting lateral teeth. Externally, up to about four elongate grooves are present on the posterior wing of each valve, the more ventrally placed of these corresponding to the internal ridges. Posterior adductor scar large, reniform or ovate, situated just posterior to the middle of the shell; a small anterior adductor scar is also present.[1] Surface of shell smooth or radially ribbed.

Remarks.—In their original diagnosis of *Pteroperna* Morris and Lycett describe the ligamental area as "internal and nearly parallel with the external margin". In point of fact, however, the ligamental area is, as described above, external and obtusely triangular. The depression occupied by the fibrous ligament is very clearly preserved in a specimen from the Inferior Oolite of Dorset in the British Museum (Natural History) (regd. L. 25725), and is also illustrated in J. A. Eudes-Deslongchamps' (1824, Pl. V, fig. 5) original figure of the genotype, "*Gervillia*" *costatula*. The ligamental area is rather wider and more exposed to the exterior than in the genus *Pteria*.

As remarked by Morris and Lycett, the parallel grooves adjacent to the hinge-margin on the posterior wing enable this genus to be distinguished from *Pteria* even when the internal characters of the specimens studied are not observable. Similar grooves may, however, occur in the genus *Bakevellia*; for example, in the species *B. waltoni* (Lycett) (p. 108).

Pteroperna sp. indet.

Plate VI, fig. 1.

Description.—The single specimen examined is a moderately large left valve in which the umbo and anterior wing, as well as part of the ventral margin, are broken away. The posterior wing, which is of moderate width, can be seen to have been well elongated and sharply pointed at its extremity when complete. The body of the shell is fairly broad; its obliquity is such that a line drawn from the umbo to the most distant point on the postero-ventral margin makes an angle of approximately 45° with the hinge-margin, while its extremity appears to have lain almost vertically below the tip of the posterior wing. It is more or less evenly, and somewhat feebly, inflated, the level of its surface falling away rather abruptly to that of the flattened posterior wing. The posterior border of the body is nearly straight, diverging from the hinge-margin at an angle of about 30°, and meeting the ventral margin in a moderately sharp curve; the ventral margin forms a fairly strongly and evenly convex curve which is most distant from the hinge-margin at about one-third of the length of the shell from its posterior end.

[1] According to Morris and Lycett; this scar has not been observed by myself.

Three well-impressed grooves parallel to the hinge-margin are present on the dorsal part of the posterior wing. Growth-rugæ are rather strongly pronounced both on the body of the shell and on the posterior wing.

Dimensions.—The following are the estimated measurements of the specimen when complete :—

Length	48 mm.
Height	40 mm.
Inflation	8 mm.

Remarks.—The parallel grooving of its posterior wing shows that this species should most probably be referred to the genus *Pteroperna*. It closely resembles the British Inferior Oolite species *Pt. plana* Morris and Lycett (1854, p. 128, Pl. XIV, fig. 4), but is too incomplete for close comparison. The Corallian species *Pt. polyodon* (Buvignier), as figured by W. J. Arkell (1933, p. 201, Pl. XXV, figs. 6-10), is to some extent similar, but the body of its shell is rather narrower and also differs in being slightly upturned at its posterior extremity. F. Vogel (1900, p. 45, Pl. I, fig. 3) has figured the interior of an undetermined representative of the genus from the Jurassic of Borneo which also appears to differ from the specimen now described in the somewhat narrower body of its shell.

Occurrence and Material.—Divesian, lower Dhosa Oolite, Juria hills, on road from Juria to Dhosa—one specimen (G. S. I. No. K 40/571, colld. A. B. Wynne).

Pteroperna ? blakei sp. nov.

Plate VI, fig. 8.

Description.—The shell is of small-medium size for the genus, and very narrow, elongate, and oblique in outline, a line joining the umbo to the postero-ventral corner making an angle of only 30° with the hinge-margin. The posterior wing is narrow, elongate, and sharply pointed; the anterior wing exceptionally elongate and acute-angled. The body of the shell (in the right valve, which alone is known) is only feebly inflated, the level of its surface declining gradually to that of the wings, neither of which is delimited by a definite groove; its extremity projects well beyond the posterior end of the hinge-margin. The umbo is acute and scarcely projects above the hinge-margin. The anterior margin of the body meets the hinge-margin in an angle of approximately 90°, and soon curves round in a posterior direction to merge with the ventral margin; the latter forms an evenly convex curve which recedes most from the hinge-margin near its posterior end. The posterior border of the body is nearly straight, diverging from the hinge-margin at a very acute angle and meeting the ventral margin in a sharp curve.

Three narrow and obscure grooves, which make a very acute angle with the hinge-margin, are present on the posterior wing. The surface of the shell is smooth.

Holotype.—Brit. Mus. L. 71405.

Dimensions.—The measurements of the holotype are as follows :—

Length	31·8 mm.
Height	13·5 mm.
Inflation	2·0 mm.

Remarks.—In the holotype, which is the only specimen known, the extremity of the posterior wing is covered by a small *Entolium* valve which it has seemed undesirable to destroy. The growth-lines, however, indicate that the hidden part of the wing is acutely pointed. The presence of longitudinal grooves on this wing may be definitely observed, although the grooves are shallow and inconspicuous. It is, therefore, more probable that the species should be referred to *Pteroperna* than to *Pteria*.

"*Avicula*" *pygmæa* Koch and Dunker (1837, p. 37, Pl. III, figs. 6*a-d*), originally described from the Corallian of Hanover, bears some resemblance to this species, but its anterior auricle is less sharply pointed. *A. pygmæa* is referred to the genus *Gervillia* by D. Brauns (1874, p. 309), and a specimen which E. Krenkel (1915, p. 290, Pl. XXVI, figs. 1, 2) refers to this species certainly appears to have serial ligamental pits, although Krenkel refers it to *Pteroperna*.

The small *Pteroperna* from the English Great Oolite which J. Morris and J. Lycett (1853, p. 19, Pl. II, figs. 11, 11*a*) erroneously refer to *Avicula pygmæa* resembles the species now described in the acuteness of its anterior auricle, but its body is shorter, more inflated, and less curved. "*Avicula*" *obliqua* Buvignier (1852, p. 22, Pl. XVI, figs. 38-40), from the Kimmeridgian of the Meuse Département of France, is also very similar, but is less pointed at its posterior end. "*Avicula*" *argoviensis* Mœsch (1867, p. 307, Pl. V, figs. 9*a*, *b*), from the Corallian of Switzerland, bears some resemblance to the species now described, but the body of its shell is shorter and more inflated.

Occurrence and Material.—Divesian, lower *athleta* Beds, east of Juria ["Middle Zone" of Blake, MS.]—the holotype only (colld. J. F. Blake), preserved on a slab containing also *Palœoneilo indicus* sp. nov., *Nuculana* (*Prœsaccella*) *juriana* sp. nov., and *Entolium partitum* (J. de C. Sowerby).

Genus : Echinotis J. Marwick, 1935.

"Some New Genera of the Myalinidæ and Pteriidæ of New Zealand", *Trans. R. Soc. New Zealand*, vol. LXV, p. 301.

Genotype.—*Avicula echinata* W. Smith [1817(2), p. 67], Middle Jurassic, almost worldwide.

Generic Characters.—Shell usually rather small for the family, very inequivalve ; left valve strongly convex and with a well incurved umbo ; right valve flat or feebly convex, and often of smaller dimensions than the left. Outline orbicular to subquadrate ; posterior wing short or rudimentary.

Right valve with a very narrow anterior auricle which is separated from the body by a deep, narrow furrow ; this furrow leads to an acute, but usually not very deep, notch in the margin of the valve, which here projects beyond the general plane of the valve margins. Anterior wing occasionally present, but

more frequently absent, in left valve; the anterior margin of this valve has a wide sinus, best seen when the margin is viewed end-on from in front of the shell.

Cardinal plate narrow in both valves; sub-vertical in the left, and inclined outwards to a varying extent in the right, where it sometimes more nearly approaches the horizontal than the vertical. A well excavated triangular ligamental pit of moderate width stretches posteriorly from below the umbo in each valve, and in the left valve is bordered on its anterior side by a tooth-like thickening of the cardinal plate; a small recess[1] may be present in the lower edge of the hinge-plate anterior to this thickening, receiving the projection of the valve margin below the anterior auricle of the right valve. Posterior adductor scar rather small, situated posterior to the centre of the valve at about the middle of its height; anterior adductor scar very small, situated just below the anterior auricle.

Left valve usually ornamented with narrow, closely spaced radial riblets crossed by well-defined growth-lamellæ, but smooth in some species. Right valve smooth or with faint radial threads.

Remarks.—The description of the internal characters of *Echinotis* given above has been based on the study of well-preserved specimens of the genotype from the British Cornbrash. Good figures of similar British specimens have been published by J. F. Pompeckj (1901, Pl. XV, figs. 1, 4, 7, 11, 15, 19), while the interiors of Russian specimens have been well figured by A. Borissiak [1909(1), Pl. II, figs. 14, 15, 17, 20]; one of this author's figures (fig. 20*f*) shows the small anterior adductor scar. It is difficult to obtain specimens of other Jurassic species of this group with interiors well enough preserved to show if they agree in every detail with the genotype.

Prior to Marwick's recent paper (1935), the group of species typified by *Avicula echinata* was included by most authors in the genus *Pseudomonotis* Beyrich (1862, p. 10). There has been some disagreement as to the type of this genus[2], but there can be no doubt that we should accept as genotype the well-known Permian species *Gryphites speluncarius* Schlotheim, as selected by F. Stoliczka (1870, p. xxi). The species in question belongs to a widely distributed Upper Palæozoic group, a characteristic representative of which, *Monotis hawni* Meek and Hayden[3], from the North American Carboniferous, was subsequently made the type of the genus *Eumicrotis* by F. B. Meek [1864(2), p. 218]; this, therefore, is an undoubted synonym of *Pseudomonotis*.

On comparing specimens of *Avicula echinata* with numerous specimens of *Pseudomonotis speluncarius* and with published figures of other Upper Palæozoic species of the same group, I fully agree with Marwick that it cannot be regarded as congeneric with them. Thus in such species (*i.e.*, in *Pseudomonotis* s. str.) the shell is of very irregular shape and uneven convexity, the general appearance of the left valve being strongly suggestive of the genus *Velata*. In the *echinata* group, on the other hand, the shell is of even convexity and regular outline.

[1] The " Gelenkgrube " of J. F. Pompeckj (1901, p. 331).

[2] See C. Diener, 1902 and 1903.

[3] For figures of this species see J. W. Beede, 1900, p. 132, Pl. XIII, figs. 11-11c, and Pl. XV, figs. 1-1*f*, 2, 2*a*.

In *Pseudomonotis* s. str. the anterior auricle of the right valve is separated from the body of the valve by a very deep sinus, which usually enlarges inwards from the margin.[1] In the *echinata* group, as already seen, the right anterior auricle is delimited only by a deep groove, which forms a comparatively shallow notch where it meets the margin.[2]

A genus *Clathrolima*, founded by M. Cossmann (1908, p. 5) on a species *C. lalmenti* from the French Bathonian, was subsequently considered by its author (1915, p. 7) to be merely a section of *Pseudomonotis*, in the synonymy of which it is placed by Dr. W. J. Arkell (1933, p. 198). As figured by Cossmann (1908, Pl. II, fig. 8), the left valve of *C. lalmenti* closely resembles that of the species belonging to the group now discussed, but its right valve is represented by him (1908, p. 5, lower text-figure) as having no anterior auricle. This figure is merely a line-drawing and it is possible that, owing to imperfect preservation, the original specimen may have been misinterpreted; Cossmann does not, however, admit this when re-discussing the genus. It would not be admissible to include the species of the group of *Avicula echinata* in a genus whose type-species is characterised by the absence of a right anterior auricle, and, until its genotype can be re-examined, I consider it preferable to disregard *Clathrolima*.

Echinotis echinata (W. Smith).

Plate VI, figs. 2-7.

Avicula echinata W. Smith, 1817, Stratigraphical System of Organized Fossils, p. 67.

Avicula echinata W. Smith, 1819, Strata identified by Organized Fossils, p. 26, Cornbrash Plate, fig. 8.

Avicula echinata J. Sowerby, 1819, Mineral Conchology of Great Britain, vol. III, p. 75, Pl. CCXLIII, fig. 1 (*non* fig. 2).

Avicula echinata J. Morris and J. Lycett, 1853, "A Monograph of the Mollusca from the Great Oolite. Part II. Bivalves," *Pal. Soc. London*, p. 16, Pl. II, figs. 7, 7*a*, *b*.

Avicula echinata R. Damon, 1860, Handbook to the Geology of Weymouth, p. 17, text-fig. 10.

Avicula echinata D. Brauns, 1869, Der mittlere Jura im nordwestlichen Deutschland, p. 237.

Avicula echinata J. Phillips, 1871, Geology of Oxford, pp. 240, 244, Pl. XI, figs. 26, 27.

Pseudomonotis echinata A. O. Schlippe, 1888, "Die Fauna des Bathonien im oberrheinischen Tieflande," *Abh. geol. Specialk. Elsass-Lothringen*, vol. IV, Pt. 4, p. 138.

Pseudomonotis echinata G. Müller, 1900, "Versteinerungen des Jura und der Kreide," *Deutsch-Ostafrika*, vol. VII, p. 518, text-figs. 31-33.

[1] See W. King, 1850, Pl. XIII, fig. 20.

[2] Since this was written, the genus *Pseudomonotis* has been very fully discussed by N. D. Newell (1937, p. 92), who also accepts the species *P. speluncarius* as genotype. One important character of the genus, which completely distinguishes it from the *echinata* group, is that the right valve was attached at the umbo to extraneous objects.

Pseudomonotis echinata J. F. Pompeckj, 1901, "Ueber Aucellen und Aucellen-ähnliche Formen," *Neues Jahrb.*, Beil.-Bd. XIV, Pl. XV, figs. 1, 4, 7, 11, 15, 19.

Pseudomonotis echinata A. Borissiak, 1909, "Die Pelecypoden der Jura-Ablagerungen im europæischen Russland. IV. Aviculidæ," *Mém. Com. géol. St. Pétersbourg*, N. S., Livr. 44, pp. 9, 22, Pl. II, fig. 13.

Pseudomonotis oolithica L. Rollier, 1914, "Fossiles nouveaux ou peu connus des terrains secondaires du Jura," *Mém. Soc. pal. suisse*, vol. XL, p. 410.

Pseudomonotis echinata L. Rollier, 1914, *loc. cit.*, p. 411.

Pseudomonotis echinata M. Cossmann, 1915, "Description de quelques pélécypodes jurassiques recueillis en France (6me article)," *C. R. Assoc. franç. Avancem. Sci.* (*Mém. hors volume*), p. 6. Pl. IV, figs. 3-6.

Pseudomonotis echinata E. Hennig, 1924, "Der mittlere Jura im Hinterlande von Daressalaam (Deutsch-Ostafrika)," *Monogr. Geol. u. Pal.*, ser. 2, Heft 2, p. 85.

Pseudomonotis echinata J. A. Douglas and W. J. Arkell, 1932, "The Stratigraphical Distribution of the Cornbrash. II. The North-Eastern Area," *Quart. Journ. Geol. Soc.*, vol. LXXXVIII, Pl. XII, figs. 7, 7*a*.

Echinotis echinata J. Marwick, 1935, "Some New Genera of the Myalinidæ and Pteriidæ of New Zealand," *Trans. R. Soc. New Zealand*, vol. LXV, p. 301, Pl. XXXV, figs. 7, 8 and Pl. XXXVI, figs. 25-27.

Pseudomonotis echinata L. R. Cox, 1937, "Notes on Jurassic Lamellibranchia. III. On a new *Trigonia* and other Species from Tanganyika Territory," *Proc. Malac. Soc. London*, vol. XXII, p. 200.

Description of the Specimens from Kachh.—The specimens which I refer to this species are mainly left valves which vary in outline from sub-orbicular to obliquely ovate, with sometimes an oblique posterior truncation. The inflation varies considerably; the majority of the specimens are evenly but not very strongly inflated; two specimens, however, are considerably more tumid, and their surface falls away rather steeply on the posterior side. The umbonal region varies in width and prominence; the umbo is more or less anterior to median in position and is incurved to a varying extent, depending on the tumidity of the specimen. The posterior wing is short and acutely pointed in those specimens in which it is preserved.

The ornamentation is variable. In the best preserved specimen (from N. W. of Jumara) it consists of fairly strong radial riblets separated by interspaces which are from two to three times as wide as the riblets; a weak secondary thread occupies the middle of most of these interspaces. The riblets are obscurely squamose and on the postero-ventral region of the shell, in particular, bear a few conspicuous, blunt, tubercle-like spines.

In the majority of specimens, however, there are numerous narrow, depressed, rounded radial riblets which vary somewhat in strength and are rather unevenly spaced; the interspaces are slightly narrower than the riblets in some specimens, but slightly wider in others, and occasionally bear a median riblet of secondary strength. The crests of the riblets are frequently jagged, and occasionally bear

short rudimentary spines near the ventral margin. Concentric ornamentation is usually absent, but in one specimen there is a series of narrow and nearly evenly spaced concentric ridges which form a reticulate pattern with the radial riblets and produce very small tubercles at the points of intersection.

Several specimens extracted from a block of limestone from Kakeendia are characterized by a left valve of very feeble convexity in which the ornamentation consists of a comparatively small number (16-20) of rather weak, narrow, unevenly spaced radial riblets whose interspaces are mostly about three or four times as wide; these interspaces may bear a weak median secondary riblet, but are otherwise smooth. The riblets are not appreciably squamose.

The only right valves preserved belong to this last-described variety from Kakeendia. They are feebly convex and smooth except for a very few obscure, depressed radial riblets.

Dimensions.—The measurements of the two best-preserved specimens are as follows:—

Locality.	*Length.*	*Height.*	*Inflation.*
N. W. of Jumara (G. S. I. No. K40/575) . .	16·7 mm.	16·7 mm.	5·7 mm.
E. of Kaora (G. S. I. No. K40/573) . .	20·0 mm.	20·0 mm.	6·0 mm.

Remarks.—There has been some disagreement among authors as to the extent of the synonymy of this species, the type-occurrence of which is the English Cornbrash. Many authors have regarded it as a variable species which persisted from the Bajocian to the Divesian or even higher. Thus D. Brauns (1869) includes in its synonymy the three forms *Avicula tegulata* Goldfuss (1836, p. 132, Pl. CXXI, figs. 6*a-c*), from the German Upper Bajocian, *Monotis decussata* Münster (in Goldfuss, 1836, p. 139, Pl. CXX, figs. 8*a-d*), from the German Bathonian, and *Avicula braamburiensis* Phillips (1829, p. 140, Pl. VI, fig. 6), from the Divesian "Hackness Rock" of Yorkshire; similar views are also expressed by A. O. Schlippe (1888), E. Greppin (1899, p. 112), and M. Clerc (1904, p. 62), the last two of whom record the species from the Bajocian of Switzerland.

The references given in the above synonymy are mainly to the typical Cornbrash form of the species (the figures by Smith, Sowerby, Morris and Lycett, Damon, Phillips, Pompeckj, Douglas and Arkell, and Marwick which are cited are all of specimens from the English Cornbrash). It seems probable, however, that the views of the authors just mentioned will eventually receive general acceptance and that the synonymy should be considerably extended. The name *Pseudomonotis oolithica* was proposed by L. Rollier for the specimen figured by Morris and Lycett, on the assumption that this came from the Great Oolite and therefore (according to his views as to the range of species) was necessarily specifically distinct from the Cornbrash form. It is, however, obvious from the remark made by Morris and Lycett to the effect that the valves found in the Great Oolite are always disunited that their figured specimen must have come from another formation. There is, in fact, little doubt that the specimen (now, unfortunately, lost) came from the Cornbrash, and that *oolithica* is a synonym of *echinata* in its most restricted sense.

In this typical Cornbrash form the left valve is usually strongly and evenly inflated, with a well incurved umbo. The radial riblets are strong, fairly numerous, and pronouncedly squamose.

The Divesian form *braamburiensis* has been described and figured most recently by J. A. Douglas and W. J. Arkell (1932, p. 163, Pl. XII, figs. 5, 5*a*, 6), who show that its left valve differs from that of the Cornbrash form in its weaker convexity, its more pointed umbonal region, and in its finer and less squamose radial riblets. They consider, therefore, that it should be regarded as a distinct species. A form very similar to *braamburiensis* occurs in the Bajocian Grey Limestone of the Yorkshire coast, and was figured as that species by J. Morris and J. Lycett (1854, p. 129, Pl. XV, figs. 6, 7); this Bajocian form was given the name *Pseudomonotis lycetti* by L. Rollier (1914, p. 430).

Echinotis braamburiensis and *E. lycetti* agree fairly well with the Russian Bajocian form described by A. Borissiak [1909 (1), pp. 9, 22, Pl. I, figs. 11, 12, and Pl. II, figs. 3-12] as *Pseudomonotis echinata* var. *doneziana*, and also with South American Bajocian specimens described as *Pseudomonotis echinata* by C. Burckhardt (1903, p. 26, Pl. II, figs. 9, 10), and with a specimen from the Bajocian of Western Australia figured by F. W. Whitehouse (1925, p. 2, Pl. I, figs. 2 *a-c*) as *P.* cf. *echinata*. It would be interesting to ascertain if the Bajocian specimens recorded by Greppin and Clerc as *P. echinata* agree with the Cornbrash form of the species or with the Bajocian specimens from other regions just mentioned.

Avicula tegulata Goldfuss, said to have come from beds of Bajocian age, is characterized by rather wide-spaced squamose riblets, and differs slightly from both the Cornbrash form and the *braamburiensis* type of shell. According to O. Terquem and E. Jourdy (1869, p. 120) shells of the *tegulata* type also occur in the French Bathonian, where they are associated with the typical *echinata*. Hence it seems probable that these two forms are varieties of the same species.

Of the Indian specimens now recorded, all of which come from beds of Bathonian age, the single one from north-west of Jumara agrees well with the typical Cornbrash form of *E. echinata*. The majority of the specimens, however, are less strongly convex, with the umbo of the left valve less incurved, and with the riblets narrower and less rugose; such specimens closely resemble *E. braamburiensis* both in shape and in ornamentation. Hence it is obvious that the difference in the stratigraphical positions of shells of the *echinata* and *braamburiensis* types observable in Great Britain does not apply to India. It seems proable that the form found in the English Cornbrash should be regarded merely as a fairly well-defined race of a long-ranging species which shows much greater variability, even at about the same horizon, in some foreign localities. There would, at least, appear to be no justification for referring the Indian specimens to more than one species.

Even in the British Cornbrash the variability of *E. echinata* in not inappreciable, and among a series of specimens examined from this formation I have observed one closely resembling the variety with a comparatively flattened, sparsely ribbed left valve described above from Kakeendia.

E. echinata has not been recorded previously from the Jurassic of Kachh, but is stated by F. Stoliczka (1865, p. 114) to occur in the Gieumal Sandstone overlying the Spiti Shales in the north-western Himalayas. It appears doubtful if specimens from so high a horizon were correctly determined, although Stoliczka states that they were "certainly identical with the original *A. braamburiensis* Phill."

Several authors [B. Semenov, 1896, p. 62; A. Borissiak, 1909 (2), p. 66, Pl. III, fig. 4; V. Pcelinzev, 1927 (3), p. 109] have recorded *E. echinata* from the Middle Jurassic of Central Asia. The specimen from the Mangishlak Peninsula figured by E. von Eichwald (1871, p. 19, Pl. II, fig. 4), however, has a well-developed anterior wing in the left valve and appears to be incorrectly determined.

The specimens from the East African Jurassic figured by G. Müller (1900, p. 518, text-figs. 31-33) as *Pseudomonotis echinata* are poorly preserved, but apparently rather variable. One of the specimens (fig. 31) appears to resemble the variety from Kakeendia referred to above. The species has also been recorded from East Africa by E. Hennig (1924) and by myself [1937 (3)].

Occurrences and Material.—Bathonian, Patcham Dolomite, of the following localities:—Bela—one specimen (Brit. Mus. L. 71526, colld. J. F. Blake); N. of Guddera (Bela) ["Lodranee Limestone" of Stoliczka, MS.]—one specimen (G. S. I. No. K40/572, colld. F. Stoliczka); Andhou—eight specimens (Brit. Mus. L. 71527-34, colld. J. F. Blake); east of Kaora (Patcham)—one specimen (G. S. I. No. K40/573, colld. A. B. Wynne); Kakeendia Bet (S. of Karrir)—block with several specimens (G. S. I. No. K40/574, colld. A. B. Wynne).

Upper Bathonian [*vel* Callovian], Lower Chari, *macrocephalus* Beds, of the following localities:—N. W. of Jumara—one specimen (G. S. I. No. K40/575, colld. F. Stoliczka); Khera ["Bed No. 10" of Blake, MS.[1]]—one doubtful specimen (Brit. Mus. L. 71535, colld. J. F. Blake).

