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A NEW GENUS *GLYPTOLEDA* AND A REVISION OF THE GENUS *NUCULANA* FROM THE PERMIAN OF AUSTRALIA.

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(Plates xix–xxii.)

Introduction.

In this paper the genus *Nuculana* occurring in the Permian rocks of Australia is revised. Generic rank is given to a well defined group of these shells with a characteristic and bizarre ornamentation under the name *Glyptoleda*. The stratigraphy of the Silverwood-Lucky Valley Permian succession has been reinterpreted on additional palaeontological evidence.

A collection of fossils from Permian beds in the Springsure area of Queensland was made some time ago by Mr. J. H. Reid, of the Queensland Geological Survey. The specimens are of particular interest and include a series of well preserved shells (Nos. 261–268) which have been referred to the new genus *Glyptoleda*. They were collected from rocks of the Coral or Ingelara Stage at Ingelara Station, near Carnarvon Creek, in the Springsure district. This collection is now in the Australian Museum, but is to be transferred to the University of Queensland. I offer my thanks to Mr. J. H. Reid for the loan of the specimens.

The assistance given by the Shell (Queensland) Development Pty. Ltd., in making available for examination, from their collection in Brisbane, a fine series of specimens of *Glyptoleda* is greatly appreciated. The company generously presented to the Australian Museum the two specimens selected as the holotypes of *G. reidi* and *G. glomerata*.

I am indebted to Dr. Curt Teichert, of the University of Western Australia, for the opportunity of examining and describing the Western Australian material used in the preparation of this paper.

Historical Notes on the Genus Nuculana from Australian Permian Localities.

The first reference to the occurrence of *Nuculana* in the Permian rocks of Australia is Dana's description (1847, p. 157) of an internal cast of a shell from Wollongong, Illawarra district of New South Wales, as *Nucula abrupta*. Two years later, the same author redescribed *N. abrupta* (1849, pp. 698–699) and also described the two additional species, *N. concinna* from Harper's Hill, and *N. glendonensis* from Glendon, both localities in the Hunter Valley of New South Wales. The two former species are referred to the genus *Nuculana*, but it is impossible to come to any definite conclusion regarding *N. glendonensis*. The species was described from an imperfect shell and the figure is meaningless.

A plastotype of *N. concinna*, figured in this paper (Pl. xxii, fig. 3), is an imperfect specimen and shows few definite characters. Although described from the Allandale Stage of the Lower Marine Series at Harper's Hill, it compares very favourably in size and outline with a specimen (F.39313) from the base of the Branxton Stage in the Upper Marine Series. This specimen is figured (Pl. xxii, figs. 4–5) and has been chosen as a plesiotype of the species.

De Koninck (1877, p. 147) described a single shell as *Tellinomya darwini*, from a greyish sandstone in a railway cutting between Maitland and Stony Creek, New South Wales. Etheridge (1888, p. 168) referred this species to the genus *Nuculana*, as he

considered the shell possessed none of the characters of *Tellinomya*. In the same publication, Etheridge described *Nuculana waterhousei*, collected from the Lower Marine Series, Farley Stage, at Wollombi Road cutting, near Farley Railway Station, New South Wales. This species has an unusual fluctuating type of concentric ornamentation which varies considerably on different shells. For various reasons, stated later in this paper, *N. waterhousei* cannot be assigned to the genus *Glyptoleda*.

Johnston (1887, p. 17) described *Tellinomya etheridgei* from the Permian rocks at Porter's Hill, near Hobart, Tasmania. He states that the species "is easily distinguished from *T. darwini* by its more convex valves, and by its more narrowly elongate form". An examination of the figure (1888, pl. xv, fig. 14) proves this species must be placed in the genus *Nuculana*.

Etheridge (1907, p. 8), describing "Carboniferous Fossils from Fossil Head, Treachery Bay, Victoria River Estuary, Northern Australia", named a new species as *Nuculana basedowi*, while a shell with supposedly close affinities to *Nuculana waterhousei* was considered a variety of that species.

The latter has been given specific status and is named *Nuculana undulostriata* to distinguish it from the Eastern Australian species *N. waterhousei* with which it has little in common.