Genus: Oxytoma F. B. Meek, 1864.

"Check List of the Invertebrate Fossils of North America. Cretaceous and Jurassic," *Smithsonian Misc. Coll.* No. 177, p. 39.

Genotype.—*Avicula münsteri* Bronn (in Goldfuss, 1836, p. 131, Pl. CXVIII, figs. 2 *a-h*[2]), here regarded as a synonym of *A. inequivalvis* J. Sowerby, Jurassic, worldwide.

Generic Characters.—Shell of small-medium to medium size for the family, very inequivalve; left valve of moderate convexity, with its umbonal region very little inflated and the umbo not at all incurved; right valve flat or very feebly convex, and often of smaller dimensions than the left. Outline suborbicular or obliquely ovate; posterior wing usually elongated and pointed in both valves, with a sinus of variable depth beneath it; in occasional specimens, however, this wing may be merely rudimentary.

Right valve with a small, narrow anterior auricle separated from the body by a deep, narrow furrow; this furrow leads to a moderately deep notch in the

[1] See L. F. Spath, 1933, p. 743.

[2] This specific name was published only as a *nomen nudum* by Bronn, 1829, p. 76, and 1830, p. 164.

margin of the valve, which here projects slightly beyond the general plane of the valve margins. The auricular margin of the body of the shell in this valve bears a comb-like row of small teeth (ctenolium), while a similar row of teeth may be present along the lower margin of the auricle. Anterior wing of left valve rudimentary; below the wing the margin of the valve has a more or less pronounced and not very wide sinus, best seen when the margin is viewed end-on from in front of the shell.

Cardinal plate narrow in both valves, sub-vertical in the left, and inclined outwards in the right, where it may more nearly approach the horizontal than the vertical. A triangular ligament pit of moderate width stretches posteriorly from below the umbo in each valve; the remainder of the cardinal area is flat, apart from a few longitudinal grooves which may be present on its posterior region, and the margin of the cardinal plate is straight, without any indentation.[1] Posterior adductor scar large, subcentral; anterior scar small and close to the auricle, or altogether absent.

Left valve ornamented with narrow radial ribs, which frequently give rise to digitations of the pallial margin; their interspaces are usually ornamented with riblets of secondary and tertiary strength, but are occasionally smooth. Right valve smoother than the left, usually ornamented with radiating grooves, but occasionally with projecting threads, which correspond to the primary ribs of the left valve; radial threads may be present in the interspaces.

Remarks.—*Oxytoma*, which ranges from the Trias to the Upper Cretaceous, is closely related to *Echinotis*, from which it differs in its less strongly inflated left valve, in its characteristic ornamentation, and (usually) in its larger posterior wing. Its cardinal plate appears to lack the tooth-like thickening anterior to the ligamental pit and the adjacent recess in its lower margin which characterise *Echinotis*, while a ctenolium, bordering the byssal notch, has not been observed by me in any right valve of the latter genus.

This ctenolium is of interest, since it so closely resembles that developed in the genus *Chlamys* of the Pectinidæ.[2] The surface ornamentation is very similar to that of the genus *Velata* of the Pectinidæ, fragments of which are easily mistaken for fragments of *Oxytoma*. The interior of the shell in *Oxytoma* is said to have been nacreous, as in Recent members of the Pteriidæ.

The problem of specific discrimination in this genus presents many difficulties, and will be discussed below, in dealing with the species *Oxytoma inequivalve* (J. Sowerby). In attempts to distinguish between the various species, most attention has hitherto been paid to the ornamentation of the left valve, while the right valve, whose exterior, unfortunately, is seldom well preserved, has been disregarded. Sometimes this valve bears radial grooves, and at other times only radial threads, but further research will be necessary before it is possible to say if such differences may be correlated with other differences in the shell.

[1] Mlle S. Gillet [1924 (1), p. 33] talks of the presence of rudimentary teeth in *Oxytoma*, stretching along the hinge-line; and elsewhere [1924 (2), p. 451] she mentions a long tooth parallel to the cardinal margin. She may refer to a sharp ridge on the cardinal area which bounds the ligamental pit on its posterior side, or even to the sharp edge of the cardinal plate, for I have been unable to observe any structure which I should term a tooth in the specimens which I have examined.

[2] A comparable ctenolium is developed in the genus *Aucellina* (*see* H. Woods, 1904, Pl. X, figs. 9, 10).

Oxytoma inequivalve (J. Sowerby).

Plate VI, figs. 9-12.

Avicula inequivalvis J. Sowerby, 1819, Mineral Conchology, vol. III, p. 78, Pl. CCXLIV, figs. 2, 3.

Oxytoma inæquivalve L. Waagen, 1901, "Der Formenkreis des *Oxytoma inæquivalve*, Sowerby," *Jahrb. k. k. geol. Reichsanst.*, vol. LI, pp. 1-23 (with synonymy), Pl. I.

Oxytoma inæquivalvis A. Borissiak, 1909, "Die Pelecypoden der Jura-Ablagerungen im europæischen Russland. IV. Aviculidæ," *Mém. Com. géol. St. Pétersb.*, N. S., Livr. 44, p. 19, Pl. I, figs. 3-8, 10.

Oxytoma cf. *interlævigata* A. Borissiak, 1909, *loc. cit.*, p. 21, Pl. I, fig. 9.

Oxytoma inequivalve L. R. Cox, 1935, Mesozoic Palæontology of British Somaliland, p. 165, Pl. XV, figs. 11, 12.

Description of the Specimens from Kachh.—The specimens from the lower horizon (the Dhosa Oolite) at which this species has been found in Kachh are very inequilateral and obliquely elongated, well inflated left valves whose length, measured in a direction parallel to the hinge-margin, is slightly in excess of the height. The anterior margin projects only slightly beyond the umbones. In the specimen in which it is most completely preserved the posterior wing is of moderate elongation, its pointed extremity, when complete, having been situated at about two-thirds of the distance posterior to the umbo to which the body of the shell extends; its posterior margin is deeply sinuate. The same specimen is characterized by a sudden descent, in a vertical step, from the body of the shell, which is limited postero-dorsally by a sharp ridge, to the posterior wing; it is, however, difficult to say if this feature has been intensified, or even entirely produced, by distortion of the specimen in fossilization. In the other specimens the descent to the posterior wing is more gradual.

These specimens are ornamented with about 14 rather narrow, smooth, and not very prominent primary ribs whose interspaces are usually smooth, but in one specimen bear a few weak radial threads of which the median one tends to stand out more prominently than the remainder. The posterior wing is smooth in the single specimen in which it is preserved.

A single specimen from a somewhat higher horizon (Argovian) is an incomplete, well inflated, oblique left valve whose posterior wing is broken away. Its ornamentation consists of thick, rounded, prominent, slightly sinuous, rather irregularly distributed radial ribs, about 18 of which may be counted near the umbo. Most of the interspaces bear a secondary riblet of varying strength which is more or less median in position, and in some of the interspaces one or two weak tertiary riblets also appear near the ventral margin.

Dimensions.—The specimens are all too incomplete for it to be possible to give their exact measurements. Those from the Dhosa Oolite range up to about 27 mm. in length. The Argovian specimen is about 17 mm. in length.

Remarks.—J. Sowerby's original types of this species came partly from the Middle Lias and partly from the Kellaways Rock. Many authors have regarded

it as a typically Callovian species, but Dr. W. J. Arkell (1933, p. 194, Pl. XXIV, fig. 9) has selected as lectotype of the species and re-figured the only surviving specimen (the original of Sowerby's fig. 2, left-hand fig.) which can unhesitatingly be pronounced to be one of the original figured syntypes. This specimen came from the Middle Lias; hence post-Liassic specimens, including those from the Callovian represented in Sowerby's fig. 3, are considered by Dr. Arkell to be referable to other species.

L. Waagen (1901) and Mlle S. Gillet [1924 (2)], however, have discussed *O. inequivalve* at length and have come to the conclusion that it must be regarded as a variable species which ranged from the Rhætic to the Lower Cretaceous and which includes in its synonymy many forms to which distinct specific names have been given. Waagen distinguishes between several varieties of the species, most of which, however, appear at two or three distinct, and often widely separated, geological horizons. Mlle Gillet finds that almost all such varietal forms are met with at every horizon, but while she states in her text (p. 452) that "aucune variété ne peut être considérée comme caractéristique d'un étage donné," she later (p. 455) contradicts herself by giving a table in which are indicated "les variétés les plus caractéristiques de chaque étage."

The question whether any forms of the *inequivalve* group, distinguishable by definite ornamental or other conchological characters, are restricted to definite geological horizons wherever they occur is of importance; if such forms do occur there seems no reason why they should not rank as distinct species.

In the English Jurassic, specimens belonging to this group are abundant at certain horizons and occur less commonly at many others. Examination of the material available certainly suggests that at every horizon where such specimens are abundant some definite type of ornamentation usually predominates in any given district. Thus a form which occurs commonly at a low horizon (*bucklandi* Zone) in the Lower Lias of southern England has very thick and somewhat irregularly distributed primary ribs, usually about 10-12 in number, together with median secondary ribs of variable strength, which may eventually attain the strength of the primary ribs, and with occasional weak tertiary ribs.[1] A form occurring commonly at a higher horizon (*semicostatus* Zone) of the Lower Lias in the same area is characterized by the very regular arrangement of its primary, secondary, and tertiary ribs;[2] the primaries are more numerous and less prominent than in the form from the lower horizon. In the upper zones of the Lower Lias and in the Middle Lias the dominant form in southern England is that to which the lectotype of the species belongs; median secondary ribs are rarely present, while the tertiary ribs, also, are weak and sometimes almost absent.[3] In the Kellaways Rock, the next horizon at which specimens belonging to this group are at all abundant in southern England, weak median secondary ribs are present, but tertiary ribs are almost absent.

[1] This form agrees fairly well with the specimen figured by C. H. von Zieten (1832, p. 73, Pl. LV, fig. 2) as *Avicula inæquivalvis* and re-named *A. sinemuriensis* by A. d'Orbigny (1850, vol. I, p. 219).

[2] As in the Alpine Rhætic specimen figured by L. Waagen (1901, Pl. I, fig. 1) as *O. inæquivalve* var. *intermedia* Emmrich.

[3] As in the form distinguished by F. A. Quenstedt (1856, p. 149, Pl. XVIII, fig. 29) as *Avicula interlævigata*.

It seems probable, however, that in most cases such varieties are characteristic of particular horizons only in a more or less restricted area. Thus among the specimens from the Callovian of Central Russia figured by A. Borissiak [1909 (1), Pl. I] there is none closely resembling the English Callovian form, but some (for example, figs. 2, 9) are very similar to specimens from the English Lower Lias.

The facts appear to support the conclusion arrived at by Waagen and Mlle Gillet that a parent stock in which no gradual evolutionary change in any particular direction is observable persisted from the Rhætic to the Lower Cretaceous. At all horizons there existed a number of local races, but most of these were closely imitated at some other geological horizon, perhaps in a locality remote from the first. A few offshoots from the parent stock may prove to be sufficiently well characterized and distinct from forms occurring at other horizons to be separable as distinct species, but it would be altogether impracticable to attempt to distinguish every local race by a different specific or even varietal name.

I see no theoretical difficulty in attributing so long a range to a single species. The problem yet to be solved is not why such a species should have persisted for a long period of geological time, but why in other instances mutational changes, producing forms which could scarcely be regarded as more highly evolved or better adapted to their environment than those from which they were derived, should ever have taken place.

In the general character of their ornamentation, particularly in the approximate number of ribs and the smoothness of their interspaces, the specimens now recorded from the Dhosa Oolite resemble many specimens which occur in the Middle Lias of England, and closely approach Quenstedt's *Avicula interlævigata* (1856, p. 149, Pl. XVIII, fig. 29), founded on a Liassic specimen. A sudden step-down from the body of the shell to the posterior wing similar to that observable in one of the Indian specimens is seen in a specimen from the Divesian (*renggeri* Zone) of Switzerland figured by P. de Loriol (1899, p. 168, Pl. X, figs. 34, 35) under the name *Avicula peralata* Greppin; the specimen in question differs, however, from the Indian ones in possessing conspicuous beads on its main ribs and strong beaded ribs on its posterior wing. In J. B. Greppin's original type of *A. peralata* (1870, p. 349, Pl. V, figs. 3*a-c*) the level of the body of the shell appears to descend gradually to the posterior wing.

The ornamentation of the Argovian specimen now recorded may be compared to that of Zieten's Liassic specimen to which reference has been made above, renamed *Avicula sinemuriensis* by A. d'Orbigny. It is also comparable to that of a specimen from the Callovian of Russia figured by A. Borissiak [1909 (1), Pl. I, fig. 9] as *Oxytoma* cf. *interlævigata* (Quenstedt). It has more ribs than specimens from the Argovian of British Somaliland figured by me in a recent paper [1935 (1), p. 165, Pl. XV, figs. 11, 12], but otherwise has much the same type of ornamentation. There is no close resemblance to the British Argovian specimens figured by Dr. W. J. Arkell (1933, pp. 190, 195, Pl. XXIV, figs. 1-8) under the names *Oxytoma expansa* (Phillips) and *O. censoriensis* (Cotteau).

Occurrences and Material.—Divesian, lower Dhosa Oolite, of the following localities :—Juria—three specimens (G. S. I. No. K40/576, colld. W. T. Blanford) ; Wanda ["Zone 1" of Blake, MS.]—one internal cast (Brit. Mus. L. 71538, colld. J. F. Blake). Unrecorded horizon, probably the same, east of Ler—one specimen (G. S. I. No. K40/577, colld. F. Fedden).

Upper Argovian, Barodia [labelled "Moondan Group" by Blake[1]]—one specimen (Brit. Mus. L. 71537, colld. J. F. Blake).

Oxytoma sp.

Plate VI, fig. 13.

Description.—The specimen, a left valve, is of medium size for the genus and of even and moderately strong convexity. Its length is slightly in excess of its height, and it is particularly characterized by its sub-symmetrical outline, its ventral margin forming a strongly convex, symmetrical curve, while its umbo, which is placed at about the anterior two-fifths of the length, is less anterior than is normally the case in the genus. The level of its surface falls away gradually to the posterior wing, which is narrow, sharply pointed, and comparatively short, with a deep sinus in its posterior margin.

The primary ribs number only ten, the most anterior one of which, adjacent to the marginal sinus, is ill-defined ; these ribs are narrow, with a slightly jagged edge, and not very prominent. A weak secondary riblet occupies the middle of each interspace, and numerous tertiary riblets, consisting of inconspicuous threads, are also present. The growth-lines, which are slightly arched in each primary interspace, are somewhat pronounced. Weak radial threads are present on the posterior wing.

Dimensions.—The measurements of this specimen are as follows :—

Length	30·5 mm.
Height	25·5 mm.
Inflation	8·5 mm.

Remarks.—In *Oxytoma inequivalve* (J. Sowerby), discussed above, the shell is normally elongated in a transverse direction, so that its ventral margin is most strongly convex towards its posterior end. The symmetrical curve of the ventral margin in the specimen now described and the less anterior position of the umbones suggest, therefore, that it may belong to a distinct species, especially as it also differs from most specimens of *O. inequivalve* in the comparatively small number of its primary ribs. In view, however, of the variability of *O. inequivalve* and the occurrence of this specimen at the same horizon as fairly typical specimens of that species, it seems advisable to refrain from giving it a new specific name until further material is available.

A specimen from the Middle Lias of Yorkshire with approximately the same number of primary ribs as the shell now described was figured by J. Phillips (1829, Pl. XIV, fig. 4) under the name *Avicula inæquivalvis* and re-named *Avicula novemcostæ* by T. Brown (1845-9, p. 162, Pl. LXVI**, fig. 12) and *Avicula* (*Oxytoma*)

[1] See L. F. Spath, 1933, p. 756.

phillipsi by L. Rollier (1914, p. 400). Like the typical *O. inequivalve*, however, this specimen is more transversely elongated than the Indian shell now described, while its primary ribs are much thicker. The specimen from the lower part of Lias γ of Suabia described by A. Oppel (1853, p. 120, Pl. IV, fig. 15) as *Monotis inœquivalvis* and re-named *Avicula* (*Oxytoma*) *oppeli* by L. Rollier (1914, p. 400) also resembles the shell now described in the comparatively small number of its primary ribs, but, like Phillips' specimen, differs in its more transversely elongated outline.

Occurrence and Material.—Divesian, lower Dhosa Oolite, valley north of Dhosa—one specimen (G. S. I. No. K40/601, colld. A. B. Wynne).

Genus : POSIDONIA H. Bronn, 1828.

"*Posidonia becheri*, eine neue fossile Muschel der Uebergangs-Periode," *Zeits. f. Min.*, vol. I, p. 262.

Genotype.—P. becheri Bronn (*loc. cit.*), Carboniferous, Europe.

Generic Characters.—Shell of small-medium to medium size for the family, thin, subequivalve, of slight or moderate convexity ; outline ovate or suborbicular, usually more or less oblique, with the auricles small and obtuse, or altogether absent, never aliform. A byssal sinus is present in early stages of growth, but is usually obsolete in the full-grown shell. Umbones small, anterior to median, not at all prominent. Ligamental area external, very narrowly triangular, sometimes with a small number of longitudinal grooves. Hinge-teeth absent. Posterior adductor scar ovate, of moderate size, placed posterior to the middle of the shell ; anterior scar small but distinct, dorsally placed. Surface of shell with concentric undulations, sometimes crossed by radial threads. Periostracum well developed.

Remarks.—This genus, which ranges from the Silurian to the uppermost Jurassic,[1] has been studied by several workers, the latest of whom are J. Weigelt (1922) and L. Guillaume (1928). Weigelt, who has carefully described the developmental stages of the genotype, shows that in early life the shell has the typical characters of a representative of the Pteriidæ. A byssal sinus is usually well developed, and the left valve is more inflated than the right. At a later stage the byssal sinus disappears and the shell becomes equivalve.

Guillaume considers that the presence of *P. ornati* Quenstedt in deposits of widely differing lithological facies may indicate a pelagic mode of life. The shell was certainly very thin, for in specimens from many formations only the flattened carbonaceous remains of the periostracum are now preserved.

A. de Gregorio (1886, p. 11) has proposed a subgenus *Bositra* for the non-auriculate Jurassic species of the group of *P. ornati*, but it is at present uncertain if these forms differ from the Carboniferous genotype in any characters of importance.

[1] F. Frech (1891, p. 212) states that the last surviving species referable with certainty to *Posidonia* appears to be *P. wengensis*, of the Trias, but gives no explanation of this statement.

The distinctive characters of the genus (or subgenus) *Steinmannia* P. Fischer (1886, p. 960[1]), the type of which is the Liassic species *P. bronni* (Voltz), have been discussed by Guillaume (1928, p. 220).

Posidonia ornati Quenstedt.

Plate VII, figs. 10, 11.

Catillus brongniarti (junge Brut) G. G. Pusch, 1836, Polens Paläontologie, p. 44, Pl. V, fig. 14 (non *Inoceramus brongniarti* G. A. Mantell, 1822, transferred to the genus *Catillus* by S. Nilsson, 1827).

Posidonia ornati F. A. Quenstedt, 1851[2], Handbuch der Petrefaktenkunde, p. 517, Pl. XLII, fig. 16.

Posidonomya alpina A. Gras, 1852, Catalogue des corps organisés fossiles qui se rencontrent dans le département de l'Isére, pp. 11, 48, Pl. I, fig. 1.

Posidonia opalina F. A. Quenstedt, 1856, Der Jura, p. 329, Pl. XLV, fig. 11.

Posidonia ornati F. A. Quenstedt, 1856, *loc. cit.*, p. 501, Pl. LXVII, fig. 27 and p. 551, Pl. LXXII, fig. 29.

Posidonia parkinsoni F. A. Quenstedt, 1856, *loc. cit.*, p. 501, Pl. LXVII, fig. 28.

Posidonomya ornati F. de Tribolet, 1876, "Note sur le genre *Posidonomya*," *Journ. Conchyl.*, vol. XXIV, pp. 249, 254.

Posidonomya alpina G. G. Gemmellaro, 1877, "Sopra alcuni fossili della Zona con *Posidonomya alpina* Gras di Sicilia," *Giorn. Sci. nat. econ. Palermo*, vol. XII, p. 74, Pl. IV, figs. 10, 11 (var. *striatula*) and Pl. IV *bis*, fig. 5.

Posidonomya alpina C. F. Parona, 1881, "I fossili degli strati a *Posidonomya alpina* di Camporovere," *Atti Soc. ital. Sci. nat.*, vol. XXIII, p. 265, Pl. V, fig. 9.

Posidonomya cf. *parkinsoni* C. F. Parona, 1881, *loc. cit.*, p. 266, Pl. V, fig. 10.

Posidonomya alpina W. Kilian, 1886, "Description géologique de la Montagne de Lure," *Ann. Sci. géol.*, vol. XIX, Pt. 2, p. 83.

Posidonomya buchi G. Steinmann, 1896, in D. Stremoouchow, "Note sur la *Posidonomya buchi*, Rœmer, des schistes de Balaclava en Crimée," *Bull. Soc. imp. Nat. Moscou*, N. S., vol. IX, p. 394, Pl. X, figs. 1-8.

Posidonomya alpina C. Burckhardt, 1903, "Beiträge zur Kenntniss der Jura- und Kreideformation der Cordillere," *Palæontographica*, vol. L, p. 20, Pl. II, fig. 11.

Posidonomya alpina G. B. M. Flamand, 1911, "Recherches géologiques et géographiques sur le Haut-Pays de l'Oranie et sur le Sahara," *Serv. géol. Algérie*, p. 882, Pl. III, fig. 10.

Posidonomya aff. *opalina* G. B. M. Flamand, 1911, *loc. cit.*, p. 894, Pl. VI, fig. 4.

Posidonomya aff. *ornati* G. B. M. Flamand, 1911, *loc. cit.*, p. 895, Pl. VI, fig. 6.

Posidonomya buchi G. Bœhm, 1912, "Beiträge zur Geologie von Niederländisch-Indien. I. Die Südküsten der Sula-Inseln Taliabu und Mangoli," *Palæontographica*, Supp. 4, Abt. 1, p. 132, Pl. XXXII, fig. 1; Pl. XXXIX, fig. 3; and Pl. XLII, fig. 2.

[1] Nom. nov. proposed by Fischer for *Aulacomya* G. Steinmann (1881, p. 259), *non* Mörch, 1853.

[2] See *Neues Jahrb.*, 1852, p. 61. Pp. 1-528 and Pls. I-LII of Quenstedt's work were published in 1851, so that Quenstedt's specific name was definitely prior to that of Gras.

Posidonia alpina F. Trauth, 1922, "Ueber die Stellung der "pieninischen Klippenzone" und die Entwicklung des Jura in den niederösterreichischen Voralpen," *Mitteil. geol. Ges. Wien*, vol. XIV, p. 180.

Posidonomya alpina L. Guillaume, 1928, "Revision des Posidonomyes jurassiques," *Bull. Soc. géol. France*, ser. 4, vol. XXVII, p. 222, text-figs. 4, 5 and Pl. X, figs. 4-13.

Posidonia ornati J. Weir, 1930, "Mesozoic Brachiopoda and Mollusca from Mombasa," *Mon. Geol. Dept. Hunterian Mus. Glasgow Univ.*, No. 4, p. 83, Pl. X, figs. 14-21.

Description of the Specimens from Kachh.—The shell is sub-ovate in outline and obliquely elongated in a postero-ventral direction; the length considerably exceeds the height in both of the available specimens, although the ratios of these measurements differ appreciably. The length of the hinge-margin is approximately one-half of the total length of the shell. The umbo is level with the hinge-margin and lies at about the anterior quarter of its length. The posterior margin, which is much more strongly convex in one specimen than in the other, meets the hinge-margin in a very obtuse angle and merges with the ventral margin in a parabolic curve. The ventral margin is of moderate convexity and converges towards the hinge-margin in an anterior direction before curving up to merge with the anterior margin. In its average direction the anterior margin forms an angle of slightly less than 90° with the hinge-margin, but it curves inwards before joining the latter, so that the antero-dorsal angle of the shell is slightly obtuse.

The surface of the shell is ornamented with strong concentric undulations which are fairly evenly distributed in one specimen, but very irregular in the other.

Dimensions.—The measurements of the two specimens, both of which are left valves, are as follows :—

	Length.	*Height.*	*Inflation.*
Specimen A	15·7 mm.	11·5 mm.	2·0 mm.
Specimen B	16·3 mm.	13·0 mm.	2·6 mm.

Remarks.—The two specimens here described agree well with *P. ornati*, as figured by Quenstedt in 1851, both in the transverse elongation of the shell and in the strong concentric ribbing.

This species and its synonymy have been much discussed. The identity of *P. ornati* and *P. alpina* Gras could scarcely be doubted if the original figures are compared. A number of authorities, however, including E. Beyrich (1861, p. 143), D. Brauns (1869, p. 242), G. Steinmann (in D. Stremoouchow, 1896, p. 394), E. W. Benecke (1909, p. 407), G. Bœhm (1912, p. 132), and L. Guillaume (1928, p. 222)[1], have considered *P. ornati* to be synonymous with *P. buchii* Rœmer (1836, p. 81, Pl. IV, fig. 8), and include, in fact, all the Dogger Posidonias in a single species for which Rœmer's name has priority.

[1] Guillaume, nevertheless, retains the name *P. alpina* for the species, as it is so familiarized in French and Italian literature.

Rœmer's figure represents an elongate, sub-rectangular form which lacks the strong concentric ribbing of the typical *P. ornati*; except in its weaker ribbing and rather more elongate form, however, it is not very different from a specimen figured by Quenstedt in 1856 (p. 501, Pl. LXVII, fig. 27) as *P. ornati*. It seems not improbable that Rœmer may have selected an unusually smooth and elongate specimen for his type, and that the views as to the synonymy of the species expressed by the authors cited may be correct. This, however, is a question which I cannot investigate personally owing to lack of material; and since such authorities as W. Kilian (1886, p. 83) and F. Trauth (1922, p. 180) have expressed the opinion that *P. buchii* and *P. ornati* [*alpina*] are not synonymous I have decided not to adopt the former name for the Indian specimens now recorded.

P. ornati ranges in Europe from the Aalenian to the top of the Callovian, and occurs in great abundance in the "*Posidonia alpina* beds" (Bathonian-Callovian) of the southern Alps and Balkans. It is also known from the Caucasus, East Africa, Madagascar, the East Indies, and South America. F. Stoliczka (1865, p. 84) has recorded a *Posidonia* which he is "unable to distinguish from *P. ornati* Quenst." from a series of clayey slates of probably Middle Jurassic age, underlying the Spiti Shales, south of Gieumal (Spiti).

Occurrence and Material.—Upper Bathonian [*vel* Callovian], Lower Chari, lower *macrocephalus* Beds ["*Scyphia* limestone" of Stoliczka, MS.], N. W. of Jumara[1]—two specimens (G. S. I. No. K40/578, colld. F. Stoliczka).

Family: *ISOGNOMONIDAE.*

The family Isognomonidæ ["Pernidæ"] was founded by W. H. Dall (1895, p. 520) for the reception of several well-known genera of highly inequilateral, posteriorly alate, byssiferous shells characterized by a serial, multivincular ligament. This family, whose earliest known representatives appear in the Upper Palæozoic, was obviously derived from the Pteriidæ, and it is possible that its various genera may have arisen independently from different genera of that family. As in the Pteriidæ, the development of hinge-teeth is inconstant. The ontogeny of the shell in *Isognomon* itself has been studied by R. T. Jackson (1890, pp. 327-330) and F. Bernard [1896 (2), pp. 432-3], who show that teeth are present at an early stage in growth, although the full-grown shell is edentulous.

One of the most interesting groups of shells referable to this family is that to which the generic name *Gervillia* is usually applied. The numerous species which have been included in this genus show such diversity in form and in dentition that the question of their more detailed classification has been much discussed, notably in papers by F. Frech (1902), E. W. Benecke (1905, pp. 126-144), L. Waagen (1907, pp. 170-2), W. O. Dietrich (1910) and Mlle S. Gillet [1924 (1)].

The genotype of *Gervillia*, *G. solenoides* J. A. Eudes-Deslongchamps (*ex* Defrance, vernac.), from the Mæstrichtian, is a narrow, elongate, curved, ensiform

[1] Other specimens from N. W. of Jumara bearing Stoliczka's same reference number and preserved in a comparable matrix belong to the species *Grammatodon* (*Indogrammatodon*) *virgatus* (J. de C. Sowerby), *Modiolus glendayi* Weir, *Modiolus* (*Inoperna*) *plicatus* J. Sowerby, *Eligmus rollandi* Douvillé, *Ctenostreon* sp., *Opis* spp., and *Ceratomya* sp.

species with terminal umbones and frequently with a rostrum-like antero-ventral projection. Between this rostrum and the umbones a short but wide gape, affecting both valves to an equal extent, served for the passage of the byssus. The dentition consists of a series of unequal, narrow, transverse crenulations which are present either along the whole length, or only at each end, of the hinge-margin, together with elongate posterior lateral teeth (one in the right valve and two in the left) which diverge only slightly from the hinge-margin.[1]

Species closely resembling *G. solenoides* in shape first appear in the Trias, and reappear in the Lias,[2] Upper Jurassic, and Lower Cretaceous. They appear to constitute a very natural group deserving separation as a distinct genus from the remaining species hitherto referred to *Gervillia*. In addition to the peculiar shape of the shell and the absence or extreme reduction of the anterior wing, these forms, from the Trias onwards, are characterized by the considerable width and high position of the byssal gape,[3] and by the rostrum which tends to be developed below it. To this group the generic name *Gervillia* [synonyms, *Gervilliopsis* R. P. Whitfield (1885, p. 73), *Dalliconcha* C. A. White (1887, p. 34), and *Ensigervilleia* W. O. Dietrich (1910, p. 236)] must be restricted. The species of the Trias and Lias are separable subgenerically on account of differences in hinge-structure, and the name *Cultriopsis* M. Cossmann (1904, p. 510) [synonym, *Angustella* L. Waagen (1907, p. 170)] is available for them. The dentition of *Gervillia* s. str. could, I consider, have been derived from that of *Cultriopsis*.

We must therefore consider what generic names are available for the remaining species which have been assigned by past authors to *Gervillia*; for L. Waagen (1907, p. 171), in proposing the name *Gervillella* to include all such species, ignored the claims of a number of names with many years' priority.

The earliest representatives of the *Gervillia* group known to us are the small Upper Palæozoic shells for which W. King (1848, p. 10; 1850, p. 166) long ago proposed the generic name *Bakevellia*. These are comparatively small, *Pteria*-like forms with two cardinal teeth and usually only one lateral tooth in each valve, all parallel with the hinge-margin. This group is continued into the Trias by a number of species comparable to the earlier ones in shape, and sometimes [*e.g. Bakevellia costata* (Schlotheim) var. *goldfussi* (Strombeck), C. v. Schauroth, 1857, Pl. V, fig. 5] with very similar dentition. The dentition, however, may vary considerably even in the same species (cf. V. Hohenstein, 1913, p. 51). In most specimens of *B. costata* the anterior teeth are more nearly perpendicular to the hinge-margin than parallel with it.

Species resembling *Bakevellia* both in shape and in dentition also occur in the Jurassic [*e.g. B. waltoni* (Lycett), here recorded from the Indian Bathonian] and in the Cretaceous. The subgenus *Pseudogervilleia* Gillet (1922, p. 106) was

[1] For figures of *G. solenoides* see J. de C. Sowerby, 1826, vol. VI, Pl. DX, fig. 4; G. B. Sowerby, 1833, *Gervillia* Plate, fig. 1; and E. Holzapfel, 1889, p. 223, Pl. XXIV, figs. 11, 12.

[2] Several such Triassic species are illustrated by A. Bittner (1895, Pl. IX, figs. 7-19; also 1901, Pl. IV, figs. 18-25). Liassic species are *G. lanceolata* (J. de C. Sowerby) (1826, vol. VI, p. 17, Pl. DXII, fig. 1), *G. acuminata* Terquem (1855, p. 316, Pl. XXI, fig. 15), and *G. falciformis* Cossmann (1904, p. 510, Pl. XVI, figs. 16-18).

[3] The byssal gape of a Triassic species of this group is clearly illustrated by A. Bittner (1901, Pl. IV, fig. 23); and that of a Cretaceous species by R. P. Whitfield (1885, Pl. XV, fig. 9).

founded on a Cretaceous species of this group; its author remarks on its close similarity to "*Gervillia*" *costata* of the Trias, and considers it to constitute a reversion to an ancestral type. It seems to be more correctly regarded as an unmodified descendant of the early Bakevellias.

I now suggest, therefore, that the generic name *Bakevellia*, which has been abandoned by most authors, should be revived and employed for the series of *Pteria*-like "Gervillias" which persisted from the Upper Palæozoic to the Cretaceous and probably constituted the parent-stock from which the remaining groups, with the possible exception of *Gervillia* as here restricted and *Hœrnesia* Laube (which cannot here be discussed), were derived.

As is well shown by the figures published by H. Credner (1851, Pl. VI), the Trias was a period in which there was great instability in the hinge-characters of the members of this stock. These Triassic forms do not, however, include any groups which are distinctive enough to be worth separating from *Bakevellia* s. str. In the Jurassic, however, there arose two well-characterized groups.

The first group is that which includes "*Gervillia*" *hartmanni* Goldfuss, of the Bajocian, and "*G.*" *alæformis* (J. Sowerby), of the Cretaceous. The shell is *Pteria*-like in outline, as in *Bakevellia* s. str., but in addition to well-defined cardinal teeth, the hinge (F. Frech, 1902, p. 614) has numerous transverse crenulations which may border the entire hinge-line; the shell may attain considerable dimensions. The dentition is probably a modification of that observable in some of the Triassic forms, in which several narrow oblique teeth may replace the laterals. For this group, which may be regarded as a subgenus of *Bakevellia*, the name *Aguileria* C. A. White (1887, p. 35; type, *A. cummingsi* White) is available.

The second group [the "group of *Gervillia aviculoides*" of F. Frech (1902, p. 613)] includes a series of elongate, narrow-bodied species which, although probably derived from *Bakevellia*, differ sufficiently both in shape and dentition to deserve recognition as a distinct genus, for which Waagen's name *Gervillella* is available. Its distinctive characters are described more fully below.

Further research will, no doubt, lead to the recognition of other groups of "*Gervillia*" to which it will ultimately prove desirable to accord subgeneric, or even generic, rank. It is particularly noticeable how, in the evolution of some of these groups, the shell has gradually increased in size and thickness. Thus from the small and comparatively thin-shelled Bakevellias of the Upper Palæozoic there evolved ultimately the two groups of large and massive forms of the Jurassic and Cretaceous which, as shown above, are separable under the subgeneric name *Aguileria* and the generic name *Gervillella* respectively. Nevertheless, this evolutionary trend is not observable in every group. In the ensiform stock to which the name *Gervillia* must be restricted the last surviving forms, which occur in the Upper Cretaceous, are not very much larger than the earliest representatives, from the Trias; and even in the Cretaceous there occur representatives of *Bakevellia* which differ but little in size from those of the Upper Palæozoic.

Genus : Bakevellia W. King, 1848.

A Catalogue of the Organic Remains of the Permien [*sic*] Rocks of Northumberland and Durham, p. 10.

Genotype.—*Avicula antiqua* Münster (in A. Goldfuss, 1836, p. 126, Pl. CXVI, fig. 7), Permian, Europe.

Generic Characters.—Shell trapeziform, bialate, very inequilateral, transversely elongated, more or less inequivalve, with the right valve the less inflated ; much resembling the genus *Pteria* in general shape. The valve-margins usually lie approximately in a plane. Dentition consisting, typically, of two short cardinal teeth and one or two elongate sub-horizontal lateral teeth in each valve ; the inclination of the cardinal teeth varies from sub-horizontal to vertical, but is usually more or less oblique. In some species, however, the teeth may be more or less obsolete, while in others (particularly in the Trias) several more or less oblique teeth occupy the whole length of the hinge-line posterior to the cardinals ; in a few forms (subgenus *Aguileria*) the greater part of the hinge-line is bordered by a series of narrow transverse crenulations. Anterior adductor scar of moderate size in the early forms, small or indistinct in the later forms. Byssal gape narrow or obsolete.

Remarks.—As already explained, I consider that the generic name *Bakevellia* should be employed for the whole series of *Pteria*-like " Gervillias " which persisted from the Upper Palæozoic to the Cretaceous, and from which the subgenus *Aguileria* and the genus *Gervillella* were derived in Jurassic times. In the Jurassic, *Bakevellia* appears to be most abundant in the Lias and Inferior Oolite, but a few species, such as the one described below, occur at higher horizons.

Subgenus : Bakevellia s. str.

Subgeneric Characters.—Shell small or of medium size. Dentition consisting of distinct cardinals and laterals ; or of cardinals and a few more or less oblique laminæ replacing the laterals.

Bakevellia waltoni (Lycett).

Plate VII, figs. 1-7.

Gervilia atala A. d'Orbigny, 1850, Prodrome de paléontologie stratigraphique universelle, vol. I, p. 313.

Gervillia waltoni J. Lycett, 1863, Supplementary Monograph on the Mollusca from the Stonesfield Slate, Great Oolite, etc., *Pal. Soc. London*, p. 110, Pl. XXXII, figs. 4, 4*a*, *b*.

Gervillia waltoni E. T. Paris, 1911, " Notes on some Species of *Gervillia* from the Lower and Middle Jurassic Rocks of Gloucestershire," *Proc. Cotteswold Nat. F. C.*, vol. XVII, p. 251, Pl. XXIX, figs. 2*a-c*.

Gervilia atala A. Thevenin, 1913, " Types du Prodrome de d'Orbigny," *Ann. Paléont.*, vol. VIII, p. 162, Pl. XXVII, fig. 39.

Gervillia waltoni W. J. Arkell, 1931, " The Upper Great Oolite, Bradford Clay and Forest Marble of South Oxfordshire," *Quart. Journ. Geol. Soc.*, vol. LXXXVII, p. 597, Pl. XLIX, figs. 1-3.

Description of the Specimens from Kachh.—The shell is of medium size for the genus, well inflated, slightly to rather pronouncedly inequivalve, with the length equal to or slightly exceeding the height, and with a straight and moderately wide body, the obliquity of which (measured by the angle between the hinge-margin and the most distant point of the postero-ventral margin) is approximately 45°. The test is thick. The valve-margins lie approximately in a plane. The posterior wing is elongate, sharply pointed, and of moderate width; the anterior wing is short, but wide, and is rounded at its extremity, with a strongly convex anterior margin. The umbones are narrow, and are curved so as to point in an anterior direction; in the left valve the umbonal region is well inflated, but the umbo is not appreciably incurved; in the right valve the umbonal region is compressed. The body of the shell is strongly convex in the left valve and feebly convex in the right; the level of its surface falls away gradually in both valves to that of the rather flattened posterior wing, and steeply to the anterior wing, from which it is separated by a more or less well-defined sulcus. The posterior extremity of the body either falls vertically below, or projects very slightly beyond, the extremity of the posterior wing. There is only a moderately deep sinus of the posterior margin below the posterior wing, and the ventral portion of this margin is straight and inclined so as to form an angle of 110°-120° with the hinge-margin. The postero-ventral margin of the body is usually evenly rounded, but is occasionally sub-angular. The antero-ventral margin has a median concavity, more pronounced in some specimens than in others. The growth-lines of the left valve indicate the presence of a byssal gape in early stages of growth, but in the full-grown shell this gape has disappeared.

The surface of the shell is usually unornamented, but in one specimen which otherwise appears to be specifically inseparable from the remainder there are traces of radial ribbing. Most of the specimens have very coarse, irregular growth-rugæ, and on the posterior wing there may be two or three pronounced ridges parallel to the hinge-margin, as in *Pteroperna*.

The cardinal areas of the two valves are fairly wide, and diverge at an angle varying between about 70° and 110°; each bears about five ligamental pits of varying width. The dentition consists usually of 2—4 narrow, oblique cardinal teeth, borne by the thick shell-wall just below the umbo and forming an angle of about 60° with the hinge-margin, together with a single short and weak, curved posterior lateral tooth, which is situated at the extreme end of the hinge-line. On the largest specimen examined (a right valve) the cardinal teeth appear, however, to be nearly obsolete.

Dimensions.—The following are the measurements of a left valve (G. S. I. No. K40/581) of about average size, and of a rather larger right valve (Brit. Mus. L. 71548):—

	Length.	*Height.*	*Inflation.*
Left valve	36·0 mm.	28·5 mm.	9·7 mm.
Right valve	41·5 mm.	41·5 mm.	8·0 mm.

Remarks.—A. B. Wynne long ago (1872, p. 105) pointed out the apparent identity of the Indian species now described with "*Gervillia*" *waltoni*, of the

English Bathonian. Dr. W. J. Arkell, who records [1931 (2), p. 572] that at one horizon in the Great Oolite of South Oxfordshire this species occurs in hundreds, has kindly lent me a series of well-preserved specimens from Gibraltar Quarry, Enslow Bridge. The Indian and Engish species appear to me to be absolutely identical, since they agree perfectly both in the general shape of the shell and in hinge-structure.

Now that the types of d'Orbigny's 'Prodrome' have been described it is obvious that *G. waltoni* is identical with the French Bathonian form to which d'Orbigny gave the name *G. atala*, which would appear, from the Index to vol. III of the 'Prodrome', to be a misprint for *G. alata*. The question whether the names for new species described in this work should be accepted as valid or whether, by suspension of the Rules, they might be rejected as being no better characterized than had they been published as mere *nomina nuda* was submitted by Dr. W. J. Arkell and myself to the International Commission on Zoological Nomenclature a few years ago. The findings of the Commission are embodied in Opinion 126.[1] This Opinion is of great importance as establishing a new (or previously unappreciated) principle in nomenclature, namely, that the systematist is free to use his discretion in rejecting specific names based on descriptions which he considers inadequate for definition of the species in favour of later but more adequately defined names.[2]

This Opinion is highly unsatisfactory in that it countenances the introduction of an element of subjectivity in the choice of a specific name which is likely to lead to an increasing lack of uniformity in nomenclature. Since, however, it has not yet been countermanded I appear to be justified in rejecting d'Orbigny's name *G. atala* on the grounds that the original diagnosis was inadequate for its definition.

G. waltoni appears to have been very little cited in the literature, and its only mention by a foreign author which I have been able to trace is by D. Ilovaisky (1904, p. 252), who records a *Gervillia* cf. *waltoni* from the Oxfordian of Russia.

Gervillia iranoënsis R. B. Newton (1895, p. 80, Pl. II, figs. 8, 9), from the Bathonian of Madagascar, bears some resemblance to this species, but is more strongly inflated, less inequivalve, and more curved.

Occurrences and Material.—Bathonian, Patcham Beds (*Corbula lyrata* horizon) of the following localities:—Dhorawar (Patcham)—six specimens (G. S. I. No. K40/581, colld. A. B. Wynne); cliffs north of Guddera (Bela)—13 specimens (G. S. I. No. K40/579, colld. A. B. Wynne); north of Lodranee (Bela)—one specimen

[1] Published in the *Smithsonian Miscellaneous Collections*, vol. LXXIII, no. 8, pp. 5-22 (1936).

[2] The argument by which this conclusion is reached, however, is based on a misquotation of the Rules. Thus the Opinion reads (p. 15) "He [Dr. Richter] maintains that, according to Article 25, a species name is validated by a description. Now Article 25 does not say this. It says that a name cannot be valid unless "accompanied by an indication, or a definition, or a description." ..... All that follows from this is that a name accompanied by a description should be considered, but whether the description is sufficient to validate the name is a question to be decided by the reviser."

Actually, Article 25 states that "the valid name of a genus or species can be only that name under which it was first designated on the condition....that this name was published and accompanied by an indication, or a definition, or a description." In other words, Dr. Richter was perfectly correct in maintaining that a species name is validated by a description irrespective of the quality of the description. It was for this reason that Dr. Arkell and I considered that d'Orbigny's names would have to stand unless the Rules were suspended in their particular case, and it was our opinion that the circumstances justified such a suspension of the Rules.

(G. S. I. No. K40/580, colld. A. B. Wynne); Karrir—nine specimens (Brit. Mus. L. 71539-47, colld. J. F. Blake); Kuari Bet—eight specimens (Brit. Mus. L. 71548-55, colld. J. F. Blake).

Upper Bathonian [*vel* Callovian], Lower Chari, *macrocephalus* Beds, north of Gaduada (Karrir) ["lower beds, *Nucula* Flags" of Blake, MS.]—seven specimens (Brit. Mus. L. 71555-61, colld. J. F. Blake).

Bakevellia (sensu lato).

Bakevellia sp.

Plate VII, fig. 9.

Description.—The shell is fairly large, of moderate inflation, probably only slightly inequivalve, and elongate, with a moderately wide body which is so strongly curved that its tapering posterior end points in a postero-dorsal direction. The valve margins lie approximately in a plane. The posterior wing, to which the level of the surface of the body declines rather gradually, is of moderate width; its extremity is broken away in the available specimens, so that it is uncertain if it was obtuse or sharply pointed. The anterior wing is acute and of moderate size. The umbones appear to have been narrow and compressed. The anterior and ventral margins meet in a very strongly convex curve.

Dimensions.—The original measurements of the more complete specimen may be estimated, very approximately, as follows:—

Length	75 mm.
Height	25 mm.

Remarks.—Unfortunately the only two available specimens, a right and a left valve found on the surface of the same slab of limestone, are so incomplete and eroded that it seems inadvisable to name them. They obviously belong, however, to a species which differs considerably from any of the other forms from Kachh described in the present Memoir; nor is there any species described in the literature of other regions to which they could definitely be referred.

They agree very closely, however, with an undetermined internal cast in the British Museum (Natural History) which probably came from the Inferior Oolite of Dundry, near Bristol.[1] This specimen could conceivably be an abnormal representative of the rare species *Gervillia aurita* Lycett [1850 (2), p. 421, Pl. XI, fig. 4; also E. T. Paris, 1911, p. 240, Pl. XXIX, fig. 6), from the English Inferior Oolite, but its posterior end is more upcurved than in Lycett's holotype, and the end of its posterior wing is broken away, so that it is impossible to say if its tip was acutely pointed.

Another comparable species is *Gervillia islipensis* Lycett (1863, p. 37, Pl. XL, fig. 35; also E. T. Paris, 1911, p. 245, Pl. XXIX, fig. 4), from the English Stonesfield Slate and Cornbrash, but that species is much less elongate.

[1] The cast to which I refer has been examined by Mr. J. W. Tutcher, of Bristol, who informs me that its matrix agrees with that of the basal Bajocian beds at Dundry, but that the specimen, if found there, is unique.

The species of the group now under discussion differ from *Gervillella* in the general shape and weaker convexity of the shell. It appears preferable to refer them to *Bakevellia* s. lat.

Occurrence and Material.—Divesian, *athleta* Beds, south of Juria[1]—two specimens (G. S. I. No. K40/582, colld. A. B. Wynne).

Genus : GERVILLELLA L. Waagen [1906], 1907.

" Über die Lamellibranchiaten der Frombachtuffe nebst Bemerkungen über deren verwandtschaftliche Beziehungen," *Verh. k. k. geol. Reichsanst.*, 1906, p. 395 (no diagnosis given or species definitely cited). Also " Die Lamellibranchiaten der Pachycardientuffe der Seiser Alm," *Abh. k. k. geol. Reichsanst.*, vol. XVIII, Pt. 2, 1907, pp. 98, 171.

Genotype.—Perna aviculoides J. Sowerby (1814, vol. I, p. 147, Pl. LXVI), Corallian, Europe. Now designated.

Generic Characters.—Shell medium-sized to large, narrow and greatly elongated, with a straight or slightly curved body ; bialate, strongly inflated, slightly inequivalve, the postero-ventral margin of the left valve sometimes overlapping that of the right ; test thick. Posterior wing narrow and obtuse-angled ; anterior wing acutely pointed, much produced postero-ventrally below the body of the shell, from which it is separated, in the left valve only, by a narrow groove. The valve margins either lie in a plane or have a slight antero-ventral sinuosity. Byssal gape absent. Dentition consisting of an anterior series of from two to four, and a posterior series of one or two, elongate, parallel teeth, which are borne by the thickened shell-wall below the cardinal area, and slope in a postero-ventral direction, forming a very acute angle with the hinge-margin. Anterior adductor obsolete.

Remarks.—The group of shells to which I apply the name *Gervillella* appears to have arisen as an offshoot from *Bakevellia*, but is sufficiently well characterized both in external characters and in dentition to rank as a distinct genus. The dentition is much more constant than in other genera of the *Gervillia* group, while the peculiar manner in which the anterior auricle is extended postero-ventrally and demarcated by a groove in the left valve is also a very constant feature.

There is some superficial resemblance between the species of this group and those of the genus *Gervillia*, as here restricted, but the latter is clearly distinguished by its wide, anteriorly situated byssal gape, by the absence or extreme reduction of the anterior auricles, and by its hinge-structure which, although variable, never approaches that of *Gervillella*.

GERVILLELLA SILIQUA (J. A. Eudes-Deslongchamps).

Plate VII, figs. 12-14.

Gervillia siliqua J. A. Eudes-Deslongchamps, 1824, " Mémoire sur les coquilles du genre Gervillie," *Mém. Soc. Linn. Calvados*, vol. I, p. 128, Pl. IV, figs. 1-4.