Several specimens from the Upper Marine Series at Burrier, South Coast of New South Wales, were described by Laseron (1910, p. 219) as *Nuculana ovata*. The species recorded by d'Orbigny as *Leda ovata* (1850, p. 236) = *Nucula ovata* Reuss (1846, p. 8) *non* Mantell, is a typical form of the genus *Nucula* and Laseron's name is therefore not a homonym.

Reid (1930, p. 60) recorded *Nuculana* sp. in a list of fossils from the Gympie Formation and from the Lower Bowen Series (1930, p. 63) of Queensland. These specimens are not available for examination and their classification must be deferred.

A single specimen, listed by Raggatt (1936, p. 127) as *Nuculana* sp., from Callytharra Spring, on the Wooramel River, North-West Division, Western Australia, has been examined and cannot be referred to the genus *Nuculana*.

Three poorly preserved specimens of *Nuculana* were collected and listed by Voisey (1939, p. 250) as *N. waterhousei* and *Nuculana* sp. These are in the Australian Museum collection and are from the Linoproductus Horizon of the Macleay Series at "Colraine", Manning River, New South Wales.

The following is a complete list of the Permian species of *Glyptoleda* and *Nuculana* known from Australia, and discussed in this paper:

Glyptoleda reidi sp. nov	Queensland
Glyptoleda glomerata sp. nov.	Queensland
Glyptoleda coleyi sp. nov.	Western Australia
Nuculana abrupta (Dana)	New South Wales
Nuculana ovata Laseron	New South Wales
Nuculana concinna (Dana)	New South Wales
Nuculana basedowi Etheridge	Western Australia
	North Australia
Nuculana etheridgei (Johnston)	Tasmania
	New South Wales
Nuculana darwini (De Koninck)	New South Wales
Nuculana waterhousei Etheridge	New South Wales
Nuculana undulostriata sp. nov.	North Australia

Stratigraphical Notes.

In a recent paper (Raggatt and Fletcher, 1937, pp. 156–159) the Springsure Section of the Queensland Permian is shown to have been revised by several geologists in unpublished reports.

Frank Reeves found the lowest known formation in the area to be the Staircase Sandstone which may underlie the Dilly Stage by a few hundred feet. The Consuelo Sandstone, Ingelara Stage, and the Serecold Sandstone therefore overlie the Dilly Stage, while Reid's Gypseous Stage was thought to be the lower part of the Dilly.

Washington Gray and I. C. H. Croll confirmed Reeve's interpretation of the Springsure Section, but regarded the Gypseous beds as a facies variant of the Dilly. They equated the Aldebaran Sandstone of Reid, which overlies them, with the Serecold Sandstone.

Reid carried out some detailed work on the southern end of the Springsure Dome after the publication of his pioneer work in 1930 and his unpublished results agree to a great extent with the above revisions.

Recent detailed field-work, however, carried out by the Shell (Queensland) Development Pty. Ltd., has made it necessary to alter the succession as it appeared, not only to Reid, but to Washington Gray, Croll and Reeves. It is now known that the Staircase Sandstone overlies the marine beds of the Dilly Stage which now mark the base of the succession in the Springsure area. The Gypseous Stage of Reid is not the equivalent of the Dilly Stage, but is separated from it by the Staircase Sandstone. The correct sequence is now known to be as follows:

Springsure Section—Descending Sequence.

Productus Bed	50–60 feet,	marine
Catherine Sandstone	750 „	non-marine
"Coral" or Ingelara Stage	0–250 „	marine
Aldebaran Sandstone	3,500 „	plants, no marine fossils
"Gypseous" Stage	450 „	
Staircase Sandstone	500 „	marine at base
Dilly Stage	1,800 „	exposed, marine

The above Permian succession has been determined by the Shell (Queensland) Development Pty., Ltd., and it is due to their courtesy that it is published here.

As far as our present knowledge is concerned, the genus *Glyptoleda* is found in Queensland in the "Coral" or Ingelara Stage where it is fairly abundant. It appears as if it is vertically restricted to this horizon. A single specimen of an internal cast of *G. reidi* was collected by Voisey, in 1936, from the Condamine Beds of the Silverwood–Lucky Valley area in Queensland, while an additional specimen was collected by the author during a visit to the area in 1945. In Western Australia the genus has been collected from the Cundlego Series of the North-West Division.