[1] The matrix contains a small ammonite which Dr. L. F. Spath has determined as *Hubertoceras* sp. and numerous specimensof *Grammatodon* (*Indogrammatodon*) *virgatus* (J. de C. Sowerby).

? *Gervillia pernoides* J. A. Eudes-Deslongchamps, 1824, *loc. cit.*, p. 126 (*partim*), Pl. II, figs. 1, 2 (*non* Pls. I and III).

Gervillia aviculoides A. d'Orbigny, 1845, in R. I. Murchison, E. de Verneuil and A. de Keyserling, Géologie de la Russie d'Europe et des montagnes de l'Oural, vol. II, p. 474, Pl. XLI, figs. 14, 15 (*non* J. Sowerby sp.).

Gervillia acuta F. Stoliczka, 1867, in Appendix to W. T. Blanford, "On the Geology of a Portion of Cutch," *Mem. Geol. Surv. Ind.*, vol. VI, p. 19, listed (*non* J. de C. Sowerby).

Gervillia aviculoides H. A. Rœder, 1882, Beitrag zur Kenntniss des Terrain à Chailles und seiner Zweischaler, p. 61, Pl. III, figs. 13 *a-d.*

? *Gervillia* cf. *pernoides* Deslongchamps; P. de Loriol, 1897, "Étude sur les mollusques et brachiopodes de l'Oxfordien supérieur et moyen du Jura bernois," *Mém. Soc. pal. suisse*, vol. XXIV, p. 122, Pl. XV, figs. 5, 7.

Gervillia rœderi P. de Loriol, 1901, *op. cit.*, premier supplément, *Mém. Soc. pal. suisse*, vol. XXVIII, p. 95, Pl. VII, figs. 2-4.

Gervillia aviculoides E. Krenkel, 1915, "Die Kelloway-Fauna von Popilani in Westrussland," *Palæontographica*, vol. LXI, p. 293, Pl. XXVI, figs. 4-7 (*non* J. Sowerby sp.).

Gervillia siliqua H. Douvillé, 1916, "Les terrains secondaires dans le massif du Moghara à l'est de l'Isthme de Suez," *Mém. Acad. Sci. Paris*, ser. 2, vol. LIV, Pl. IX, fig. 11.

? *Gervillia acuta* E. Hennig, 1924, "Der mittlere Jura im Hinterlande von Daressalaam (Deutsch-Ostafrika)," *Monogr. Geol. u. Pal.*, ser. 2, Heft 2, p. 105, Pl. II, fig. 14 (*non* J. de C. Sowerby).

Description of the Specimens from Kachh.—The shell, which attains a moderately large size for the genus, is narrow, greatly elongated, strongly inflated, and moderately inequivalve. The test is thick. Except in the smaller specimens, the body of the shell is nearly parallel-sided along the greater part of its length; in early stages of growth it is nearly straight, with its main axis diverging from the hinge-margin at an angle of about 25°; in later stages of growth, however, its posterior end is pronouncedly upcurved. The hinge-margin is short, the posterior wing very obtuse-angled, narrow, and flattened: the anterior wing is acutely pointed and rather elongate. The umbones are acute, the left moderately inflated and rising very slightly above the hinge-margin, the right compressed and level with the hinge-margin. In the left valve the body of the shell is evenly and strongly convex, the level of its surface falling away rather steeply to the posterior and anterior wings, the latter of which is demarcated by a narrow groove; in the right valve the body is less strongly convex and, in one specimen, is separated from the posterior wing by a depression of the surface. The valve-margins lie approximately in a plane. The ventral margin presents an even convexity, and there is no trace of a byssal sinus. The posterior extremity of the shell is evenly rounded.

The details of the cardinal area are not visible in any of the available specimens, nor is the interior of the shell exposed in any complete specimen. A frag-

ment of a left valve, however, shows an anterior series of three parallel, moderately elongate teeth, which diverge from the hinge-margin at an angle of about 15°.

Dimensions.—The measurements of the largest specimen are as follows:—

Length (original, estimated)	120 mm.
Height	40 mm.
Inflation	23 mm.

Remarks.—The original type of *Gervillia siliqua* came from the Divesian of the Vaches-Noires, on the coast of Normandy, where the species appears to be not uncommon. Another specimen from the type-locality is figured by A. d'Orbigny in his work on Russian fossils cited above in the synonymy, but is referred by him to *G. aviculoides* (J. Sowerby). There are also some good topotypes in the collection of the British Museum (Natural History).

G. siliqua is especially characterized by its slightly curved, narrow, parallel-sided body, by its short hinge-margin and consequently very obtuse-angled posterior wing, and by its long and acute anterior wing.

In the paper in which it was originally described its description followed that of the species *G. pernoides* (J. A. Eudes-Deslongchamps, 1824, p. 126, Pls. I-III), from which it was stated to be distinguishable mainly by its smaller size. More than one species appears, however, to have been included by Eudes-Deslongchamps in *G. pernoides*. The original of his Pl. I, which I designate as lectotype of the species, came from the Inferior Oolite of the quarries at Quilly, near Bretteville-sur-Laize, in Normandy. Better preserved specimens from the type-locality must be figured before this species can be accurately interpreted, but it may prove to be identical with the Inferior Oolite form later described by J. Lycett (1857, p. 127, Pl. VI, fig. 6) as *Gervillia prælonga*. The differences between *G. prælonga* and *G. siliqua* are very slight, but in the former species there is a definite sinuosity of the antero-ventral margin, so that the valve-margins do not lie exactly in a plane. I attach no importance to the difference in size stated by Eudes-Deslongchamps to distinguish *G. siliqua* from *G. pernoides*. The original of his Pl. II illustrating *G. pernoides* came, like the type of *G. siliqua*, from the Divesian of the Vaches-Noires, and is most probably a larger specimen of the same species. The original of Pl. III came from an unknown horizon of the German Jurassic.

The specimen from the Terrain à Chailles of southern Alsace figured as *G. aviculoides* by H. A. Rœder appears to me to be referable to *G. siliqua*, with which it agrees in all essential characters, apart from the fact that the umbonal region of its left valve is slightly more prominent. Rœder's specimen is of about the same size as the original type of *G. siliqua*, but de Loriol figures much larger specimens which he considers identical with Rœder's species (re-named by him *G. rœderi*); these specimens came from the Divesian of the Bernese Jura. A further synonym of *G. siliqua* appears to be Krenkel's *G. aviculoides*, from the Callovian (*jasoni* Zone) of Popilani, in Lithuania.

G. siliqua and related species, including the large forms of the group of *G. aviculoides*, may have been derived from *G. acuta* J. de C. Sowerby (1826, vol. VI,

p. 15, Pl. DX, fig. 5), described originally from the Aalenian Collyweston Slate of Lincolnshire. *G. acuta* has itself been recorded in England from all horizons from the Aalenian to the Oxford Clay, but records from the higher horizons need confirmation. It rarely attains the size even of the original type of *G. siliqua*, and never that of the much larger specimens which I now include in that species. From specimens of *G. siliqua* of comparable size it is distinguished by its more pronounced posterior taper. Thus the specimen from the Divesian (?) of East Africa assigned by Hennig to *G. acuta* may be a small specimen of *G. siliqua*.

The Indian specimens now described were originally determined by Stoliczka as *G. acuta*; although incomplete, they appear, however, to agree with *G. siliqua* in the essential characters of the shell. Their geological horizon, moreover, is approximately the same as that at which *G. siliqua* occurs in Europe. I consider, therefore, that they may be definitely assigned to that species.

Occurrences and Material.—Divesian, *athleta* Beds, of the following localities:—Charwar [" Bed No. 2 " of Blake, MS.[1]]—one specimen (Brit. Mus. L. 71566, colld. J. F. Blake); Fakirwadi-Samatra range—two specimens (G. S. I. No. K 22/294, colld. J. H. Smith).

Divesian, lower Dhosa Oolite, of the following localities:—East of Badi [" Bed No. 3 " of Blake, MS.[2]]—one specimen (Brit. Mus. L. 71567, colld. J. F. Blake); Walakhavas [" Bed No. 2 " of Blake, MS.[3]]—one specimen (Brit. Mus. L. 71568, colld. J. F. Blake); Juria—nine specimens (G. S. I. No. K 40/583, colld. W. T. Blanford).

Gervillella kantkotensis sp. nov.

Plate VIII, figs. 1-5.

Description.—The shell is large and massive, strongly inflated, elongate, and claviform in shape; it is slightly inequivalve, with the postero-ventral margin of the left valve overlapping that of the right. The valve-margins do not lie in a plane; when the shell is viewed from below, the antero-ventral margin of the left valve is seen to have a wide and shallow sinus, to which there corresponds a slight convexity in the margin of the right valve. The body of the shell, whose median line curves downward more or less pronouncedly in a posterior direction, is of medium width, and more or less parallel-sided posteriorly, but is very noticeably attenuated anteriorly, the attenuation being accentuated in most specimens by a concavity of the antero-ventral margin. The line of maximum inflation of the body, which coincides approximately with its median line, makes an average angle of about 16° with the hinge-margin; in some specimens the most inflated region of the shell lies at about the middle of its length, but in others its position is considerably more anterior. The hinge-margin is of moderate elongation, occupying up to two-thirds of the total length of the shell; the posterior wing is flattened, obtuse-angled, and of moderate width, the anterior wing elongated and sharply pointed. The level of the surface of the body falls away

[1] *See* L. F. Spath, 1933, p. 753.
[2] *See* L. F. Spath, 1924, p. 23.
[3] *See* L. F. Spath, 1933, p. 752.

rather steeply to that of the posterior wing, the line of separation of these two portions of the shell presenting a more or less pronounced upward-facing concavity. The postero-dorsal margin is straight or slightly concave, meeting the hinge-margin in an angle of about 150° and merging in an even curve with the strongly convex postero-ventral margin.

The cardinal areas of the two valves diverge at an angle of about 60°; each area may attain a width of as much as 16 mm., but is narrower in some specimens. The ligamental pits, which are deeply impressed and of variable width, number up to about seven in each valve. The hinge-teeth of the anterior series, which form an angle of about 15° with the hinge-margin, consist, in the right valve, of a strong median tooth separated by a wide and deep groove from a much weaker tooth above it, and by a narrower and shallower groove from a similarly weak tooth below it; above and posterior to these, about three short, inconspicuous teeth may also occur. The teeth of the posterior series diverge from the hinge-margin at a slightly smaller angle than those of the anterior series, from which they are well separated, and consist of a strong, elongate tooth below, separated by a deep groove from a weaker tooth above it.

The surface of the shell is unornamented except for irregularly spaced growth-rugæ.

Holotype.—G. S. I. type No. 16533 (Pl. VIII, fig. 1).

Dimensions.—The measurements of the holotype are as follows:—

Length	157 mm.
Height	55 mm.
Inflation (probably diminished by crushing)	28 mm.

Remarks.—This species very closely resembles *Gervillella aviculoides* (J. Sowerby),[1] from the Argovian of England, but in that species the body of the shell has a graceful sigmoidal curve and the boundary between it and the posterior wing presents a distinct upward-facing concavity along the greater part of its length, in contrast to the corresponding convexity in the species now described. *G. aviculoides* has not the pronouncedly claviform shape of the species now described, as its anterior attenuation is less gradual. These differences are at least as marked as those which distinguish *G. aviculoides* from comparable species from other horizons, such as *G. sublanceolata* (d'Orbigny), from the Lower Cretaceous.

The Kimmeridgian species *Gervillella tetragona* (Rœmer), as interpreted by J. Thurmann and A. Étallon (1862, p. 233, Pl. XXXI, fig. 3) and by P. de Loriol (1872, p. 366, Pl. XX, fig. 8; also 1875, p. 165, Pl. XIX, figs. 3-5), is also comparable in size and general appearance, but, like *G. aviculoides*, from which it differs in its straighter body, has not the claviform shape and gradual anterior attenuation which characterize the Indian species now described.

Occurrences and Material.—Argovian of the following localities:—Iddurghur [" *Astarte* beds A and B " of J. H. Smith][2]—the holotype and six paratypes (G. S. I. type No. 16534 and No. K 40/584, colld. J. H. Smith; also K 40/587,

[1] *See* W. J. Arkell, 1933, p. 203, Pl. XXVI, figs. 1-5, for the most recent discussion of this species.

[2] *See* L. F. Spath, 1935, pp. 185-6.

colld. F. Stoliczka; and Brit. Mus. L. 71563, colld. J. F. Blake); east of Chowbari —seven specimens (G. S. I. type No. 16535 and No. K 40/585, colld. A. B. Wynne); between Kantkote and Adooi—one specimen (G. S. I. No. K 40/586, colld. A. B. Wynne); Gangta Bet [labelled "higher beds" by Blake[1]]—two specimens (Brit. Mus. L. 71564-5, colld. J. F. Blake).

GERVILLELLA ANCEPS (Deshayes MS., Leymerie).

Plate IX, figs. 1-5.

Gervillia anceps Deshayes, A. Leymerie, 1842, "Mémoire sur le terrain crétacé du département de l'Aube," *Mém. Soc. géol. France*, ser. 1, vol. V, Pt. 1, p. 9, Pl. X, figs. 3 *a-c*.

Gervillia anceps A. d'Orbigny, 1845, Paléontologie française. Terrains crétacés, vol. III, p. 482, Pl. CCCXCIV.

Gervillia dentata F. Krauss, 1850, "Über einige Petrefacten aus der untern Kreide des Kaplandes," *Verh. K. Leopold.-Carol. Akad. Naturforscher*, vol. XXII, Pt. 2, p. 458, Pl. L, figs. 1 *a.c.*

Gervillia anceps E. von Eichwald, 1868, Lethæa Rossica, vol. II, p. 528.

Gervillia anceps F. J. Pictet and G. Campiche, 1869, "Description des fossiles du terrain crétacé des environs de Sainte-Croix," *Mat. Pal. suisse*, ser. 5, p. 82, Pl. CLV, fig. 5 (copied from d'Orbigny).

Gervillia dentata G. Müller, 1900, "Versteinerungen des Jura und der Kreide," Deutsch-Ostafrika, vol. VII, p. 548, Pl. XXIV, figs. 8, 9.

Gervillia anceps N. I. Karakasch, 1907, "Le crétacé inférieur de la Crimée et sa faune," *Trav. Soc. imp. Nat. St. Pétersbourg*, vol. XXXII, Livr. 5, p. 194.

Gervillia dentata E. Krenkel, 1910, "Die untere Kreide von Deutsch-Ostafrika," *Beitr. Pal. Österr.-Ungarns*, vol. XXIII, p. 204 (*partim*).

Gervillia dentata E. Lange, 1914, "Die Brachiopoden, Lamellibranchiaten und Anneliden der *Trigonia schwarzi* Schicht," *Archiv. f. Biont.*, vol. III, Heft 4, p. 204 (*partim*).

Gervilleia (*Gervillela*) *anceps* S. Gillet, 1922, "Étude de la fauna de Lamellibranches du Calcaire à Spatangues (Hauterivien supérieur)," *Bull. Soc. Sci. hist. nat. Yonne*, vol. LXXV, Pt. 2, p. 105.

Gervilleia anceps S. Gillet, 1924, "Études sur les Lamellibranches néocomiens," *Mém. Soc. géol. France*, N. S., No. 3, p. 43, text-fig. 17.

Gervillela anceps G. Corroy, 1925, "Le Néocomien de la bordure orientale du bassin de Paris," *Bull. Soc. Sci. Nancy*, ser. 4, vol. II, p. 336.

Gervillia anceps C. E. Weaver, 1931, "Paleontology of the Jurassic and Cretaceous of West Central Argentina," *Mem. Univ. Washington*, vol. I, p. 203, Pl. XIV, figs. 58, 59.

Gervillia dentata J. V. L. Rennie, 1936, "Lower Cretaceous Lamellibranchia from Northern Zululand," *Ann. S. African Mus.*, vol. XXXI, p. 310, Pls. LI-LV.

[1] *See* L. F. Spath, 1933, p. 756. The ammonites *Epimayaites excentricus* Spath and *Prososphinctes virguloides* (Waagen) are in Blake's collection from the same beds.

Description of the Specimens from Kachh.—The shell is large and massive, very strongly inflated, and elongate-rhomboidal in shape; it is very slightly inequivalve, with the postero-ventral margin of the left valve overlapping that of the right. The margins of each valve lie almost in a plane. The body of the shell is moderately wide, and is almost straight except in some crushed and possibly distorted specimens, in which it has a slight sigmoidal curvature; in most specimens its ventral margin is straight and it tapers evenly in an anterior direction; occasionally, however, the ventral margin presents a distinct convexity towards its anterior end. The line of maximum inflation of the body, which coincides approximately with its median line, makes an angle of about 18° with the hinge-margin; the most inflated region of the shell usually lies at about the anterior third of its length. The hinge-margin is of moderate elongation, occupying about one-half of the total length of the shell; the posterior wing is flattened, obtuse-angled, and of moderate width; the anterior wing is usually rather wide and apparently somewhat bluntly pointed. The level of the surface of the body, particularly in the left valve, falls away steeply to that of the posterior wing; the line of separation between these two portions of the shell may be almost straight, or else present an upward-facing convexity. The postero-dorsal margin is straight or slightly concave, meeting the hinge-margin in an angle of about 150° and joining the rather flattened postero-ventral margin, which is more or less parallel to the hinge-margin, in a rather sharp curve.

The cardinal areas of the two valves diverge at an angle of about 60°; each area may attain a width of as much as 20 mm. The ligamental pits, which are deeply impressed and of variable width, number up to about eight in each valve. The hinge-teeth of the anterior series, which form an angle of about 30° with the hinge-margin, vary to some extent in their arrangement; they consist, in the right valve, of either three or four teeth, of which the second from the top is the strongest. The teeth of the posterior series diverge from the hinge-margin at a slightly smaller angle than those of the anterior series, from which they are well separated, and consist of a strong, elongate tooth below, separated by a deep groove from a weaker one above it.

The surface of the shell is unornamented except for irregularly spaced growth-rugæ and a series of closely spaced, raised growth-threads which are present on the anterior auricle.

Dimensions.—The measurements of two specimens are as follows:—

Specimen.	*Length.*	*Height.*	*Inflation.*
	mm.	mm.	
N. E. Umia (No. K 40/588)	175	66	(crushed).
			mm.
Unlocalized (No. K 40/591)	175 (estimated).	68	47

Remarks.—The species *Gervillia dentata* Krauss can scarcely be said to have been adequately known before the publication of J. V. L. Rennie's recent paper, in which a number of specimens from the type-locality, the Upper Valanginian Sundays River beds of the Uitenhage Series of Cape Province, are figured, in

addition to several from the Lower Cretaceous of northern Zululand. Rennie discusses the supposed differences between this species and the European Aptian species *Gervillella sublanceolata* (d'Orbigny), which has been very fully described and illustrated by H. Woods (1904, p. 74, Pl. X, figs. 14-16, and Pl. XI, fig. 1). He does not, however, compare it with the more closely contemporaneous species *G. anceps*, which occurs in deposits of Valanginian and Hauterivian age. I am unable to detect any difference at all between the South African form and this European species, and so regard *G. dentata* as a synonym of *G. anceps*. Other lamellibranch species are known to be common to the Neocomian deposits of the two areas, and there is nothing remarkable in a species having had so wide a geographical distribution. *G. anceps* has already been recognized as occurring so far from its type-locality as the Mangishlak peninsula of Trans-Caspia, where it is assigned to an Hauterivian horizon (N. Louppov, 1932, pp. 626, 633), and the Argentine.

The question of specific discrimination between *G. anceps* and *G. sublanceolata* cannot here be discussed in detail, but, judging by the well-preserved specimens of the latter species which have been obtained in such abundance at Atherfield, in the Isle of Wight, this differs from *G. anceps* in its narrower and more acutely pointed anterior wing, and in the less abrupt descent from the body of the shell to the posterior wing, which is, in consequence, less flattened. G. Corroy (1925, p. 472) speaks of *G. sublanceolata* as a mutation of *G. anceps*.

The specimens now recorded from India come from a horizon (Tithonian) from which no representative of this group has been described previously. They serve as a link between the Argovian-Kimmeridgian group of species of which *Gervillella aviculoides* (J. Sowerby) is the best-known representative and the Lower Cretaceous forms just discussed. In deciding to refer them to *G. anceps* rather than to a new, or to some described Jurassic, species I have been guided solely by the characters of the shell. These specimens agree so closely with some specimens of *G. anceps* (for example, Rennie's Pl. LIII, fig. 1, and Pl. LIV, illustrating specimens from the type-locality of *G. dentata*) that I can see no reason for distinguishing them under another specific name on account of their different horizon. Like *Cucullæa* (*Megacucullæa*) *kraussii* Tate, described above,[1] and *Trigonia ventricosa* Krauss,[2] *G. anceps* must, therefore, be considered to have ranged from the uppermost Jurassic to the Lower Cretaceous.

The specimens now recorded are clearly distinguishable from the European Argovian species *Gervillella aviculoides* (J. Sowerby) by the wider and straighter body of the shell; for in that species the boundary between the body of the shell and the posterior wing presents a distinct upward-facing concavity, in contrast to the corresponding straightness or convexity in the specimens now recorded. These specimens have not the pronouncedly attenuated anterior end and claviform shape of the Indian Argovian species *G. kantkotensis* sp. nov., described above[3]. In shape they resemble more closely the Kimmeridgian

[1] *See* page 57.

[2] L. F. Spath (1931, p. 542) records that this species may occur in association with Tithonian ammonites in India, while in South Africa it occurs in the Upper Valanginian Uitenhage Beds.

[3] *See* page 115.

species *G. tetragona* (Rœmer), of which the most satisfactory figures are those published by P. de Loriol (1872, p. 366, Pl. XX, fig. 8; also 1875, p. 165, Pl. XIX, figs. 3-5), who includes *Gervillia aviculoides* Goldfuss (1836, p. 123, Pl. CXV, fig. 8), *non* J. Sowerby sp., in its synonymy. In that species, however, the body of the shell is distinctly narrower than in *G. anceps*, and diverges from the hinge-margin at a more acute angle on account of the narrowness of the posterior wing.

The specimens from East Africa referred by E. Krenkel[1] and E. Lange to *Gervillia dentata* come partly from the Neocomian *Trigonia schwarzi* beds and partly from the Upper Jurassic. Specimens from the former horizon collected by the British Museum East Africa Expedition agree well with *G. anceps*, as does also the Neocomian shell figured by G. Müller. W. O. Dietrich (1933, p. 60) considers it impossible to associate any definite specific name with the Upper Jurassic specimens, owing to the difficulty of defining specific characters in this group. Unfortunately the British Museum East Africa Expedition collected no specimens of *Gervillella* from the Jurassic, so that I am unable to express any opinion as to the specific affinities of the specimens occurring at that horizon in East Africa.

Occurrences and Material.—Tithonian, Umia Group, of the following localities:—N. E. of Umia—five specimens (G. S. I. No. K 40/588, colld. F. Stoliczka); Huroora, E. of Umia—four specimens (G. S. I. No. K 40/590, colld. F. Stoliczka); N. E. of Goonaree [queried as "*Trigonia*-bed" by Stoliczka]—one specimen (G. S. I. No. K 40/589, colld. F. Stoliczka); west of Soorkha [labelled "Moondan Group" by Blake[2]]—one fragment, associated with *Cucullæa* (*Megacucullæa*) *eminens* sp. nov. (Brit. Mus. L. 71498, colld. J. F. Blake); west of Narrha[3]—one specimen (Brit. Mus. L. 71571, colld. J. F. Blake); north of Moondan ["Bed No. 5" of Blake, MS[4].]—one specimen (Brit. Mus. L. 71572, colld. J. F. Blake).

Genus: Isognomon D. C. Solander MS., Humphrey (?), 1786.

A Catalogue of the Portland Museum, lately the Property of The Dowager Duchess of Portland, p. 41.[5]

Genotype.—*Ostrea perna* Linné (1767, p. 1149), Recent.[6]

[1] *See* the synonymy for references.

[2] The beds N. W. of Soorkha Peak are described by A. B. Wynne (1872, p. 226). *See* also L. F. Spath (1933, p. 757). A highly fossiliferous bed yielding Tithonian fossils is here 50 feet thick.

[3] The locality "W. of Narrha" has yielded a small ammonite described by L. F. Spath (1931, p. 541, Pl. LXXVII, fig. 4) as *Aulacosphinctes* sp. juv. and referred by him to the Lower Umia Group.

[4] *See* L. F. Spath, 1933, p. 757.

[5] The identity of the anonymous compiler of the Portland Catalogue, who had access to the unpublished conchological notes of Solander, then deceased, is uncertain. According to Dillwyn the Catalogue was compiled by Humphrey (*see* T. Iredale, 1916, p. 88). A slightly different generic name, *Isognoma* Solander MS., is published on p. 9 in connexion with the species *Ostrea* "*isognomon*" Linné. The two names *Isognomon* and *Isognoma* might, therefore, be applied respectively to the two groups of Recent species which are recognized as distinct sections by J. Thiele (1934, p. 802). The name *Isognoma* has page precedence, but is less familiar than *Isognomon*, which I therefore herewith select to have preference as the generic name.

I am unable to accept *Pedalion* Solander MS., Huddesford, 1870, as a valid generic name, as this was published in a column devoted to English vernacular names.

[6] The identity of this Linnean species, which was described without any figure references, is rather doubtful. S. Hanley (1855, p. 117) apparently failed to find any specimen in the Linnean collection which could unquestionably be accepted as the type, but in Pl. II, fig. 7, figures a specimen which may have been the type.

Generic Characters.—Shell sub-equivalve, very variable in outline, but with the height usually in excess of the length. Umbones directed anteriorly, not at all, or very little, incurved, and placed at the anterior end of a hinge-line of variable length. Anterior auricle very small or, more frequently, completely absent; a posterior wing may, or may not, be present. The anterior margin of the body of the shell may, or may not, project past the umbones. Commissure plane or sinuous. A byssal gape, which usually affects both valves equally, is present except in some species of the subgenus *Mytiloperna*.

Ligamental area wide, flat, with numerous narrow, transverse, more or less straight-sided ligamental pits whose interspaces may be slightly narrower, but are frequently wider, than the pits. Hinge usually edentulous, but sometimes with one or more oblique tooth-like ridges underlying the ligamental area towards its posterior end. Adductor scar large, sub-central.

Exterior of shell often lamellose, but without concentric undulations.

Remarks.—In *Isognomon* s. str., which has persisted with but little change from Triassic times to the present day, the anterior margins of the shell are strongly inflected just below the umbo and gape appreciably for the passage of a byssus. This group is well represented in the Jurassic, one of the best-known species being *I. promytiloides* Arkell (="*Perna*" *mytiloides* auctt., *non* Hermann sp.), of the Upper Jurassic. In view of the general tendency in many other genera (for example, in *Gervillella* and *Inoceramus*) for thicker-shelled forms to become increasingly abundant as the stock progresses, it is rather remarkable that in this group the Recent species are thin-shelled in comparison with many fossil forms, both from the Mesozoic and Tertiary. The Recent and fossil forms have the same lamellose shell-structure, the lamellæ peeling off very readily when the shell has undergone no appreciable mineralization.

Although many Jurassic species which have been referred to "*Perna*" belong to *Isognomon* s. str., a few, such as *P. infraliasica* Quenstedt (1856, p. 48, Pl. IV, fig. 19), appear to be Bakevellias with reduced anterior auricles; others, such as *P. thermarum* Mœsch (1867, p. 308, Pl. III, fig. 2), probably have closer affinities with *Inoceramus*. A small group of species, to which the only representatives of the genus now described belong, may be distinguished as *Mytiloperna*.

Subgenus: Mytiloperna L. Rollier, 1914.[1]

"Fossiles nouveaux ou peu connus des terrains secondaires (Mesozoïques) du Jura et des contrées environnantes," *Mém. Soc. pal. suisse*, vol. XL, p. 426.

Type.—*Perna mytiliformis* Schlippe (1888, p. 141, Pl. II, fig. 11), Bathonian.

Subgeneric Characters.—Shall smaller than in many species of *Isognomon* s. str., rhomboidal, trapezoidal, or trapeziform in shape, obliquely elongated, narrowing in a ventral direction; no posterior wing; anterior margin not projecting beyond the umbones. Byssal inflexion inconspicuous or absent.

[1] Since this was sent to press I find that the name *Mytiloperna* was first proposed by H. von. Ihering (1903, p. 123), with *Perna americana* Forbes, Lias, Chile, as type. Rollier's *Mytiloperna* proposed independently, may provisionally be included in the same group, but the diagnosis and discussion here given need modifying. This cannot be done in proof.

Remarks.—In restricting this subgenus to comparatively small, mytiliform "Pernas" I exclude from it a few of the species, such as *Perna bayani* de Loriol (1875, p. 168, Pl. XX, figs. 8 *a*, *b*, 9) and *P. lusitanica* Sharpe (1850, p. 189, Pl. XXIII, figs. 7, 8), which Rollier considers to be referable to it. Unfortunately the type-species is known to me only by the description and figures published by Schlippe. The specimen figured appears to be characterized by its comparatively narrow ligamental area. The species *Perna murchisonii* Forbes (1851, p. 111, Pl. V, figs. 1 *a-c*), from the Bathonian Estuarine Series of Skye and eastern Scotland, appears to be closely related to *P. mytiliformis*, and may have a ligamental area of considerable width, although in Forbes' holotype the area is narrow. Hence this is obviously a character which may vary considerably in the same species.

Isognomon (Mytiloperna) patchamensis sp. nov.

Plate VI, figs. 15-20.

Description.—The shell is of small-medium size for the genus, thick-walled, sub-equivalve, well inflated, mytiliform, narrowing gradually in a ventral direction. The umbones are sharp, terminal, anteriorly directed, rather hamate, and very slightly incurved. The height of the shell is equal to about one and a half times its length, and a line joining the umbo to the most distant point of the ventral margin makes an angle of about 60° with the hinge-margin. A straight or slightly curved carina, which coincides with the most inflated part of the shell and is very sharp near the umbo, runs in each valve from the umbo to the antero-ventral angle of the shell. The surface anterior to the carina is flattened and falls away almost perpendicularly to the margin. There is no postero-dorsal wing or demarcated area. The hinge-margin is elongate, its length being only slightly less than the total length of the shell. The posterior margin is straight or feebly convex, and meets the hinge-margin in a rounded-off angle which slightly exceeds 90°. The ventral margin is sharply curved and the anterior margin, which is not inflected towards its dorsal end for the passage of a byssus, evenly concave. In one specimen, however, the anterior margins appear to have a narrow gape which is situated more ventrally than the usual byssal gape in *Isognomon*.

The surface of the shell is eroded in most of the specimens examined, but the growth-layers appear to imbricate at more or less regular intervals.

The ligamental area in each valve is nearly flat and of moderate width, the two areas diverging at an acute angle. The ligamental pits are straight-sided and rather wide-spaced, and are only about five or six in number; in some specimens they are wider, and in others narrower, than their interspaces. In one left valve whose interior is visible the ligamental area is separated from the anterior margin by a well-defined groove.

Holotype.—G. S. I. type No. 16536.

Dimensions.—The measurements of the holotype are as follows :—

Length	39·0 mm.
Height	47·5 mm.
Inflation	27·7 mm.

Another specimen, less complete and somewhat crushed, was originally about 55 mm. in height.

Remarks.—The pronounced anterior carination of its two valves readily serves to distinguish this species from any representative of the genus hitherto described from the Jurassic, including the species of comparable size and gibbosity from the Bathonian of Madagascar recorded by R. B. Newton (1895, p. 80, Pl. II, figs. 4, 5) under the name *Perna orientalis* Hamlin. Its mytiliform shape and uninflected anterior margins suggest that it should be included in the subgenus *Mytiloperna*.

Occurrences and Material.—Bathonian, Patcham beds, *Corbula lyrata* horizon, of the following localities:—Kuari Bet—six specimens (G. S. I. type No. 16539 and No. K 40/593. colld. A. B. Wynne; Brit. Mus. L. 71573-6, colld. J. F. Blake); cliff over Runn, N. of Guddera (Bela)—two specimens (G. S. I. No. K 40/594, colld. A. B. Wynne); Karrir—one specimen (Brit. Mus. L. 71577, colld. J. F. Blake); Dhorawar (Patcham)—the holotype and four paratypes (G. S. I. type Nos. 16537-8 and No. K 40/592, all colld. A. B. Wynne): Lodai—one specimen (Brit. Mus. L. 71578).

Upper Bathonian, lower *macrocephalus* Beds, N. W. of Jumara—one specimen in the matrix of a specimen of *Eligmus rollandi* Douvillé (G. S. I. No. K 40/596, colld. F. Stoliczka).

Isognomon (Mytiloperna ?) sp.

Plate VI, figs. 14 *a*, *b*.

Description.—The single available specimen consists of the broken dorsal half of a thick, medium-sized shell which, when complete, was apparently trapeziform and obliquely elongated, with its height slightly in excess of its length. Its inflation is moderate; the left valve is slightly more gibbose than the right, particularly in the umbonal region. The umbonal region is not at all produced; the umbones are sub-terminal, that of the left valve being almost imperceptibly incurved and that of the right level with the hinge-margin. A very small anterior auricle is present in the left valve. The hinge-margin is rather short, meeting the posterior margin in an obtuse curve. The anterior margin is nearly straight, forming an angle of about 80° with the hinge-margin. The two valves are evenly inflated and without umbonal ridges; the level of the surface falls away very gradually to the anterior margin, where there is no trace of a byssal inflexion such as is present in most species of *Isognomon*.

The ligamental area in each valve attains a width of about 7 mm. and is quite flat; that of the left valve lies approximately in the plane of the valve margins, while that of the right valve diverges from this plane at an angle of about 30°. The ligamental pits, which are straight-sided and mostly slightly wider than their interspaces, number about 13 in each valve.

The surface of the shell, which is rather eroded, appears to have been smooth and not at all lamellose. As in *Inocĕramus*, the test is formed of two layers. The outer layer, which is composed of calcite prisms, is thin except near the

hinge-margin, while the inner layer, the structure of which has been altered in fossilization, is of considerable thickness.

Dimensions.—The estimated original length and height of the specimen and its inflation are as follows :—

Length	60 mm.
Height	80 mm.
Inflation	23 mm.

Remarks.—This shell agrees with the genus *Isognomon* in the width of its ligamental area and thickness of its test, but differs from most species of the genus in the presence of a small anterior auricle and in the absence of a byssal sinus, as well as in the structure of its test, which, except for its thickness, is similar to that of *Inoceramus*. I refer it provisionally to the subgenus *Mytiloperna*.

This shell does not closely resemble any species previously described under the genus *Isognomon* [*Perna*], but shows a striking similarity in outline to the species from the Kimmeridgian of Switzerland described by L. Rollier (1914, p. 364, Pl. XXVI, fig. 1) under the name *Mytilus* (*Pernomytilus*) *randenensis* Mœsch MS. The hinge-structure of the species in question is unknown, and it is by no means certain that it belongs to the Mytilidæ.

Occurrence and Material.—Bathonian-Callovian, S. of Khera Hill, near Chari —one specimen only (G. S. I. No. K 40/595, colld. A. B. Wynne).

Genus : INOCERAMUS J. Sowerby MS., W. Smith, 1816.

Strata identified by Organized Fossils, p. 10.

Genotype.—Inoceramus cuvieri J. Sowerby MS., W. Smith (*loc. cit.*, p. 10, "Lower Chalk" Plate, fig. 1), Chalk, British.[1]

Generic Characters.—Shell equivalve except in the more aberrant species, ovate, rhomboidal, trapezoidal, or trapeziform in outline, with the height most frequently, but not invariably, in excess of the length. Test comparatively thin except near the hinge-margin. Umbones more or less incurved, and situated towards the anterior end of a hinge-line of variable length. Anterior auricle small or merely rudimentary ; a posterior wing may, or may not, be present. Commissure plane ; no byssal gape.

Ligamental area narrow or of only moderate width, flat or concave, with numerous transverse ligamental pits whose interspaces are appreciably narrower than the pits. Hinge usually edentulous, but occasionally with one or two short oblique teeth in the antero-dorsal angle.

Surface of shell usually concentrically plicated, or ridged, but not lamellose.

Remarks.—For the purpose of the present Memoir, in which only a single very incomplete specimen is referred to *Inoceramus*, this genus is conceived in a

[1] As pointed out by me in a previous paper (L. R. Cox, 1930, p. 291), the species figured as *Inoceramus cuvieri* by W. Smith, which must be accepted as genotype of *Inoceramus*, is not the *I. cuvieri* of J. Sowerby (1822) and later authors, but is identical with *I. involutus* J. de C. Sowerby.

wide sense. Within recent years its Cretaceous species have been studied in great detail by R. Heinz, who has proposed (1932) a " neue Systematik " in which what was formerly regarded as a single genus is erected into two families, containing numerous subfamilies and genera. It seems, however, doubtful if this " neue Systematik " will prove acceptable to other authorities, most of whom are likely to share, with the present writer, the opinion that intensive specialization has here led to the loss of all sense of proportion. It is possible that two or three distinct genera and several subgenera may eventually prove to be distinguishable among the species hitherto included in *Inoceramus*, but in any classification of this group due consideration will have to be paid to its evolutionary history from its first appearance in Liassic times onwards.

Although most Cretaceous species of *Inoceramus* are readily distinguishable from *Isognomon* [*Perna*], the differences between the two genera are less obvious in the case of some of the Jurassic forms, and I am inclined to include in the former genus a few of the species which L. Rollier (1914, pp. 426-437) lists under the latter.

The differences between the two genera lie mainly in the more prominent umbonal region, the narrower ligamental area, and the thinner and non-lamellose shell of *Inoceramus*, in which, moreover, the surface of the shell is usually concentrically plicated or ridged. A byssal sinus of the anterior margins, which, as already seen, is present in all species of *Isognomon* with the exception of those referable to the subgenus *Mytiloperna*, is invariably absent in *Inoceramus*. An anterior auricle is frequently present in *Inoceramus*, but is completely absent in *Isognomon* except in a very few species, where it is merely rudimentary. The well-developed external layer of the shell-wall, formed of prisms of calcite, is a well-known feature of the Upper Cretaceous species of *Inoceramus*; this layer is also present in the Jurassic forms, in which, however, it is comparatively thin.

Certain other points of distinction between *Inoceramus* and *Isognomon* are enumerated by R. Heinz (1932, p. 4). The structure of the hinge-region, he maintains, is quite different in the two genera. The ligamental area is perfectly flat in *Isognomon*, whereas it is concave in *Inoceramus*—strongly so beneath the umbo, but gradually flattening out in a posterior direction. In *Isognomon* the ligamental pits, he states, are usually narrower than their interspaces, whereas in *Inoceramus* the opposite is the case. In *Isognomon* the lateral margins of the ligamental pits are straight, whereas in *Inoceramus* these margins are convex.

I find, however, that these points of distinction do not invariably hold good. Thus the ligamental pits are wider than their interspaces in almost as many species of *Isognomon* as those in which they are narrower. Further, in some species of *Inoceramus*, even from the Upper Cretaceous, the ligamental area is quite flat, and the lateral margins of the ligamental pits are often straight. As already stated, however, the ligamental area is nearly always wider in *Isognomon* than in *Inoceramus*.

L. Rollier (1914, p. 415) suggests that the shell of *Inoceramus*, like that of *Lima* and *Chlamys*, was adapted for natation. This may have been the case

with the Jurassic species and some of the smaller Cretaceous ones, but the large forms of the Upper Cretaceous, in some of which the shell is pronouncedly inequivalve, must have led a sedentary life.

The ancestry of *Inoceramus* is a question which invites speculation. Some of the Jurassic species, such as the Aalenian form figured by E. W. Benecke (1905, p. 145, Pl. VIII) under the name *Inoceramus polyplocus* F. Rœmer, with their ovate, concentrically plicated shells, are strongly reminiscent, except in size, of the genus *Posidonia*, and it may be pointed out that L. Guillaume (1928, p. 221) has demonstrated the existence of serial ligamental pits in the genus (or subgenus) *Steinmannia* P. Fischer, typified by the well-known Upper Liassic species *Posidonia bronni* Voltz MS., Zieten. Miss C. Maury, moreover, has recently (1925, p. 596; also 1936, p. 117, Pl. VIII, fig. 15) described a "section" *Sergipia* which she regards as intermediate between *Posidonia* and *Inoceramus*.

The species of another Jurassic group, of which *Inoceramus ventricosus* (J. de C. Sowerby) (1823, vol. V, p. 64, Pl. CCCCXLIII), from the Lias, may be regarded as typical, are not, however, in the least like *Posidonia*. The shells of this group, in which I would also include such species as "*Perna*" *thermarum* Mœsch (1867, p. 308, Pl. III, fig. 2), are characterized by their rhomboidal outline, by their anteriorly directed, sub-terminal, and not very prominent umbones, and by the fact that the concentric undulations of the surface of the shell are absent, or else less pronounced than in the group discussed above. Apart from their comparatively thin shell, their narrow ligamental area, and their closed anterior margins, these species are, in fact, rather similar to *Isognomon*. I should, however, hesitate to regard them as derived from that genus.

It may be of interest to record that short, oblique teeth are present in the antero-dorsal angle of the shell in the Liassic species *Inoceramus substriatus* Münster (in A. Goldfuss, 1836, p. 108, Pl. CIX, fig. 2, and Pl. CXV, figs. 1 *a*, *b*).

Among other genera which have been suggested as the possible ancestor of *Inoceramus*, mention may also be made of *Atomodesma* Beyrich, which is found in the Permian of Timor, and has been re-described in detail by C. Wanner (1922, p. 60, Pl. CLIII). In this genus the shape of the shell is reminiscent of that of the more pronouncedly inequilateral and transversely elongated species of *Inoceramus*, but serial ligamental pits are absent. As in the later species of *Inoceramus*, an external layer of the shell composed of calcite prisms is well developed. Since, however, this layer is comparatively thin in the Jurassic species of *Inoceramus*, it is doubtful if its conspicuous development in *Atomodesma* is a very strong argument for this genus having been directly ancestral to any of the forms included in *Inoceramus*.

The Jurassic species of this group certainly deserve closer study than has hitherto been devoted to them. From the above considerations it will be seen that there is at least a possibility that two or more stocks of quite independent origin may be represented among them. Owing to convergence it may prove impossible to determine from which of these stocks any particular Cretaceous representatives of the group were derived.

INOCERAMUS sp.

Plate VII, fig. 8.

Description.—The single available specimen consists of the broken ventral half of a moderately large and evenly convex valve which originally was probably more or less ovate in outline. The surface is ornamented only with wide-spaced, narrow concentric ridges, which have the appearance of imbricating in a ventral direction. These ridges are about 1 cm. apart on the upper part of the specimen, which corresponds to about the middle of the original shell, but become increasingly further apart towards the ventral margin. The test is thin, and is formed mainly of an outer layer of calcite prisms. A thin inner layer, probably composed originally of aragonite, has been replaced by a ferruginous mineral.

Dimensions.—The original height of the specimen may be estimated, very approximately, at 100 mm.

Remarks.—Owing to its imperfect condition it is impossible to compare this specimen at all closely with any species described previously. In its large size and ornamentation it recalls the species *Inoceramus oosteri* E. Favre (1876, p. 64, Pl. VI, fig. 2),[1] from the Argovian of Switzerland.

Occurrence and Material.—Divesian, *athleta* Beds. east of Ler—one specimen (Brit. Mus., L. 71579. colld. J. F. Blake).

Family: *VULSELLIDAE.*

This family, which makes its appearance in Jurassic times, forms the subject of an interesting study by H. Douvillé (1907), to whose observations there is little to add. It includes several genera of sub-equivalve, monomyarian molluscs of irregular outline, which bear some external resemblance to oysters. The Recent forms live commensally with sponges, which more or less envelop the shell and usually render it incapable of opening and closing. Hence, to allow the passage of water from the exterior of the shell to the animal inside, there is usually an opening of the posterior margins, which may take the form of a series of deep, irregular notches.

As Douvillé shows, it is probable that this family was derived from the Pteriidæ and is not closely related to the Ostreidæ, notwithstanding the oyster-like appearance of the shell. Significant differences from the latter family lie in the absence of an attachment-area at the umbo of the left valve, in the posterior gape of the margins, and, most of all, in the structure of the shell. In the Vulsellidæ (or, at least, in the Recent representatives of the family) the shell is built up, as in the Pteriidæ, of a nacreous inner layer and an outer layer of prismatic calcite. In the Ostreidæ the structure is very different, for the test is here built up of lamellæ of porcellanous calcite which actually form its outer surface, while prismatic calcite may line or even fill the spaces between these lamellæ; a nacreous layer is absent.

[1] Described also by W. A. Ooster (1869, p. 38, Pl. XIII, figs. 7-14) and referred to the species *I. brunneri* Ooster, which had been founded on specimens of Cretaceous age.

Owing to the mineral changes which most specimens have undergone in fossilization it is not yet certain if all the fossil genera included in the Vulsellidæ were characterized by a nacreous shell. Some authorities (cited by Douvillé, *loc. cit.*, p. 102) have maintained that the shell in *Eligmus* has a structure similar to that of *Ostrea*. Certainly in specimens which I have studied from some localities, including British Somaliland and Kachh, there is no appreciable difference in the apparent constitution of the shell between species referred to *Eligmus* and those referred to *Ostrea*. In these specimens, however, the shell has been considerably altered in fossilization. In specimens of *Eligmus* from Trans-Jordan examined by me there has been less alteration and the surface of the shell has a peculiar sheen not possessed by species of *Ostrea*.

It has not, moreover, been definitely established that all the fossil genera referred to the Vulsellidæ were commensal with sponges. For this reason it is of interest to record that the Indian specimens of *Eligmus* described below came from a deposit in which sponge remains are abundant.

Genus: ELIGMUS J. A. Eudes-Deslongchamps, 1856.

"Description d'un nouveau genre de coquilles bivalves fossiles *Eligmus*," *Mém. Soc. Linn. Normandie*, vol. X, p. 272.

Genotype.—E. polytypus J. A. Eudes-Deslongchamps (*loc. cit.*), Bathonian—Callovian, Europe and northern Africa.

Generic Characters.—Shell ovate, sub-equivalve, ostreiform, but with no attachment area; a varying proportion of the surface is ornamented with radial costæ; a smooth area usually extends from the umbo along the postero-dorsal margin, where the shell gapes to a varying extent. Ligament internal, situated on an obtusely triangular area very similar to that of the genus *Ostrea*. A prominently projecting platform on the interior of each valve serves for the attachment of the adductor muscle.

ELIGMUS ROLLANDI H. Douvillé.

Plate X, figs. 1-8.

Heligmus rollandi H. Douvillé, 1907, "Études sur les Lamellibranches. Vulsellidés," *Ann. Paléont.*, vol. II, p. 105, Pl. XV, figs. 1-3.

Heligmus integer H. Douvillé, 1916, "Les terrains secondaires dans le massif du Moghara à l'est de l'Isthme de Suez," *Mém. Acad. Sci. Paris*, ser. 2, vol. LIV, p. 33, Pl. II, figs. 13-16.

Heligmus cf. *rollandi* M. Cossmann, 1924, "Extension dans les Deux-Sèvres de la faune du Callovien de Montreuil-Bellay," *Mém. Soc. géol. min. Bretagne*, vol. I, p. 25, Pl. V, figs. 32, 40, and Pl. VI, fig. 63.

Alectryonia pulligera J. Weir, 1925, "Brachiopoda, Lamellibranchiata, Gastropoda and Belemnites" [from Somaliland], *Mon. Geol. Dept. Hunterian Museum Glasgow Univ.*, No. 1, p. 86, Pl. XII, fig. 5 (*non* Goldfuss sp.).

Lopha humei G. Stefanini, 1925, "Description of Fossils from South Arabia and British Somaliland," in O. H. Little, The Geography and Geology of Makalla (South Arabia), p. 165, Pl. XXVIII, fig. 8.

Heligmus rollandi V. Pcelincev, 1927, "On some Jurassic Fauna from the Bolshie Balkhany (Turkmenia)," *Bull. Com. géol. Leningrad*, vol. XLVI, p. 1093, Pl. LV, fig. 14.

Heligmus asiaticus J. Weir, 1929, "Jurassic Fossils from Jubaland, East Africa, ... and the Jurassic Geology of Somaliland," *Mon. Geol. Dept. Hunterian Museum Glasgow Univ.*, No. 3, p. 22, Pl. I, figs. 20-23.

Heligmus rollandi J. Weir, 1929, *loc. cit.*, p. 23, Pl. I, figs. 24, 27 (*non* figs. 25, 26, 28).

Heligmus rollandi L. Barrabé, 1929, "Contribution à l'étude..... de la partie médiane du pays Sakalave (Madagascar)," *Mém. Soc. géol. France*, N. S., No. 12, p. 124, Pl. VII, fig. 20.

Heligmus rollandi H. Besairie, 1930, "Recherches géologiques à Madagascar," *Bull. Soc. Hist. nat. Toulouse*, vol. LX, fasc. 2, p. 200, Pl. X, figs. 4, 4*a*, 5.

Eligmus rollandi L. R. Cox, 1935, Mesozoic Palæontology of British Somaliland, p. 168, Pl. XVI, figs. 6-10.

Description of the Specimens from Kachh.—The specimens vary from ovate to sub-trigonal in outline, the length of the shell being almost invariably in excess of the height. The anterior end is more or less evenly convex, while the posterior end tapers to a varying extent. In most specimens the umbones, which are seldom at all prominent, are placed at about the anterior third of the length. The inflation is moderate. The postero-dorsal margins of the two valves usually have a narrow gape, but are appreciably sinuous only in occasional specimens; they are never deeply indented as in *Eligmus polytypus.*

The surface of the shell is ornamented with a variable number of rather sharp-edged costæ which are more or less equal in width and prominence in the majority of specimens, although in some they become narrower and less prominent towards the posterior end of the shell. A narrow strip of the surface bordering the postero-dorsal margin is usually smooth, while the costæ are also frequently absent from the posterior end of the shell.