The occurrence of *Glyptoleda*, together with other palaeontological evidence, leads to an interesting revision of the latest work carried out by Voisey in the Silverwood–Lucky Valley area.

Professor H. C. Richards and Dr. W. H. Bryan (1924, pp. 44–107), after a detailed review of the Silverwood–Lucky Valley area, interpreted the Upper Palaeozoic succession, in descending sequence, as follows:

Volcanic Series.
Condamine Beds.
Wallaby Beds.
Eurydesma Beds.

The Eurydesma beds were correlated with the Eurydesma horizon of the Allandale Stage, Lower Marine Series, in the Hunter Valley of New South Wales. The Wallaby Beds were considered the equivalent of the Greta Series, while the Condamine beds and the Volcanic Series were correlated with the Upper Marine Series.

Reid (1930, p. 48) disagreed with this arrangement of the beds, as he considered the available evidence proved the position of the Condamine Beds to be stratigraphically at the base of the series.

The discovery by Voisey (1935, p. 60) of *Monilopora* at the base of the Eurydesma Beds, and its occurrence in the top of the Condamine Beds, made it imperative, according to that author, to place the latter as the basal beds. Additional geological evidence in support of this conclusion is the presence of tuffaceous grits at the top of the Condamine Beds and the base of the Eurydesma Beds, but there is some doubt whether these are lithologically the same.

Voisey and Reid at that time had placed the sequence as follows:

Wallaby Beds.
Volcanic Series.
Eurydesma Beds.
Condamine Beds.

In the Springsure section there is a well defined Cladochonus and Thamnopora zone indicative of the Ingelara Stage. The same conditions exist at Cracow where the coral zone is found high in the sequence. The Eurydesma horizon in the Dilly Stage at Springsure and at Cracow can be correlated with the same horizon in the Allandale Stage of the Hunter Valley of New South Wales. Recent field investigations support this correlation, as it is now known that the Dilly Stage is at the base of the Permian sequence at Springsure. *Thamnopora*, in the Hunter Valley, is found only in the Mulbring Stage of the Upper Marine Series and its equivalent in the South Coast of New South Wales.

It will be seen, therefore, that the above palaeontological evidence from the two Permian successions which have been mapped in the greatest detail, is sufficient to make necessary a revision of the Silverwood-Lucky Valley sequence as then outlined by Reid and Voisey. The Condamine Beds containing the Thamnopora and Cladochonus zone must be placed well above the Eurydesma Beds. Additional evidence is the presence of *Glyptoleda reidi* in the Condamine Beds. This genus is restricted in Queensland to the Ingelara Stage, where it is found associated with the two corals.

Thamnopora wilkinsoni, however, is known only from the Upper Marine Series in the Hunter Valley, where it is found in abundance. Hill (1940, p. 67) records it from "the Coral Stage of the Bowen marine of the Springsure Basin, Queensland, and in the Condamine Fault Block, near Silverwood, Queensland".

Cladochonus nicholsoni has very little value as a "marker" fossil, but in this case, where it occurs in abundance in a well defined zone, it must have some correlative significance. Specimens from the Condamine Fault Block and from the "Coral" or Ingelara Stage of Springsure have been identified by Dr. D. Hill (1942, p. 69) as being identical, and very close to specimens from Balmaningarra, Mount Marmion, Western Australia.

Voisey has from time to time published the results of his investigations in Permian areas on the north coast of New South Wales.

At Drake and Boorook, he (1936, pp. 159–162) found *Thamnopora wilkinsoni* associated with *Cladochonus nicholsoni* in a mudstone near the base of the Upper Division of the Drake Series in the Crooked Creek area and in abundance near the top of the Series at Sawpit Gully in Zone D.

During a recent visit to Boorook and Silverwood, both Voisey and the author came to the conclusion that Zone D at Sawpit Gully and the Condamine Bed at Silverwood bear a strong resemblance to one another and must be correlated. The evidence in favour of this course is the very close similarity of the two corals, their mode of preservation, and the close lithological resemblance of the matrix in the two localities.