The test is somewhat thickened along the dorsal margin, so as to constitute an irregularly undulating cardinal area in which a triangular depression below the umbo served for the reception of the fibrous ligament. On the interior of the shell a raised circular platform for the attachment of the adductor muscle is well preserved in several specimens.

Dimensions.—The measurements of one of the largest specimens are as follows :—

Length	33 mm.
Height	28 mm.
Inflation (single valve)	8·5 mm.

The average length of the specimens is about 20 mm.

Remarks.—The specimens now recorded agree very well with Douvillé's original figures of this species, the synonymy of which has been discussed in my

previous paper. It is distinguished from *E. polytypus* J. A. Eudes-Deslongchamps, the genotype of *Eligmus*, by the absence of the deep notches of the postero-dorsal margin which characterize that species, and by the less conspicuous gape along that margin.

The original types came from the Callovian of Lifol-le-Petit, in the Meuse Département of France, but the species has since been recorded from Sinai, Somaliland, Arabia, Madagascar, and Central Asia; its range appears to extend from the Bajocian to the Callovian.

Occurrences and Material.—Upper Bathonian, lower *macrocephalus* Beds, N. W. of Jumara—numerous specimens (G. S. I. No. K 40/596, colld. F. Stoliczka), associated with *Nucula blanfordi* sp. nov., *Bakevellia waltoni* (Lycett), a carinate *Opis*, sponge remains, etc.; Jumara [" Beds Nos. 15*a* and 16*a* " of Blake, MS.][1]—five specimens (Brit. Mus., L. 71582-6, colld. J. F. Blake).

Family: *PINNIDAE*.

This family extends back to the Devonian, if we include in it the imperfectly known genus *Palæopinna* J. Hall (1885, p. xiv); or in any case to the Carboniferous, where quite typical representatives of *Pinna* occur. In the Carboniferous and Permian genus *Aviculopinna* F. B. Meek [1864 (2), p. 212] the anterior end of the shell projects slightly beyond the umbones, but in other genera of the family the umbones are quite terminal. No doubt the Pinnidæ were derived from the Pteriidæ, and represent an early adaptation of some offshoot from that family to a burrowing habitat. As shown below, *Pinna* itself, which is usually equivalve, burrows into the sediment of the sea-floor, and is anchored by its byssus in an upright position, with the posterior end of the shell protruding to some extent. The very thick-shelled genus *Trichites*, whose valves are irregular in shape and more or less unequal, is usually associated with a coral-reef fauna and may have led a slightly different mode of life, perhaps wedged into cavities in the reef.

Genus: Pinna Linné, 1758.

Systema Naturæ, edit. 10, p. 707.

Genotype.—*Pinna muricata* Linné (*loc. cit.*), Recent, East Indies.[2]

Generic Characters.—Shell equivalve, usually wedge-shaped, but occasionally trapeziform, with a more or less pointed anterior end and terminal umbones. Valve-margins plane except for a narrow anterior gape for the protrusion of the byssus, and a wide posterior gape, which is absent, however, in the subgenus *Stegoconcha*. Hinge-line more or less elongated; ligament sub-internal, placed in a narrow groove which underlies the whole length of the hinge-margin. No.

[1] The section at Jumara given by L. F. Spath (1933, p. 740) goes down only to Bed No. 14 of Blake (the Patcham Coral Bed). Presumably Beds 15 and 16 were below this. The horizon appears to be near the at present ill-defined limit of the Patcham and Chari Beds.

[2] The question of the genotype of *Pinna* is discussed by U. S. Grant and H. R. Gale (1931, p. 145). Most previous authorities have cited the species *P. rudis* Linné as genotype. Fortunately this belongs to the same group as *P. muricata*, so that our conception of the genus is not materially affected.

hinge-teeth are present. Dimyarian, the anterior adductor small and situated in the umbonal angle, the posterior one large, subcentral. Pallial line entire. Test consisting of a coarsely prismatic outer layer, which frequently attains a considerable thickness, and a thin, nacreous inner layer. The nacreous layer does not extend much beyond the posterior adductor scar, and is also absent from a narrow strip bordering the ventral margin. Sculpture usually predominantly radial.

Remarks.—The genus *Pinna* is of considerable antiquity, quite typical representatives occurring in the Carboniferous. The Recent species form the subject of an interesting paper by R. Winckworth (1929), who gives an account of the anatomy and habits of the animal. It is sedentary, and lives secured by its byssus in an upright position, with its narrow anterior end deeply buried in the sediment, while about one-quarter of the length of the shell, at its broad posterior end, is exposed above its burrow. Growth is entirely confined to the posterior end of the shell, so that it assumes a triangular shape. As it grows, the animal moves bodily upward in its shell, while both adductor scars move continuously in the same direction. As the growing shell burrows, its empty anterior end is worn away by friction, but the mantle produces new shell ends to protect the anterior adductor at each growth-stage. Consequently, the anterior end of the shell shows a series of loculi formed by these temporary shell-ends. The upper or posterior end of the shell, from which the inner or nacreous layer is absent, is flexible and, although normally gaping, can be held completely closed by the animal when it needs special protection.

The early development of the shell is described briefly by F. Bernard (1898, pp. 45, 85-6). The prodissoconch is trigonally ovate, with prominent, submedian umbones and two short bands of transverse crenulations serving as primitive hinge-teeth, separated by an internal ligament. In further growth, however, the shell rapidly acquires its characteristic wedge-like shape and the ligament quickly extends in a posterior direction, obliterating all traces of the primitive hinge-teeth. This mode of development is similar to that of the Mytilidæ, but much more " accelerated ".

Subgenus: Pinna s. str.

Subgeneric Characters.—Shell narrow, wedge-shaped, with an elongate hinge-margin. Posterior end gaping. The nacreous layer of the interior of the shell is divided by a groove which runs from the anterior end of the shell to the ventral side of the posterior adductor. On the exterior of each valve a median carina marks the position of this groove. Sculpture consisting of radial riblets.

Remarks.—*Pinna* s. str. is a well-defined subgenus which includes many of the Jurassic species of the genus. As explained by R. Winckworth (1929, p. 280) the characteristic internal groove is due to the position of the point of attachment of the mantle, which lies immediately ventral to the posterior adductor scar, and does not secrete nacre at this point. The muscles which control the ventral margin and the posterior part of the mantle radiate from this point of attachment; and all this part of the mantle secretes prismatic shell only.

PINNA cf. MITIS Phillips.

Plate X, fig. 11.

The following are references to descriptions of typical *P. mitis* :—

Pinna mitis J. Phillips, 1829, Illustrations of the Geology of Yorkshire, p. 137, Pl. V, fig. 7.

Pinna mitis I. Lahusen, 1883, " Die Fauna der jurassischen Bildungen des Rjasanschen Gouvernements," *Mém. Com. géol. St. Pétersb.*, vol. I, Pt. 1, p. 27, Pl. II, fig. 12.

Pinna mitis E. Krenkel, 1915, " Die Kelloway-Fauna von Popilani in Westrussland ", *Palæontographica*, vol. LXI, p. 293.

Description of the Specimen from Kachh.—This specimen, which was about 80 mm. in length when complete at its anterior end, has been subjected to dorso-ventral pressure, so that the shell has become more gibbose than was originally the case and the two valves have cracked along the median carina.

The shell is wedge-shaped, with straight dorsal and ventral margins, and of medium acuteness. The median carina divides the surface of each valve into two areas, of which the ventral is slightly wider than the dorsal. The dorsal portion of the surface is ornamented with narrow longitudinal ribs, about nine of which are present at a distance of 50 mm. from the umbo ; further from the umbo additional riblets become intercalated in the interspaces, so that the total number is considerably increased and the riblets more or less alternate in strength.

The dorsal half of the part of the surface ventral to the carina is also ornamented with narrow radial riblets ; near the carina these are nearly as strong as those on the dorsal side, but the more ventrally situated ones are extremely faint ; about ten are present in all. The ventral half of this portion of the surface is ornamented only with growth-lines and occasional undulations parallel to them.

Remarks.—This specimen closely resembles *Pinna mitis* Phillips, from the Oxford Clay of England, both in shape and in the general character of its ornamentation. Typical specimens of that species, however, have only six or seven riblets on the dorsal side of the median carina at a distance of 50 mm. from the umbo, and four riblets on the ventral side of the carina ; that is, considerably fewer than in the Indian specimen. In English specimens, moreover, the ventral growth-undulations of the surface are more strongly pronounced than in the shell now described.

A specimen figured by C. H. von Zieten (1833, p. 73, Pl. LV, fig. 4) as *P. mitis* came, according to L. Rollier (1914, p. 389), from an Argovian horizon, and so is renamed by him *P. stuifensis.* This specimen is closely comparable to the one now described, except that faint radial ribbing extends to quite near the ventral margin.

K. A. Redlich (1894, p. 70, Pl. II, fig. 6) refers a Bajocian specimen from the Caucasus to *P. mitis*, but V. Pcelincev [1927 (2), p. 1145] considers this to belong to *P. buchi* Koch and Dunker. Redlich's specimen agrees well with the

one now recorded, except for the greater prominence of the concentric plications on its ventral region.

E. Hennig (1924, p. 71, Pl. II, fig. 7) refers a specimen from the Callovian of East Africa to *P. mitis*. This specimen appears to be slightly more acute than the one now recorded, while on the ventral side of its median carina the ribs, although all very weak, persist almost to the ventral margin. Specimens from the Kimmeridgian *Nerinea*-bed of Tendaguru (East Africa) described by W. O. Dietrich (1933, p. 60, Pl. VIII, figs. 131-134) under the name *Pinna* cf. *constantini* de Loriol are also closely comparable to the one now recorded.

It is, in fact, obvious that this belongs to a persistent group of *Pinna* of which the various species which are assumed to be characteristic of different geological horizons, are distinguishable, if at all, only when a considerable amount of material is available. Since *P. mitis* was the first Jurassic representative of this group to be described, and also comes typically from a horizon not very remote from that of the specimen now recorded, this specimen may be recorded provisionally as *Pinna* cf. *mitis*.

Occurrence and Material.—Callovian or Divesian, S. W. of Lodai (G. S. I. No. K 40/597, colld. A. B. Wynne).

Subgenus : STEGOCONCHA J. Böhm, 1907.

" Über *Cardium Neptuni* Goldf.," *Zeits. deut. geol. Ges.*, vol. LIX, Monatsber., p. 148.

Type (now designated) :—*Pinna granulata* J. Sowerby (1822, vol. IV, p. 65, Pl. CCCXLVII), Corallian (? and Kimmeridgian), England, etc.

Subgeneric Characters.—Shell large, of moderate thickness, strongly inflated, more or less mytiliform, with the height usually in excess of the length. Valve-margins closed posteriorly. A rounded ridge frequently passes diagonally from the umbo to the postero-ventral angle of the shell, dividing the surface of the shell into two areas ; the antero-ventral area, which may be somewhat impressed, is smooth, while the rest of the surface is usually ornamented with irregularly distributed, depressed radial ribs or threads, which frequently break up into rows of granules, or become replaced by sinuous striæ. As in *Pinna* s. str., an internal groove appears to have run from the anterior end of the shell to the ventral margin of the posterior adductor scar ; in this group the groove does not correspond to the external ridge.

Remarks.—This is the group of shells to which L. Rollier (1914, pp. 379-395) and W. J. Arkell (1933, p. 224) apply the name *Trichites*. For reasons explained later,[1] however, I consider that that generic name should be used for a different group of Mesozoic Pinnidæ, characterized by an extremely thick and irregular shell and a sinuous commissure.

Many authorities on Jurassic mollusca, such as J. Morris and J. Lycett, P. de Loriol, and P. Choffat, have included the shells of the group now discussed in *Pinna*, although they have regarded *Trichites* (in the sense of the present

[1] *See* page 136.

paper) as a distinct genus. J. Böhm proposed to separate the group now discussed as a distinct genus *Stegoconcha*, while W. J. Arkell also regards it as generically distinct from *Pinna*.

In my opinion the differences between *Stegoconcha* and *Pinna* are only of subgeneric value. In shape the species of this group are not unlike some species of the subgenus *Atrina*, from which they differ, however, in their more inflated form, in the absence of a posterior gape, and in the presence of an internal groove joining the anterior end of the shell to the lower margin of the posterior adductor scar. The presence of this groove has been detected by me on an internal cast of the species *Pinna* (*Stegoconcha*) *ampla* (J. Sowerby), from the English Inferior Oolite.

PINNA (STEGOCONCHA) cf. G.-MÜLLERI Krenkel.

Plate X, fig. 12.

The following are references to descriptions of typical *Pinna g.-mülleri* :—

Pinna g.-mülleri E. Krenkel, 1910, "Die untere Kreide von Deutsch-Ostafrika," *Beitr. Pal. u. Geol. Österr.-Ungarns*, vol. XXIII, p. 203, Pl. XXI, fig. 5.

Stegoconcha solida J. Böhm var. *tendagurensis* W. O. Dietrich, 1933, "Zur Stratigraphie und Palæontologie der Tendaguruschichten," *Palæontographica*, Suppl. VII, 2te Reihe, Abt. 2, p. 61, Pl. IX, figs. 138, 139.

Description of the Specimens from Kachh.—Even the most complete specimen (the others are mere fragments) is poorly preserved, but may be described as a large, strongly inflated, mytiliform shell whose height and length were probably originally approximately equal. In the better preserved valve (the left) a rounded ridge, which coincides with the most inflated region of the shell, curves round from the umbo to the postero-ventral corner. Posterior to this ridge the surface is ornamented with numerous irregularly spaced, unequal, flattened radial ribs, separated by interspaces which are, on the average, somewhat narrower than the ribs. On the anterior side of the ridge the surface, which falls away steeply to the margin, is smooth except for growth-lines. The maximum thickness of the test is about 2 mm.

Dimensions.—The original length and height of this specimen may be estimated very approximately at 110 mm. Its inflation is 62 mm.

Remarks.—Several specimens of *P. g.-mülleri*, from the Kimmeridgian *Nerinea*-beds of Tendaguru (Tanganyika Territory), the type-locality of the species, are in the British Museum collection. These agree very closely with the specimens now recorded from India both in shape and in the details of their ornamentation. Hence, notwithstanding their lower geological horizons, the Indian specimens may be referred (with some qualification owing to their incompleteness) to the same species.

The England Inferior Oolite species *Pinna ampla* (J. Sowerby) (1812, vol. I, p. 27, Pl. VII) has the same type of ribbing as this species, but is less strongly inflated, with a less pronounced diagonal ridge. The persistent radial ribs, which are not at all broken up into granulations, distinguish *P. g.-mülleri* from most of the remaining European Jurassic representatives of the subgenus *Stegoconcha*.

Occurrences and Material.—Divesian ?, East of Juria [" Zone 1 " of Blake, MS.]—one specimen (Brit. Mus. L. 71588, colld. J. F. Blake), containing a specimen of the brachiopod *Rhynchonella nobilis* J. de C. Sowerby in its matrix.[1]

Divesian, *athleta* Beds, of the following localities :—Fakirwadi—three fragments (G. S. I. No. K 40/598, colld. J. H. Smith) ; Samatra—one fragment (G. S. I. No. K 22/131, colld. J. H. Smith).

Subgenus incertum.

PINNA STOLICZKAI sp. nov.

Plate X, figs. 9, 10.

Description.—The shell is of medium size, strongly inflated, somewhat falciform in shape, and transversely elongated ; the length, measured in a direction parallel to the hinge-margin, is, however, considerably in excess of the height. At its anterior end the shell is very acute, but it widens considerably posteriorly, the ventral margin being pronouncedly concave. A well-defined ridge, which coincides with the most inflated part of the shell, runs in a slight curve from near the umbo to the postero-ventral corner ; in all the available specimens this ridge is more pronounced in the left valve than in the right. On the dorsal side of the ridge the surface is ornamented with numerous depressed, rounded radial ribs, which are separated by much narrower interspaces ; rather more than 30 of these ribs are present at a distance of about 70 mm. from the umbo. On the ventral side of the ridge the surface, which falls away rather steeply to the margin, is smooth except for a series of undulations which are parallel to the growth-lines and particularly well marked at the anterior end of the shell. The test attains a thickness of about 2 mm.

Holotype.—G. S. I. type No. 16532.

Dimensions.—The measurements of the holotype are as follows :—

Length (original)	112 mm.
Height	65 mm.
Inflation (estimated)	43 mm.

Remarks.—As in the various semi-carinate species of *Pinna* which are here referred to the subgenus *Stegoconcha*, the diagonal ridge in this species does not occupy a median position and coincide with an internal groove joining the umbo to the lower margin of the posterior adductor scar, but occupies a more ventral position, separating the radially ribbed portion of the surface from a ventral area on which the ribbing follows the direction of the growth-lines. It is possible, therefore, that the species should be included in *Stegoconcha*, but it is more elongate and less mytiliform than the typical representatives of that subgenus. On the other hand, it may possibly belong to the subgenus *Atrina*, in which the inner surface of the shell is undivided by the groove just mentioned. There is no sign of the presence of this groove in a few places where the shell is partly

[1] Dr. L. F. Spath (1933, p. 779) records the presence of this brachiopod in the *athleta* beds, but some specimens of this species in the Blake Collection come from a Callovian horizon.

eroded away, but the condition of the material studied does not allow any definite pronouncement to be made as to whether it is present or absent in the species.

No closely comparable Jurassic species appears to have been described. In *Pinna suprajurensis* d'Orbigny, as figured by P. de Loriol (1872, p. 352, Pl. XX, fig. 1), the surface of the shell is ornamented in a somewhat similar manner, but the ventral margin is not down-curved posteriorly, while an ill-defined angularity of the valves is more or less median in position; it is obvious from a previous figure of *P. suprajurensis* published by de Loriol (1868, Pl. XIII, fig. 4) that that species belongs to the subgenus *Pinna* s. str., whereas the species now described undoubtedly belongs to a different group.

Occurrences and Material.—Callovian, Kumagoona—the holotype, containing in its matrix an ammonite fragment of the genus *Choffatia* (colld. F. Stoliczka).

Divesian, *athleta* Beds, Jikadi [" Bed No. 22 " and " Bed no. 22 or lower " of Blake, MS.][1]—two specimens (Brit. Mus. L. 71589-90, colld. J. F. Blake).

Callovian or Divesian, S. W. of Lodai—one specimen (G. S. I. No. K 40/600, colld. A. B. Wynne).

Genus: TRICHITES Voltz MS., J. Thurmann, 1833.

" Essai sur les soulèvements jurassiques de Porrentruy," *Mém. Soc. Hist. nat. Strasbourg*, vol. I, livr. 2, p. 13.

Genotype.—*Trichites saussuri* Voltz MS., Thurmann (*loc. cit.*), Argovian to Infravalanginian.

Generic Characters.—Shell very thick, composed almost entirely of fibrous calcite, irregularly trapeziform or falciform in outline, wide, and usually with the height nearly equal to, or in excess of, the length; more or less inequivalve, with either valve the more strongly inflated, and with an irregularly undulating commissure. Valve margins entirely closed, or with a narrow anterior gape for the byssus. Umbones bluntly pointed. Hinge edentulous; ligament sub-internal, supported by a rounded ridge underlying the hinge-margin. In the umbonal angle the thick test is usually strongly hollowed out internally in a radial direction, forming, in each valve, a sort of channel crossed transversely by well-defined lamellæ which probably represent, as in *Pinna*, temporary partitions for the protection of the anterior adductor. Posterior adductor scar deep, often much elongated in a radial direction; anterior adductor scar situated on the wall of the shell in the umbonal angle.

Surface of shell usually very uneven, sometimes ornamented with a few wide, depressed, bifurcating radial or oblique ribs or irregular nodosities, at other times ornamented only with faint radial riblets, and occasionally quite unornamented.

Remarks.—In applying the generic name *Trichites* to the group of shells typified by *T. saussuri* I am in disagreement with L. Rollier (1914, pp. 379-395) and W. J. Arkell (1933, p. 224), who use this name for the subgenus of *Pinna* termed

[1] *See* L. F. Spath, 1924, p. 23.

Stegoconcha in the present Memoir,[1] and employ the name *Pinnigena* for the group now under discussion. I am, however, in agreement with many previous authorities, including J. Lycett and P. de Loriol.

As shown by Dr. Arkell, the name *Trichites* was introduced by R. Plot in 1676 for the thick masses of fibrous calcite found in the Corallian quarries at Headington, near Oxford. In 1699 Plot's successor, E. Lhwyd, who appears to have recognized the organic origin of these structures, described them under the name *Trichites rutilans deciduus Plotii.* In view of Dr. Arkell's contention that the genus *Trichites* should be employed for the species from which these fragments were derived and allied forms, it is of interest to establish the main characters of the species in question, which must bear the name *Trichites plotii* Lycett.

I am indebted to Dr. Arkell for the loan of the most complete specimen yet found in the Oxford district, which, although broken at both ends, attains a length of 250 mm. The thickness of the test of this specimen is very variable, but is nearly 20 mm. at the anterior end. Both valves have an unevenly undulating surface on which faint radial ribbing is visible; there is no diagonal ridge. The valve margins are broken away, but it is probable that the commissure was irregularly undulating. The species is very closely related to *Trichites undatus* Lycett [1850 (1), p. 347; also E. Witchell, 1880, p. 127, Pl. I, figs. 1, 2, and Pl. II, fig. 1], of the English Inferior Oolite, of which more perfect specimens are obtainable than those of the Corallian form.[2]

Dr. Arkell is of the opinion that *T. plotii* belongs to the same group as *Pinna granulata* J. Sowerby (1822, vol. IV, p. 65, Pl. CCCXLVII) and related forms, which are referred to the subgenus *Stegoconcha* in the present Memoir, but on account of its very uneven surface and probably undulating commissure I am inclined to associate it with the group to which the generic name *Trichites* is here applied.

Since, however, Plot and Lhwyd were pre-Linnean authors, the identity of their *Trichites* does not appear to affect the question of generic nomenclature. In post-Linnean literature we find descriptions of "le Trichite" given by E. Bertrand (1763, vol. I, p. 83, and vol. II, p. 229), who suggests that the structure may have belonged to the shell of a gigantic *Pinna*, by M. J. L. Defrance (1828, p. 206), and by G. P. Deshayes (1832, p. 1044). These authors, however, use the word in the vernacular form and not as a generic name; hence it is not established in zoological nomenclature by these references.

In 1833, however, the specific name *Trichites saussuri*, attributed to Voltz, was published by J. Thurmann, and this name was accompanied by the reference "Pinnigène de Saussure, Voy. dans les Alpes, t. I". This reference is sufficient to establish the generic name *Trichites*, the genotype, *T. saussuri*, being the shell described and figured by De Luc in the volume of Saussure's work

[1] *See* page 133.

[2] I am very doubtful of the specific identity of the large specimen from Yorkshire which Dr. Arkell (1934, Pl. XXX, fig. 1) figures as *T. plotii* with the true *T. plotii* from the Oxford district.

cited.[1] De Luc's name "Pinnigène" was not published in Latin form until 1836, when H. G. Bronn (1836, p. 341) published the name *Pinnogena*—without, however, definitely adopting it as a generic name. The form *Pinnigena* we owe to G. P. Deshayes (1839 ?, p. 24 of Explic. des Planches[2]) and A. d'Orbigny (1850, vol. I, p. 313 and vol. II, p. 21), the latter of whom appears to have been the first author definitely to adopt it as a generic name. It is, of course, a synonym of *Trichites*.

The characters of *Trichites* were first clearly established by J. Lycett [1850 (1)]. Our knowledge of the genus has since been particularly enhanced by G. Boehm's (1882, pp. 170-173, Pls. XXXII-XXXVI) description of several species from the Tithonian of Kelheim, and by P. Choffat's description (1888, pp. 67-76, Pls. XIII-XVIII) of a number of species from the Jurassic of Portugal. It is undoubtedly an offshoot from *Pinna*, but sufficiently distinct to rank as a separate genus.

Trichites indicus sp. nov.

Plate X, figs. 13*a*, *b*.

Description.—The shell, which is of moderate size and of considerable thickness, is trapezoidal in outline, with its height approximately equal to its length. The two valves are well inflated, the right being the more gibbose in the better preserved specimen examined (the holotype). The umbones are bluntly pointed. In its average direction the posterior margin, which is slightly concave, makes an angle slightly exceeding 90° with the hinge-margin, which is rather short; the anterior margin, which is also concave, makes an angle of about 60° with the hinge-margin. The posterior and anterior margins thus converge slowly in a ventral direction until each merges into the very strongly convex ventral margin. The commissure is very undulatory, both anterior and posterior margins presenting a pronounced median convexity which faces towards the left-hand side. There is a narrow byssal gape of the anterior margins.

The surface of both valves is very uneven, owing to the presence of pronounced concentric undulations at irregular intervals. In the right valve the antero-dorsal part of the surface bulges very strongly, and the antero-ventral region below is conspicuously hollowed out. Traces of weak radial riblets are visible on the postero-dorsal part of the surface, which forms an ill-defined and slightly flattened wing in each valve.

The internal characters are unknown.

Holotype.—Brit. Mus. L. 71591.

Dimensions.—The measurements of the holotype are as follows:—

Length	83 mm.
Height (estimated)	82 ,,
Inflation	41·5 ,,

[1] The International Rules of Zoological Nomenclature do not stipulate how precise a bibliographic reference should be in order to serve as an "Indication". I assume that in a case like the present, where no ambiguity could arise, an exact page reference is not essential, although, of course, desirable.

[2] The exact dates of publication of the various sheets of the "Explication des Planches" of this work by Deshayes are uncertain.

This specimen, however, does not appear to be full-grown. A second specimen, very broken and largely without its shell, but probably referable to the same species, was originally about 110 mm. in height.

Remarks.—The absence of broad radial or oblique ribs clearly distinguishes this species from such forms as *Trichites nodosus* Lycett [1850(1), p. 347, Pl. X; also J. Morris and J. Lycett, 1853, p. 35, Pl. III, fig. 11], of the Inferior and Great Oolite, and *Trichites saussuri* Thurmann, which ranges from the Argovian to the Infravalanginian.[1] It more closely resembles the species *Trichites planus* Étallon (J. Thurmann and A. Étallon, 1862, p. 219, Pl. LXII, fig. 11), from the Argovian of Switzerland, but the figured specimen of that species is so incomplete that exact comparison is impossible.

Occurrences and Material.—Callovian, Middle Chari, *anceps* Beds, of Khera ["Bed No. 7" of Blake, MS.[2]]—the holotype (colld. J. F. Blake).

Callovian or Divesian, valley north of Dhosa—one very imperfect specimen (G. S. I. No. K40/599, colld. A. B. Wynne).

[1] L. Rollier (1914, pp. 372-3) bestows several distinct specific names on the Jurassic specimens referred by previous authors to *Trichites saussuri*, but these specimens belong, in my opinion, to a single well-characterized species which ranges from the Upper Jurassic to the Lower Cretaceous.

[2] See L. F. Spath, 1924, p. 21, and 1933, p. 743.

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PLATE I.

(ALL FIGURES ARE OF NATURAL SIZE UNLESS IT IS OTHERWISE STATED.)

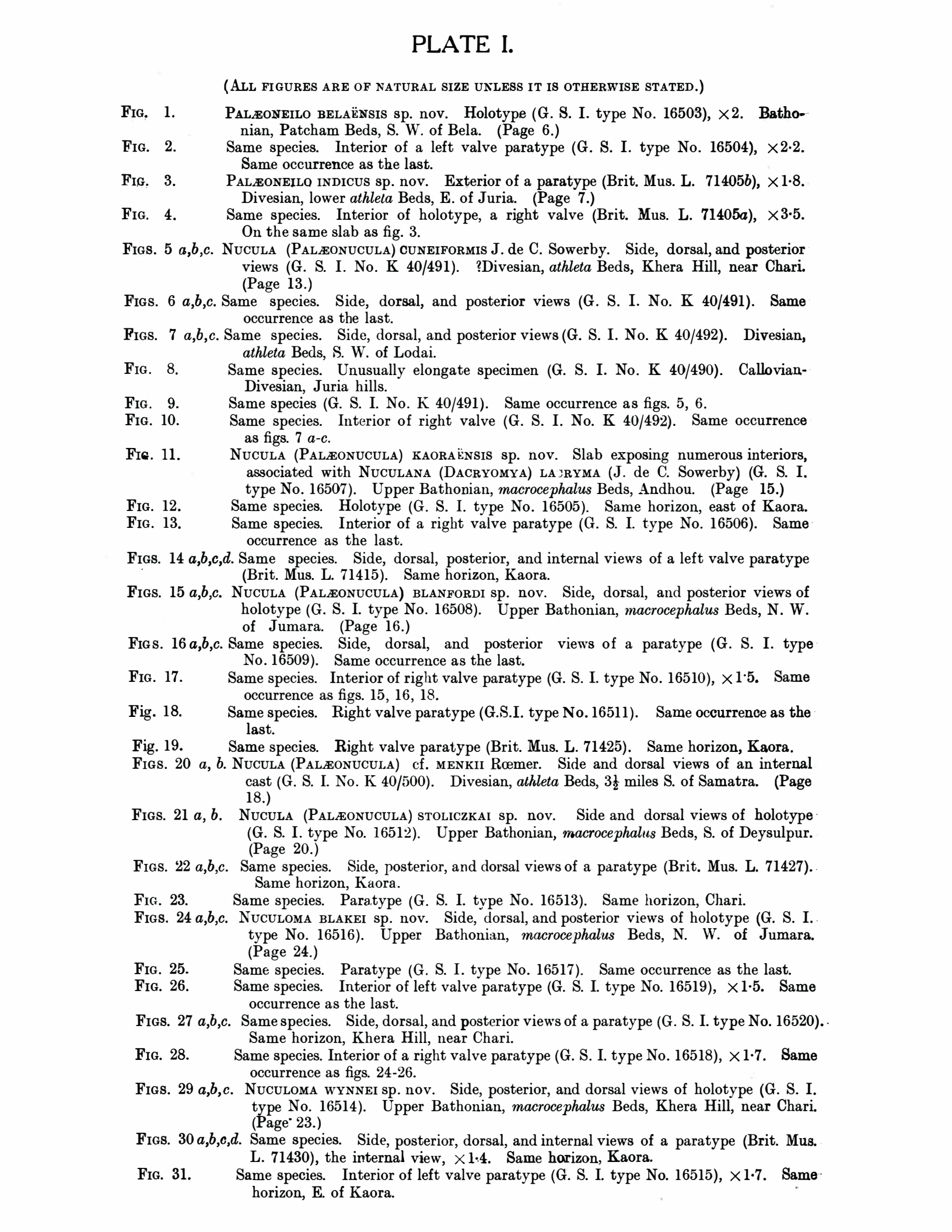


FIG. 1. PALÆONEILO BELAËNSIS sp. nov. Holotype (G. S. I. type No. 16503), ×2. Bathonian, Patcham Beds, S. W. of Bela. (Page 6.)

FIG. 2. Same species. Interior of a left valve paratype (G. S. I. type No. 16504), ×2·2. Same occurrence as the last.

FIG. 3. PALÆONEILO INDICUS sp. nov. Exterior of a paratype (Brit. Mus. L. 71405*b*), ×1·8. Divesian, lower *athleta* Beds, E. of Juria. (Page 7.)

FIG. 4. Same species. Interior of holotype, a right valve (Brit. Mus. L. 71405*a*), ×3·5. On the same slab as fig. 3.

FIGS. 5 *a,b,c*. NUCULA (PALÆONUCULA) CUNEIFORMIS J. de C. Sowerby. Side, dorsal, and posterior views (G. S. I. No. K 40/491). ?Divesian, *athleta* Beds, Khera Hill, near Chari. (Page 13.)

FIGS. 6 *a,b,c*. Same species. Side, dorsal, and posterior views (G. S. I. No. K 40/491). Same occurrence as the last.

FIGS. 7 *a,b,c*. Same species. Side, dorsal, and posterior views (G. S. I. No. K 40/492). Divesian, *athleta* Beds, S. W. of Lodai.

FIG. 8. Same species. Unusually elongate specimen (G. S. I. No. K 40/490). Callovian-Divesian, Juria hills.

FIG. 9. Same species (G. S. I. No. K 40/491). Same occurrence as figs. 5, 6.

FIG. 10. Same species. Interior of right valve (G. S. I. No. K 40/492). Same occurrence as figs. 7 *a-c*.

FIG. 11. NUCULA (PALÆONUCULA) KAORAËNSIS sp. nov. Slab exposing numerous interiors, associated with NUCULANA (DACRYOMYA) LACRYMA (J. de C. Sowerby) (G. S. I. type No. 16507). Upper Bathonian, *macrocephalus* Beds, Andhou. (Page 15.)

FIG. 12. Same species. Holotype (G. S. I. type No. 16505). Same horizon, east of Kaora.

FIG. 13. Same species. Interior of a right valve paratype (G. S. I. type No. 16506). Same occurrence as the last.

FIGS. 14 *a,b,c,d*. Same species. Side, dorsal, posterior, and internal views of a left valve paratype (Brit. Mus. L. 71415). Same horizon, Kaora.

FIGS. 15 *a,b,c*. NUCULA (PALÆONUCULA) BLANFORDI sp. nov. Side, dorsal, and posterior views of holotype (G. S. I. type No. 16508). Upper Bathonian, *macrocephalus* Beds, N. W. of Jumara. (Page 16.)

FIGS. 16 *a,b,c*. Same species. Side, dorsal, and posterior views of a paratype (G. S. I. type No. 16509). Same occurrence as the last.

FIG. 17. Same species. Interior of right valve paratype (G. S. I. type No. 16510), ×1·5. Same occurrence as figs. 15, 16, 18.

Fig. 18. Same species. Right valve paratype (G.S.I. type No. 16511). Same occurrence as the last.

Fig. 19. Same species. Right valve paratype (Brit. Mus. L. 71425). Same horizon, Kaora.

FIGS. 20 *a, b*. NUCULA (PALÆONUCULA) cf. MENKII Rœmer. Side and dorsal views of an internal cast (G. S. I. No. K 40/500). Divesian, *athleta* Beds, 3½ miles S. of Samatra. (Page 18.)

FIGS. 21 *a, b*. NUCULA (PALÆONUCULA) STOLICZKAI sp. nov. Side and dorsal views of holotype (G. S. I. type No. 16512). Upper Bathonian, *macrocephalus* Beds, S. of Deysulpur. (Page 20.)

FIGS. 22 *a,b,c*. Same species. Side, posterior, and dorsal views of a paratype (Brit. Mus. L. 71427). Same horizon, Kaora.

FIG. 23. Same species. Paratype (G. S. I. type No. 16513). Same horizon, Chari.

FIGS. 24 *a,b,c*. NUCULOMA BLAKEI sp. nov. Side, dorsal, and posterior views of holotype (G. S. I. type No. 16516). Upper Bathonian, *macrocephalus* Beds, N. W. of Jumara. (Page 24.)

FIG. 25. Same species. Paratype (G. S. I. type No. 16517). Same occurrence as the last.

FIG. 26. Same species. Interior of left valve paratype (G. S. I. type No. 16519), ×1·5. Same occurrence as the last.

FIGS. 27 *a,b,c*. Same species. Side, dorsal, and posterior views of a paratype (G. S. I. type No. 16520). Same horizon, Khera Hill, near Chari.

FIG. 28. Same species. Interior of a right valve paratype (G. S. I. type No. 16518), ×1·7. Same occurrence as figs. 24-26.

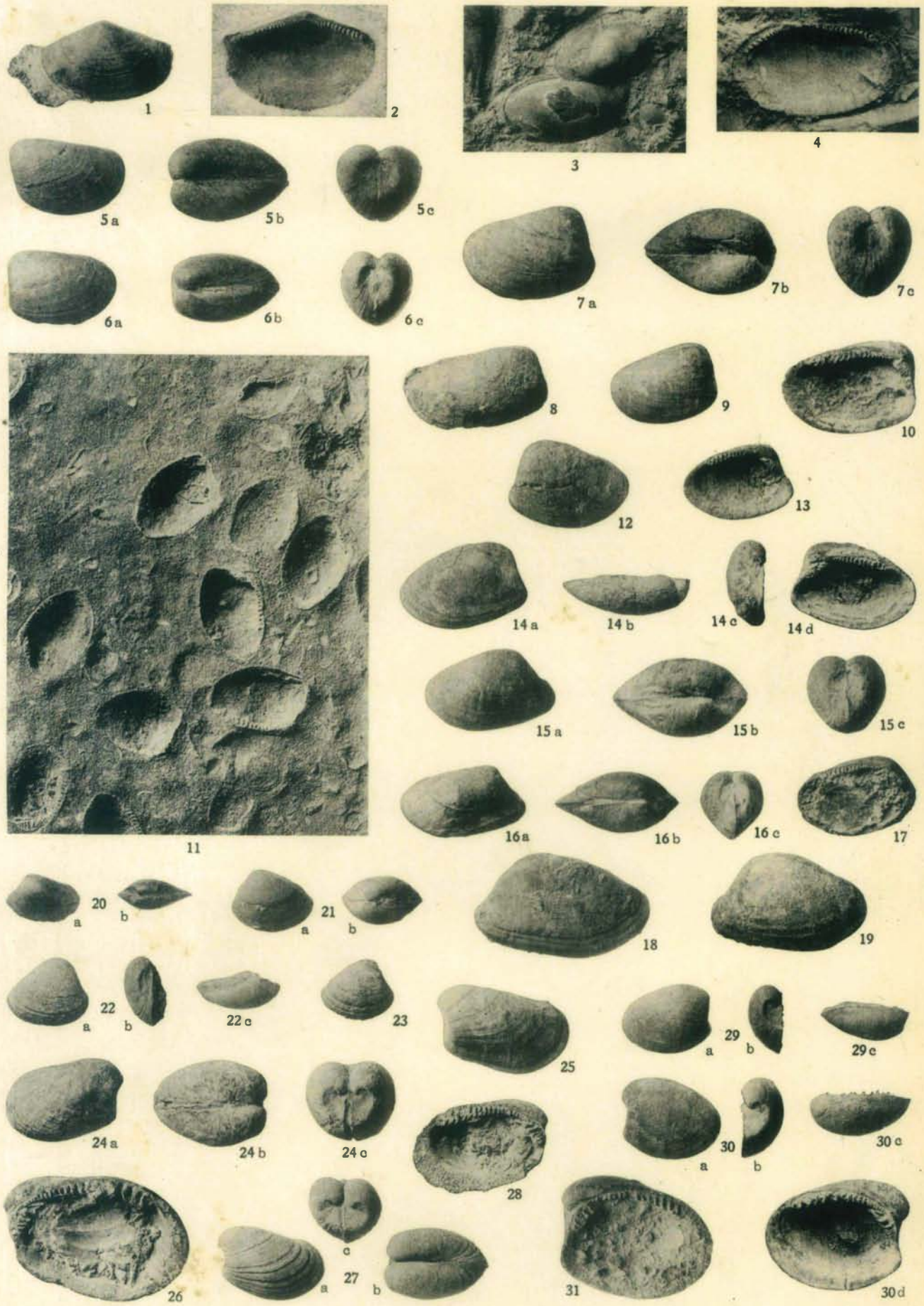
FIGS. 29 *a,b,c*. NUCULOMA WYNNEI sp. nov. Side, posterior, and dorsal views of holotype (G. S. I. type No. 16514). Upper Bathonian, *macrocephalus* Beds, Khera Hill, near Chari. (Page 23.)

FIGS. 30 *a,b,c,d*. Same species. Side, posterior, dorsal, and internal views of a paratype (Brit. Mus. L. 71430), the internal view, ×1·4. Same horizon, Kaora.

FIG. 31. Same species. Interior of left valve paratype (G. S. I. type No. 16515), ×1·7. Same horizon, E. of Kaora.

Geol. Surv. of India

Plate I.



L. R. Cox. photo.

Zinco-Collotype Co., Edinburgh.

PLATE II.

(ALL FIGURES ARE OF NATURAL SIZE UNLESS IT IS OTHERWISE STATED.)

FIGS. 1 *a,b.* NUCULA sp. Side and dorsal views (Brit. Mus. L. 71428). Bathonian, Patcham Dolomite, Andhou. (Page 21.)

FIGS. 2 *a,b.* NUCULANA (DACRYOMYA) LACRYMA (J. de C. Sowerby). Side and dorsal views (G. S. I. No. K 40/514), ×2. Upper Bathonian, *macrocephalus* Beds, Khera Hill, near Chari. (Page 29.)

FIG. 3. Same species. Interior of a left valve (Brit. Mus. L. 71443), ×2. Same occurrence as the last.

FIG. 4. Same species (G. S. I. No. K 40/516). Bathonian, Patcham Beds, Gora Dongar (Patcham).

FIG. 5. Same species, associated with NUCULA (PALÆONUCULA) STOLICZKAI sp. nov. (G. S. I. No. K 40/513). Upper Bathonian, *macrocephalus* Beds, N. of Kumagoona.

FIG. 6. NUCULANA (PRÆSACCELLA) JURIANA sp. nov. Paratype (Brit. Mus. L. 71444), ×2·2. Divesian, *athleta* Beds, S. of Rataupur. (Page 33.)

FIG. 7. Same species. Holotype (Brit. Mus. L. 71405*c*), ×4. Same horizon, E. of Juria. (See Pl. VI, fig. 8, for a natural-sized figure of the slab on which this and the next two specimens are preserved.)

FIG. 8. Same species. Interior of a left valve paratype (Brit. Mus. L. 71405*e*), ×4. Preserved on the same slab as the last.

FIG. 9. Same species. Paratype (Brit. Mus. L. 71405*d*), ×4. Preserved on the same slab as the last.

FIGS. 10 *a,b,c.* ROLLIERIA cf. MERIANI (Rollier.) Side view (natural size and ×2) and dorsal view (×2) of an internal cast (G. S. I. No. K 40/519). Divesian, *athleta* Beds, 3½ miles S. of Samatra. (Page 35.)

FIG. 11. PARALLELODON LERENSIS sp. nov. Holotype (Brit. Mus. L. 71445), ×1·3. Divesian, *athleta* Beds, E. of Ler. (Page 39.)

FIG. 12. GRAMMATODON ANDHOUENSIS sp. nov. Paratype (Brit. Mus. L. 71447*a*). Bathonian, Patcham Dolomite, Andhou. (Page 41.)

FIG. 13. Same species. Holotype (Brit. Mus. L. 71446). Same occurrence as the last.

FIG. 14. Same species. Paratype (Brit. Mus. L. 71447*b*), ×1·7. On the same slab as fig. 12.

FIGS. 15 *a, b.* GRAMMATODON JURIANUS sp. nov. Side and dorsal views of holotype (G. S. I. type No. 16521). Divesian, *athleta* Beds, valley N. of Dhosa. (Page 43.)

FIGS. 16 *a,b.* Same species. Side and dorsal views of an internal cast (G. S. I. type No. 16522). Same horizon, " Bowl " at Fakirwadi.

FIGS. 17 *a,b.* Same species. Side and dorsal views of an internal cast (G. S. I. type No. 16523). Same occurrence as the last.

FIG. 18. Same species. Internal cast (G. S. I. type No. 16524). Same occurrence as the last.

FIG. 19. Same species. Paratype (Brit. Mus. L. 71448), associated with *Grammatodon* (*Indogrammatodon*) *virgatus* (J. de C. Sowerby). Same horizon, east of Juria.

FIGS. 20 *a,b.* Same species. Paratype (Brit. Mus. L. 71450), fig. *b* showing ornamentation of ventral region, ×2. Same horizon, Jikadi.

FIGS. 21 *a,b.* GRAMMATODON sp. Side and dorsal views (G. S. I. No. K 40/524). Upper Bathonian, lower *macrocephalus* Beds, N. W. of Jumara. (Page 44.)

FIG. 22. GRAMMATODON (INDOGRAMMATODON) VIRGATUS (J. de C. Sowerby). Right valve (Brit. Mus. L. 71483). Divesian, lower Dhosa Oolite, W. of Juria. (Page 47.)

FIG. 23. Same species. Right valve (G. S. I. No. K 40/542). Same horizon, locality unrecorded.

FIG. 24. Same species. Left valve (G. S. I. No. K 40/531). Callovian-Divesian, *anceps* or *athleta* Beds, river on road from Guddera to Jenane.

FIG. 25. Same species. Right valve (G. S. I. No. K 40/531). Same occurrence as the last.

FIG. 26. Same species. Specimen (G. S. I. No. K 40/526) from the lowest stratigraphical horizon at which the species was collected. Bathonian, lower *macrocephalus* Beds, N. W. of Jumara.

FIG. 27. Same species. Lectotype, the original of Sowerby's fig. 1 (Brit. Mus., No. 9957 of Geol. Soc. Register). Divesian ?, Habo hills.

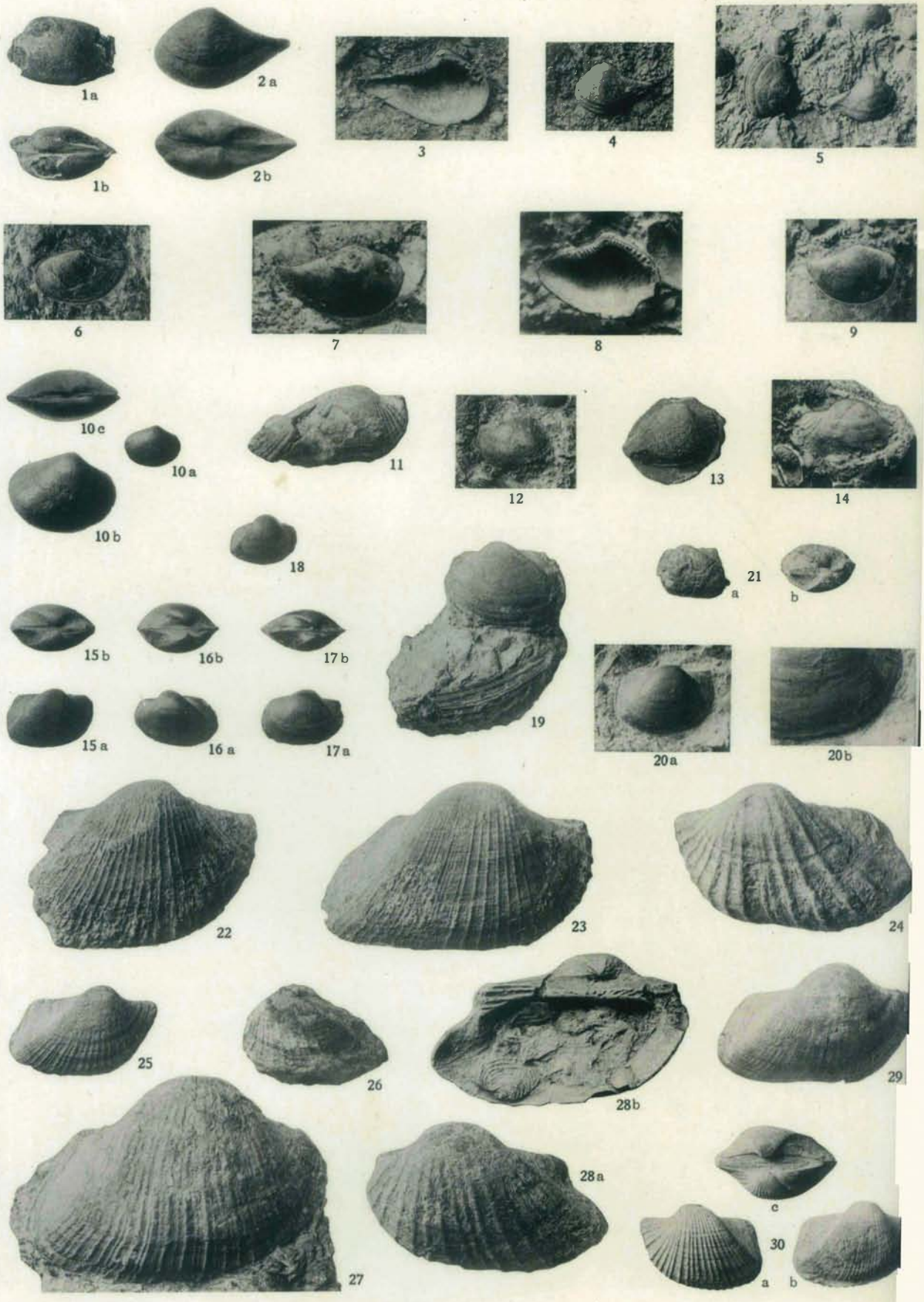
FIGS. 28 *a,b.* Same species. Exterior and interior of a left valve (G. S. I. No. K 40/531). Same occurrence as figs. 24, 25.

FIG. 29. Same species. Right valve (G. S. I. No. K 40/531). Same occurrence as the last.

FIGS. 30 *a,b,c.* Same species. Left and right valves and dorsal view of a well-preserved but immature specimen (G. S. I. No. K 40/541). ? Divesian, *athleta* Beds, locality unrecorded.

Geol. Surv. of India

Plate II.



L. R. Cox. photo.

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PLATE III.

(ALL FIGURES ARE OF NATURAL SIZE.)

FIGS. 1 *a,b,c.* GRAMMATODON (INDOGRAMMATODON) KANTKOTENSIS sp. nov. Left and right valves and dorsal view of holotype (Brit. Mus. L. 71493). Argovian, Kantkote. (Page 51.)