The Zone D at Sawpit Gully is high in the Permian sequence and agrees well with the position of *Thamnopora* and *Cladochonus* in the well-known Permian successions.

Eurydesma has not been collected at Drake or Boorook, but it has been recorded by Andrews to the north in the Rivertree district from strata of which the stratigraphical position has not yet been determined.

Voisey has traced the Permian beds, the equivalents of the Lower Marine Series, from the Macleay River to the Manning River and refers to them as the Macleay Series. These beds are not of great thickness and are easily traced because of the outstanding *Eurydesma* limestone horizon.

At the base of the sequence at Dondingalong, near Kempsey, in Zone A, *Ptychomphalina* is recorded in abundance, while in the Hunter Valley this small gastropod is plentiful both in the Upper Marine Series and low in the Lower Marine Series.

The known range of *Linoproductus springsurensis*, in the type locality at Springsure, is the upper section of the Dilly Stage, from the main Eurydesma horizon to the top of the stage. The Dilly Stage of Springsure can be considered the age-equivalent of the Allandale Stage of the Hunter Valley and the Eurydesma bed at Silverwood. At Dondingalong, *Linoproductus* is found in a definite zone below the main Eurydesma horizon, while at Kimbriki on the Manning River it is high in the sequence of that area and is found in abundance in beds which could be the equivalent of the Farley Stage of the Hunter Valley.

It is a remarkable fact that neither *Cladochonus* nor *Linoproductus* has been found in the Permian beds of the Hunter Valley. There appears to be no valid explanation to account for their absence and it is possible they may yet be collected.

It will be seen from the above review of palaeontological evidence that the Thamnopora wilkinsoni and Cladochonus nicholsoni zone is not found below the Eurydesma horizon. Voisey (1936, p. 196) has recorded its occurrence in the Eurydesma horizon, but the main zone is much higher in the sequence. This evidence precludes any possibility of the Condamine Bed of the Silverwood-Lucky Valley area being placed below the Eurydesma Bed. Furthermore, the occurrence of *Glyptoleda reidi* in the Condamine Bed strengthens its correlation with the "Coral" or Ingelara Stage of Springsure. The Eurydesma Bed must be placed at the base of the Permian sequence at Silverwood.

Sussmilch (1935, p. 108) is of the opinion that Reid is correct in his interpretation of the Silverwood-Lucky Valley sequence, but considers the strata of the Condamine Block, including the volcanic rocks, to be probably of Upper Carboniferous age. Voisey (1939, pp. 389–390) revised his previous conclusions regarding the Silverwood area after he had completed detailed field-work at Drake and Boorook. He considers the Condamine and Wallaby Beds are the equivalents, at Silverwood, of part of the Upper Division of the Drake Series.

The Volcanic Series is correlated with the Lower Division of the Drake Series, while there is some doubt regarding the position of the Eurydesma Beds.

I have already stressed that the rather general palaeontological evidence outlined in this paper strongly suggests that the Condamine Beds must be placed at the top of the Silverwood-Lucky Valley Permian succession, while the Eurydesma Beds, with a well-defined horizon crowded with *Eurydesma cordata*, must be considered the basal beds in that area.

Richards and Bryan were of the opinion that the lower freshwater beds of the Wallaby Stage showed a marked similarity with the Greta horizon of the Hunter Valley, and in my opinion the evidence strongly supports this. It is significant that in the lower portion of the Wallaby Stage, *Gangamopteris* predominates over *Glossopteris* as is the case in the Greta Beds. In the Upper Coal Measures the reverse is the case. Furthermore, the occurrence of abundant *Terrakea* and *Strophalosia* in the marine beds of the upper portion of the Wallaby Stage strongly suggests a correlation with the Branxton Stage of the Hunter Valley and its South Coast equivalent.

The Volcanic Beds are a problem as the fauna is typical of either the Lower or Upper Marine Series. *Aviculopecten mitchelli* and *Deltopecten farleyensis* cannot be accepted as indicating a lower marine age for these beds as both species are now known to be not uncommon in the Upper Marine Series. Specimens of the latter species were collected by Mr. E. C. Andrews from near the Golden Age Mine at Boorook, in beds which I presume would belong to the upper division of the Drake Series. This locality is less than forty miles from Silverwood. On the other hand, there is a decided Upper Marine aspect in the list of fossils collected from the Volcanic Beds. The abundance of *Martiniopsis*, together with the associated species, and particularly if *Terrakea brachythaera* is plentiful, suggests an Upper Marine age similar to the upper portion of the Wallaby Beds and the Branxton Stage of the more southern Permian sequence. It is certain that extensive collecting from the Fault Block Series would throw a good deal of light on the arrangement of the beds.

A microscopical examination of the volcanic rocks at Silverwood and comparisons made with those at Drake and Boorook would also lead to some important conclusions in correlation.

The obvious correlation of the Volcanic Beds at Silverwood would appear to be with the volcanics of the Lower Division of the Drake Series. In this series, however, there are no known fossiliferous horizons, and furthermore the palaeontological evidence tends towards them being higher in the Permian sequence in beds the age equivalent of the Upper Marine Series of the Hunter Valley.

I am of the opinion that the descending sequence of the Fault Block Series should be considered as follows:

Condamine Beds.
Volcanic Series.
Wallaby Beds.
Eurydesma Beds.

A summary of the Upper Palaeozoic stratigraphy in the North-West Basin of Western Australia has been published by Raggatt (1937, p. 167) and by Teichert (1941, p. 381). In the Cundlego Series of the Minilya River the genus *Glyptoleda* is represented by *G. coleyi*. This species has only a few points of difference from the Queensland shells and, if my assumption that the genus *Glyptoleda* with its highly specialized ornamentation is restricted in its vertical range is correct, then it is interesting and significant to find the genus occurring in both these two widely separated Permian horizons.

Description of Species.

Class LAMELLIBRANCHIA Blainville.

Family Nuculanidae Stoliczka.

Genus Glyptoleda gen. nov.

Genotype: *Glyptoleda reidi* sp. nov.

Generic characters.—Shell equivalve, elongate, narrowing posteriorly, acuminated; closed all round, comparatively robust with thickened test. Umbones small, depressed, contiguous and slightly recurved posteriorly. Lunule and escutcheon well developed, elongated. Posterior umbonal ridge concave, bent upwards at the extremity.

Hinge plate furnished with strong teeth which abruptly diminish in size nearing the umbo. There are about ten wide teeth on the short convex anterior portion while on the concave posterior portion twelve–fourteen narrower teeth are present. A ligamental pit situated below the umbones divides the teeth into two sets.

Anterior and posterior adductor muscle scars well marked, deeply excavate. Pallial line entire.

Surface ornamented with diverging V-shaped ribs the sides of which in many cases have been developed into a wavy, zig-zag design.

The shells range from 30 mm. to 50 mm. in length and from 18 mm. to 33 mm. in height.

Observations.—The shells included under the genus *Glyptoleda* have many characters which link them with the genus *Nuculana*. The general shape is essentially the same, as are also the hinge structures and musculature markings. They differ, however, in being much larger in size, having a solid, thick test and possessing a well-marked V-shaped ornamentation. These characters denote a definite specialized group of *Nuculana*-like shells which are quite distinct from the normal genus with its, for the most part, surface ornamentation of fine, regular, concentric ribs.

The ornamentation on shells of *Glyptoleda* differs in pattern on valves of the one shell, but, in the series examined, remains constant in the species.

The presence of a somewhat similar type of ornamentation to that found in *Glyptoleda* is characteristic of several species in closely allied genera. The surface ornamentation on *Nuculana waterhousei* Etheridge, is composed of numerous fine wavy striae which form an irregular V-shaped pattern. In this species the ornamentation varies a good deal on individual specimens. Specimens of *Nucula* (*Acila*) *bivirgata*

Sowerby possess an ornamentation which may be compared somewhat with *Glyptoleda*. The form of the ornamentation however is not constant and varies markedly in different shells.