FIGS. 2 *a,b,c.* GRAMMATODON (INDOGRAMMATODON) BLAKEI sp. nov. Left and right valves and dorsal view of holotype (Brit. Mus. L. 71485). ? Callovian, *anceps* Beds, E. of Juria. (Page 50.)

FIG. 3. GRAMMATODON (INDOGRAMMATODON) IDDURGHURENSIS sp. nov. Right valve of holotype (G. S. I. type No. 16525). Argovian, Iddurghur. (Page 52.)

FIG. 4. Same species. Less elongate right valve paratype (G. S. I. type No. 16527). Same occurrence as the last.

FIG. 5. Same species. Interior of a left valve paratype (G. S. I. type No. 16528). Same occurrence as the last.

FIGS. 6 *a,b.* Same species. Internal and dorsal views of a right valve paratype (Brit. Mus. L. 71488). Same occurrence as the last.

FIG. 7. GRAMMATODON (INDOGRAMMATODON) sp. (Brit. Mus. L. 71494). Argovian, N. of Wamka. (Page 54.)

Geol. Surv. of India

Plate III.



1a



1b



1c



2a



2b

3



2c

4



5



6b



6a



7

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PLATE IV.

(ALL FIGURES ARE OF NATURAL SIZE.)

FIG. 1. GRAMMATODON (INDOGRAMMATODON) IDDURGHURENSIS sp. nov. Right valve paratype (Brit. Mus. L. 71487). Argovian, Iddurghur. (Page 52.)

FIG. 2. Same species. Left valve paratype (G. S. I. type No. 16526). Same occurrence as the last.

FIGS. 3 *a*,*b*. CUCULLÆA (MEGACUCULLÆA) KRAUSSII Tate. Side and dorsal views of an immature right valve (Brit. Mus. L. 71495). Tithonian, N. of Moondan. (Page 57.)

FIG. 4. Same species. Incomplete right valve (G. S. I. No. K 40/551). Same horizon, N. E. of Umia.

FIGS. 5 *a*,*b*,*c*,*d*. CUCULLÆA (MEGACUCULLÆA) EMINENS sp. nov. Side, internal, posterior, and dorsal views of holotype, a right valve (Brit. Mus. L. 71496). Tithonian, W. of Soorkha. (Page 59.)

FIG. 6. Same species. Left valve paratype (Brit. Mus. L. 71497). Same occurrence as the last.

FIG. 7. Same species. Left valve paratype (Brit. Mus. L. 71498). Same occurrence as the last.

FIG. 8. MODIOLUS PATCHAMENSIS sp. nov. Holotype (G. S. I. type No. 16529). Bathonian, Patcham Beds, Kuari Bet. (Page 63.)

Geol. Surv. of India

Plate IV.


1


3 a


b


4


2


6


7


5b


5d


5a


5c


8

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PLATE V.

(ALL FIGURES ARE OF NATURAL SIZE.)

FIGS. 1, 2. MODIOLUS IMBRICATUS J. Sowerby. Large specimens flattened by pressure (G. S. I. No. K 40/557). Bathonian, Patcham Beds, flanks of Mooanna Hill, Bela. (Page 64.)

FIG. 3. Same species. Large specimen of trigonal outline (Brit. Mus. L. 71509). Upper Bathonian, *macrocephalus* Beds, Khera Hill, near Chari.

FIG. 4. Same species. Medium-sized specimen somewhat crushed ventrally (Brit. Mus. L. 71503). Bathonian, Patcham Beds, Kuari Bet.

FIG. 5. Same species. Small reniform specimen (G. S. I. No. K 40/554). Same horizon, N. of Lodranee (Bela).

FIG. 6. Same species (G. S. I. No. K 40/556). Same horizon, N. of Gudjeuva (Karrir).

FIG. 7. Same species. Rather crushed specimen with well-marked concentric imbrications (Brit. Mus. L. 71508). Same horizon, Karrir.

FIG. 8. MODIOLUS GLENDAYI (Weir) (G. S. I. No. K 40/602). Callovian, *rehmanni* or *anceps* Beds, N. W. of Jumara. (Page 69.)

FIG. 9. Same species (G. S. I. No. K 40/564). Divesian, *athleta* Beds, Fakirwadi.

FIG. 10. Same species (G. S. I. No. K 40/559). Upper Bathonian, *macrocephalus* Beds, N. W. of Jumara.

FIG. 11. MODIOLUS cf. BIPARTITUS J. Sowerby (Brit. Mus. L. 71511). Upper Bathonian, *macrocephalus* Beds, Khera Hill, near Chari. (Page 67.)

FIG. 12. Same species. Broken specimen (G. S. I. No. K 40/558). Same locality and probably about the same horizon as the last.

FIG. 13. MODIOLUS (INOPERNA) PLICATUS J. Sowerby. Slightly distorted specimen (Brit. Mus. L. 71518). Upper Bathonian, *macrocephalus* Beds, Gaduada (Karrir). (Page 71.)

FIG. 14. Same species (G. S. I. No. K 40/560). Same horizon, N. W. of Jumara.

FIG. 15. BRACHIDONTES (ARCOMYTILUS) LAITMAIRENSIS (de Loriol). Right valve (G. S. I. No. K 40/570) associated with the brachiopod "*Terebratula*" *aurata* Kitchin. ? Upper Bathonian, *macrocephalus* beds, locality unrecorded. (Page 81.)

FIG. 16. Same species (G. S. I. No. K 40/566). Upper Bathonian, *macrocephalus* Beds, N. W. of Jumara.

FIG. 17. Same species (G. S. I. No. K 40/567). Same horizon, Khera Hill, near Chari.

FIG. 18. MYTILUS (FALCIMYTILUS) TRAMAUENSIS sp. nov. Holotype (Brit. Mus. L. 71524). Argovian, Tramau River. (Page 77.)

FIGS. 19 *a,b*. LYCETTIA INDICA sp. nov. Holotype (G. S. I. type No. 16530), fig. *b* showing the flattened antero-ventral surface, with the carina forming the left-hand edge of the figure. Jurassic, Kachh. (Page 85.)

FIG. 20. Same species. Paratype showing interior of umbonal region (G. S. I. type No. 16531). Jurassic, Kachh.

FIG. 21. LITHOPHAGA sp. indet. B. (Brit. Mus. L. 71521). Callovian, *anceps* Beds, Khera Hill, near Chari. (Page 74.)

FIG. 22. LITHOPHAGA sp. indet. C. (Brit. Mus. L. 71523). Tithonian, N. of Moondan. (Page 74.)

FIG. 23. LITHOPHAGA sp. indet. A. (Brit. Mus. L. 71520). Upper Bathonian, *macrocephalus* Beds, Habo. (Page 73.)

Geol. Surv. of India

Plate V.



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PLATE VI.

(ALL FIGURES ARE OF NATURAL SIZE.)

FIG. 1. PTEROPERNA sp. (G. S. I. No. K 40/571). Divesian, Dhosa Oolite, Juria Hills, on road from Juria to Dhosa. (Page 88.)

FIG. 2. ECHINOTIS ECHINATA (W. Smith). Typical specimen (G. S. I. No. K 40/575). Upper Bathonian, *macrocephalus* Beds, N. W. of Jumara. (Page 92.)

FIG. 3. Same species. Feebly inflated and sparsely ribbed left valve (G. S. I. No. K 40/574). Bathonian, Patcham Dolomite, Kakeendia Bet.

FIG. 4. Same species. Specimen approaching the form *braamburiensis* (Phillips) (G. S. I. No. K 40/573). Same horizon, E. of Kaora.

FIG. 5. Same species. Left valve with a prominent pointed posterior wing (Brit. Mus. L. 71527). Same horizon, Andhou.

FIG. 6. Same species. Left valve with reticulate ornamentation (eroded) (Brit. Mus. L. 71528). Same occurrence as the last.

FIG. 7. Same species. Left valve with ornamentation of the *braamburiensis* type (G. S. I. No. K 40/572). Same horizon, N. of Guddera (Bela).

FIG. 8. PTEROPERNA BLAKEI sp. nov. Holotype (Brit. Mus. L. 71405*f*), partly obscured by an *Entolium* valve, preserved on the same slab as the type-specimens of PALÆONEILO INDICUS sp. nov. (Pl. I, figs. 3, 4) and NUCULANA (PRÆSACCELLA) JURIANA sp. nov. (Pl. II, figs. 7-9). Divesian, lower *athleta* Beds, E. of Juria. (Page 89.)

FIG. 9. OXYTOMA INEQUIVALVE (J. Sowerby). Obliquely elongate specimen with smooth intercostal spaces and a step-down from the body to the posterior wing (G. S. I. No. K 40/577). ?Divesian, lower Dhosa Oolite, E. of Ler. (Page 98.)

FIGS. 10, 11. Same species. Small specimen with almost smooth interspaces (G. S. I. No. K 40/576). Divesian, lower Dhosa Oolite, Juria.

FIG. 12. Same species. Specimen with thick primary ribs, and a secondary riblet in each interspace (Brit. Mus. L. 71537). Upper Argovian, Barodia.

FIG. 13. OXYTOMA sp. (G. S. I. No. K 40/601). Divesian, lower Dhosa Oolite, valley N. of Dhosa. (Page 101.)

FIGS. 14 *a,b*. ISOGNOMON (MYTILOPERNA ?) sp. Right and left valves (about two-thirds of the specimen is broken away) (G. S. I. No. K 40/595). Bathonian-Callovian, Khera Hill, near Chari. (Page 123.)

FIG. 15. ISOGNOMON (MYTILOPERNA) PATCHAMENSIS sp. nov. Paratype (Brit. Mus. L. 71576). Bathonian, Patcham Beds, Kuari Bet. (Page 122.)

FIG. 16. Same species. Interior of a right valve paratype (G. S. I. type No. 16538). Same horizon, Dhorawar (Patcham).

FIG. 17. Same species. Interior of a left valve paratype (G. S. I. type No. 16539). Same occurrence as fig. 15.

FIG. 18. Same species. Largest specimen examined (Brit. Mus. L. 71578). Same horizon, Lodai.

FIGS. 19 *a,b*. Same species. Left valve and foreshortened dorsal view of a paratype, showing carina (G. S. I. type No. 16537). Same occurrence as fig. 16.

FIG. 20. Same species. Holotype (G. S. I. type No. 16536). Same occurrence as figs. 16, 19.

Geol. Surv. of India

Plate VI.

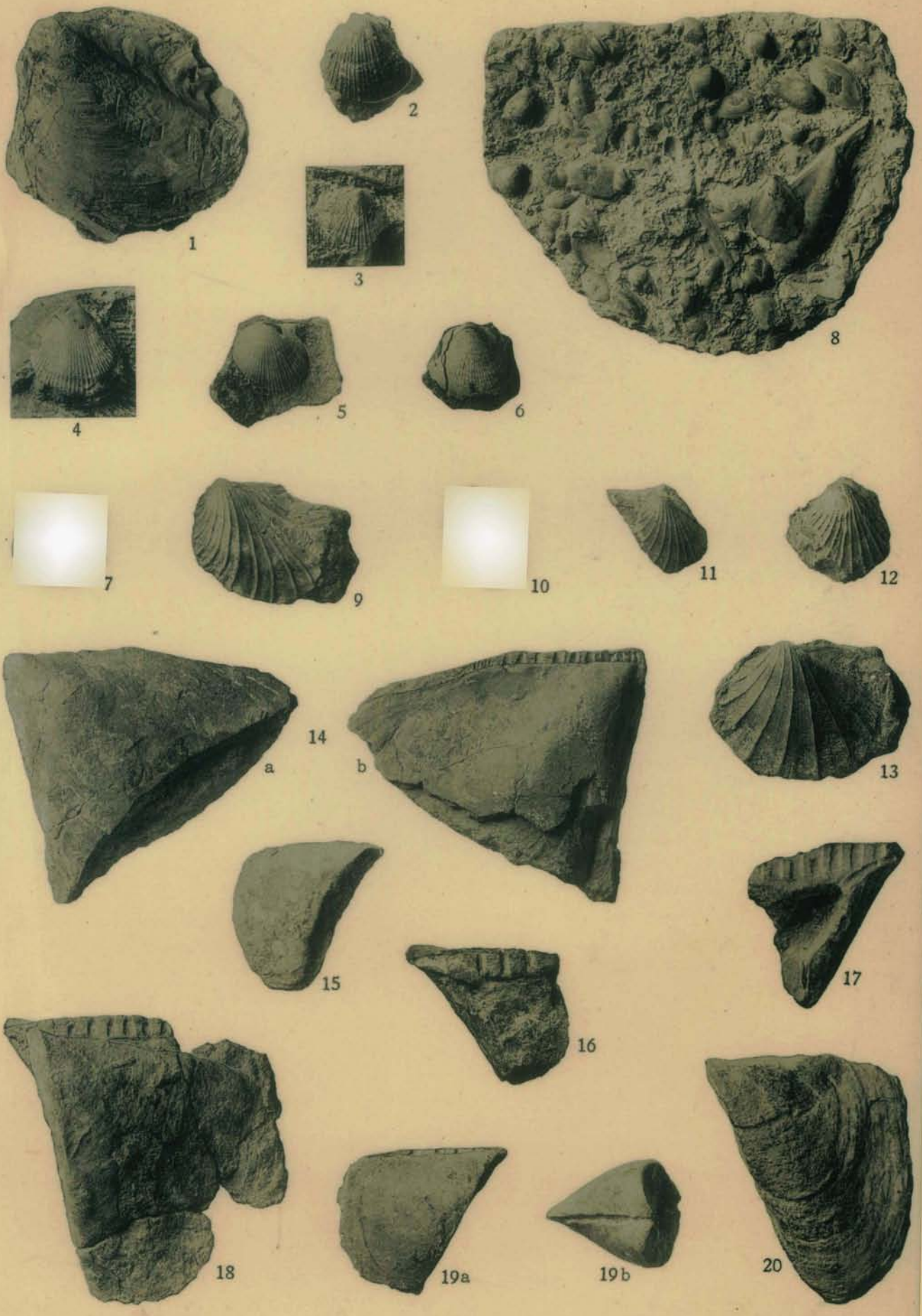

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PLATE VII.

(ALL FIGURES ARE OF NATURAL SIZE.)

FIGS. 1*a-c*. BAKEVELLIA WALTONI (Lycett). Right and left valves of the same specimen and dorsal view, with the right valve uppermost (G. S. I. No. K 40/581). Bathonian, Patcham Beds, Dhorawar (Patcham). (Page 108.)

FIG. 2. Same species. A left valve, showing pointed posterior wing (G. S. I. No. K 40/581). Same occurrence as the last.

FIG. 3. Same species. A right valve (G. S. I. No. K 40/579). Same horizon, N. of Guddera.

FIG. 4. Same species. Interior of a left valve, showing cardinal teeth (G. S. I. No. K 40/580). Same horizon, N. of Lodranee (Bela).

FIG. 5. Same species. Interior of a left valve (G. S. I. No. K 40/581). Same occurrence as figs. 1, 2.

FIG. 6. Same species. Right valve (Brit. Mus. L. 71548). Same horizon, Kuari Bet.

FIG. 7. Same species. Interior of a left valve, showing cardinal teeth (G. S. I. No. K 40/579). Same occurrence as fig. 3.

FIG. 8. INOCERAMUS sp. indet. Fragment consisting of about one-half of the original shell (Brit. Mus. L. 71579); the dotted lines indicate the suggested reconstruction of the dorsal half of the shell. Divesian, *athleta* Beds, E. of Ler. (Page 127.)

FIG. 9. BAKEVELLIA sp. Right valve (G. S. I. No. K 40/582), the dotted line showing probable shape of the broken posterior end. Divesian, *athleta* Beds, S. of Juria. (Page 111.)

FIGS. 10, 11. POSIDONIA ORNATI Quenstedt (G. S. I. No. K 40/578). Upper Bathonian, lower *macrocephalus* Beds, N. W. of Jumara. (Page 103.)

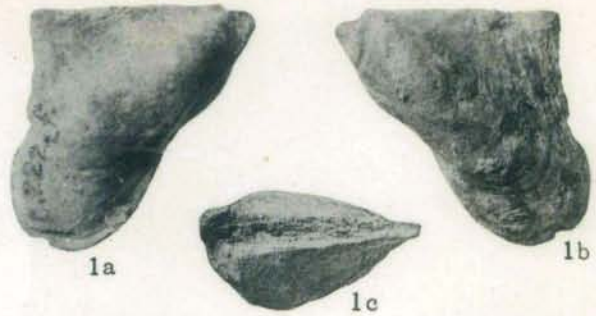
FIG. 12. GERVILLELLA SILIQUA (J. A. Eudes-Deslongchamps). Largest specimen examined, broken away anteriorly (G. S. I. No. K 40/583). Divesian, lower Dhosa Oolite, Juria. (Page 112.)

FIG. 13. Same species. Left valve, broken away anteriorly (G. S. I. No. K 40/583). Same occurrence as the last.

FIG. 14. Same species. Fragment of a right valve, showing anterior auricle (G. S. I. No. K 40/583). Same occurrence as the last.

Geol. Surv. of India

Plate VII.


1a

1b

1c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3

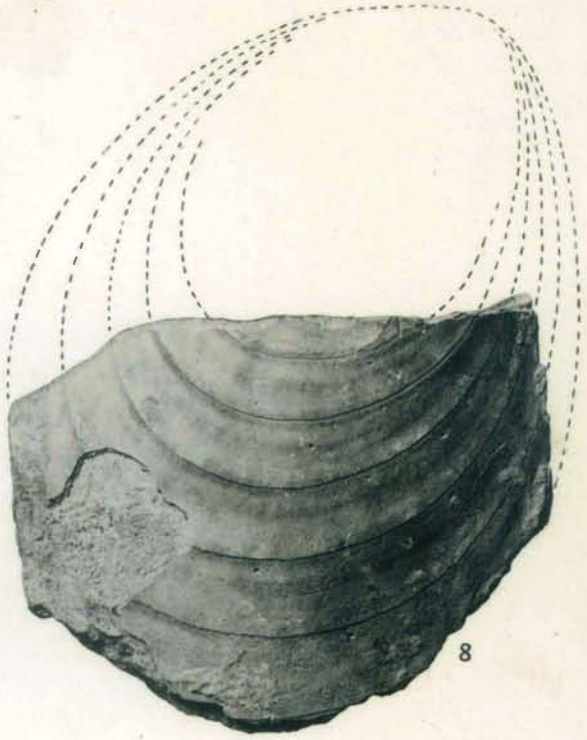
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PLATE VIII.

(ALL FIGURES ARE OF NATURAL SIZE.)

FIG. 1. GERVILLELLA KANTKOTENSIS sp. nov. Holotype (G. S. I. type No. 16533). Argovian, Iddurghur. (Page 115.)

FIG. 2. Same species. Paratype (G. S. I. type No. 16535). Argovian, E. of Chowbari.

FIG. 3. Same species. Paratype, showing anterior auricle (Brit. Mus. L. 71564). Argovian, Gangta Bet.

FIGS. 4 *a*,*b*. Same species. Right valve and dorsal view of a paratype (Brit. Mus. L. 71565). Same occurrence as the last.

FIG. 5. Same species. Interior of part of a right valve (G. S. I. type No. 16534). Same occurrence as fig. 1.

Geol. Surv. of India

Plate VIII.



L. R. Cox. photo.

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PLATE IX.

(ALL FIGURES ARE OF NATURAL SIZE.)

FIG. 1. GERVILLELLA ANCEPS (Deshayes MS., Leymerie). Crushed left valve (G. S. I. No. K 40/588). Tithonian, N. E. of Umia. (Page 117.)

FIGS. 2 *a*,*b*. Same species. Right valve and dorsal view of a broken but uncrushed specimen (G. S. I. No. K 40/591). Tithonian ?, locality unrecorded.

FIGS. 3, 4. Same species. Interiors of two broken right valves, showing variation in dentition and in width of ligamental area (G. S. I. No. K 40/590). Tithonian, Hurooras.

FIG. 5. Same species (Brit. Mus. L. 71572). Tithonian, N. of Moondan.

Geol. Surv. of India

Plate IX.



1



2b



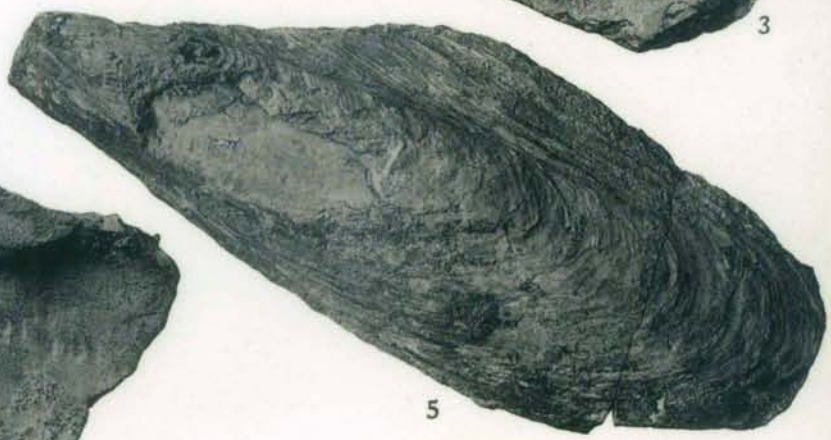
2a



3



4



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L. R. Cox. photo.

Zinco-Collotype Co., Edinburgh.

PLATE X.

(ALL FIGURES ARE OF NATURAL SIZE.)

FIGS. 1-8. ELIGMUS ROLLANDI Douvillé (G. S. I. No. K 40/596). Figs. 2 and 6 show the raised myophorous platform on the interior of the shell; the remaining figures illustrate the variation in shape and ribbing. Upper Bathonian, lower *macrocephalus* Beds, N. W. of Jumara. (Page 128.)

FIG. 9. PINNA STOLICZKAI sp. nov. Holotype (G. S. I. type No. 16532). Callovian, Kumagoona. (Page 135.)

FIG. 10. Same species. Paratype (Brit. Mus. L. 71589). Divesian, *athleta* Beds. Jikadi.

FIG. 11. PINNA cf. MITIS Phillips (G. S. I. No. K 40/597). Callovian-Divesian, S. W. of Lodai. (Page 132.)

FIG. 12. PINNA (STEGOCONCHA) cf. G.-MÜLLERI Krenkel (Brit. Mus. L. 71588). Divesian ?, E. of Juria. (Page 134.)

FIGS. 13 *a,b*. TRICHITES INDICUS sp. nov. Left and right valves of holotype (Brit. Mus. L. 71591). Callovian, *anceps* Beds, Khera Hill, near Chari. (Page 138.)

Geol. Surv. of India

Plate X.


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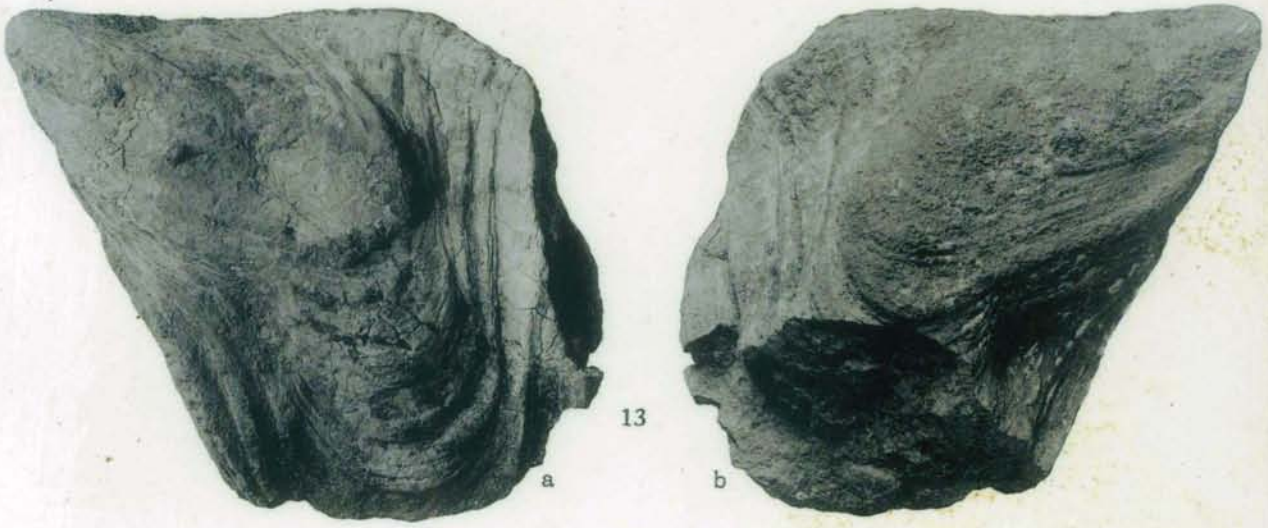
13

a

b

L. R. Cox, photo.

Zinco-Collotype Co., Edinburgh.