The genus *Nuculana* is cosmopolitan in its distribution and has a geological range from the Silurian to present day. *Glyptoleda*, on the other hand, as far as present knowledge is concerned, is restricted in its vertical range and is known only from the "Coral" or Ingelara Stage, the Condamine Beds (Queensland), and the Cundlego Series of the Permian sequence in Western Australia.

Glyptoleda reidi sp. nov.

(Plate xix, figures 1–5.)

Holotype: F.41404, Australian Museum Collection.

Paratype: No. 265, University of Queensland Collection.

Specific Characters.—Shell transversely elongated, robust, more than twice as long as high. Umbones small and depressed, recurved posteriorly and contiguous, situated well in the anterior half of the shell.

Anterior end inflated, less than half the length of the shell, margin oval. Inferior margin gently curved, posterior end long and tapering, with an umbonal ridge extending from the umbo to the posterior extremity. Posterior extremity pointed. Posterior umbonal ridge broadly concave, cutting off a flattened dorsal area or rostrum. Hinge-line depressed anteriorly, posteriorly straight, slightly raised above the escutcheon, and sloping gradually from the mid-line of the escutcheon to the pointed posterior extremity.

In front of the umbones is an elongate, narrow, depressed lunule. Posterior to the umbones is a broad escutcheon bordered by the two umbonal ridges which extend from the apex of the umbones and, sloping downwards, join at the pointed extremity of the shell. The escutcheon is again divided by two ridges which originate from near the base of the umbones and pass obliquely backwards to meet at a point on the hinge-line more than half-way to the posterior extremity of the escutcheon. The inner enclosed area is diamond-shaped and ornamented with fine longitudinal striae. The outer portion of the escutcheon is convex, ornamented with wavy striae which extend over the umbonal ridge from the surface of the valve and pass obliquely forward.

The surface ornamentation consists of about 25–30 fine ribs which follow a complicated pattern. The anterior portion of the valve is sculptured with wavy, confused ribs, more or less concentric until they reach a position below the apex of the umbo when they pass upwards to join the umbonal ridge. On the posterior part of the valve the zig-zag nature of the ribs is more pronounced with small series of Vs developed at fairly regular intervals.

An internal cast shows well-marked muscle scars and a well-defined entire pallial line. Anterior adductor muscle scar situated slightly above the extreme anterior extremity, slightly excavate posteriorly. Posterior adductor muscle scar situated on the umbonal ridge near its extremity, excavate anteriorly.

A small ligamental pit immediately below the umbo divides the hinge-plate into anterior and posterior portions. The anterior portion is slightly convex with about eight–ten moderately curved strong teeth. The posterior portion is concave and bears 12–16 similarly shaped teeth. The teeth abruptly diminish in size near the base of the umbo.

The dimensions of several shells are as follows:

	Holotype. (F.41404.)	Paratype. No. 265.	(Int. Cast). F.36431.
Length	41 mm.[1]	47 mm.	37 mm.
Height	21 mm.	22 mm.	16 mm.
Thickness	12 mm.	16 mm.	—
Apical Angle	138°	140°	140°

Observations.—This species is represented by a series of well preserved specimens and an internal cast of a left valve. It differs markedly from *G. glomerata*, with which it is associated in the Ingelara Stage, by being more elongated and possessing an apical

[1] Posterior portion incomplete: actual length would be at least 46 mm.

angle of 140° whereas *G. glomerata* has an angle of 124°. It is easily distinguished from *G. coleyi* as that species has the inferior margin separated into a convex anterior portion and a straight posterior portion. The ornamentation of the valve also consists of ribs which are finer and more widely separated than in *G. reidi*.

Localities and Geological Horizons.—Queensland: Ingelara, Carnarvon Creek, near Springsure, Queensland. Paratype locality. (Coral or Ingelara Stage.) Southern plunge of the Serecold Structure, 2·19 miles N. 265°E. of Ingelara Station[2]—Springsure district, Queensland. (Holotype locality.) (Coral or Ingelara Stage.) Silverwood, Queensland. (Condamine Beds.) F.36431.

Glyptoleda glomerata sp. nov.

(Plate xx, figures 1–3.)

Holotype: F.41405, Australian Museum Collection.

Description.—Shell equivalve, inequilateral, transversely ovate, inflated, less than twice as long as high. Anterior margin elliptically oval. Inferior margin broadly convex, posterior margin bluntly pointed. Antero-dorsal margin convex, postero-dorsal margin concave. A well-marked, slightly concave umbonal ridge extends from the umbo to the posterior extremity. Between the umbonal ridge and the cardinal line a flattened rostrum is developed.

Umbones prominent, contiguous, recurved posteriorly, situated in the anterior half of the shell, but almost central. Umbonal region swollen but tapering rapidly to all margins. Anterior of the umbones is a well-defined depressed lunule, slightly raised in the mid-line to form the hinge-line; posterior to them is an elongated broad escutcheon marked off by the posterior umbonal ridge. The escutcheon itself is divided into two portions by a ridge originating from the lower part of each umbo and extending obliquely inwards and backwards to meet in the middle line. Both portions of the escutcheon are flatly concave. The inner surface is ornamented with fine longitudinal lines, the outer surface with oblique wavy striae. Test comparatively thick.

Internal characters not exhibited.

The surface ornamentation is different on the two valves of the one shell and consists of large V-shaped ribs the sides of which are wavy and developed into small Vs at regular intervals. The ornamentation of the right valve is divided into anterior and posterior portions by a well-defined mid-line formed by the bases of the large Vs. On the anterior half the ribs pass obliquely, with narrow interspaces, from the antero-dorsal margin to the mid-line, where they abruptly change direction and pass upwards to the umbonal ridge, thus forming a large V, the bases of which are approximately in the mid-line of the valve. The ribs arising from the lower part of the antero-dorsal margin and the anterior margin pass obliquely to the inferior margin and do not extend to the mid-line. The ribs are wavy and occasionally series of small Vs are developed at regular intervals on the anterior half. Narrow zones are thus formed radiating from the umbo to the inferior margin.

The ribs on the posterior half of the large Vs consist of wavy almost straight striae, with wider interspaces, which pass upwards to the umbonal ridge and continue on to the outer portion of the escutcheon. Small Vs are not developed on the posterior striae. On the left valve the ornamentation is similar, except that the base of the large V, formed in the mid-line by the longer striae, is wide and crenulated.

The dimensions of the holotype and a large specimen are as follows:

	Holotype. (F.41405.)	(W.1738, No. 3.)
Length	30 mm.	55 mm.
Height	19 mm.	30 mm.
Thickness	12 mm.	21 mm.
Apical angle	124°	122°

Observations.—This species is fairly common in the Ingelara beds and varies a good deal in size. A specimen in the Shell Company's collection in Brisbane (W.1738, No. 3)

[2] Co-ordinates of Ingelara Station. Lat. 24° 56′ 50″, Long. 148° 18′ 16″.

attains considerable size as shown in the list of dimensions. The holotype is the smallest shell in the series but is the most perfectly preserved. The rapidly sloping umbonal ridge with an apical angle of 124° easily distinguishes this species from *G. reidi* and *G. coleyi*. The shell is more truncate and the umbones are situated almost centrally.

The species is represented by a series of ten well-preserved shells found in the Ingelara Stage associated with *G. reidi*.

Localities and Geological Horizon.—Queensland: Ingelara, Carnarvon Creek, near Springsure (Ingelara Stage). Southern plunge of the Serecold Structure, 3·44 miles N. 192° E. of Trig 37[3] (Ingelara Stage). Western flank of the Serecold Structure of Bela Creek, 1·06 miles N. 330° E. of Mt. Serecold[4] (Ingelara Stage). Southern plunge of the Serecold Structure, 2·19 miles N. 265° E. of Ingelara Station[5] (Holotype locality) (Ingelara Stage).

Glyptoleda coleyi sp. nov.

(Plate xix, figs. 7–9.)

Holotype: No. J35 (2) University of Western Australia Collection.

Paratype: No. T168, University of Western Australia Collection.

Description.—Shell transversely elongated, equivalve, inequilateral, more than twice as long as high. Anterior end inflated, produced inferiorly, bluntly rounded. Posterior end long, slightly compressed, tapering to a pointed extremity. A distinct umbonal ridge extends from the apex of the umbo to the posterior extremity cutting off a flattened dorsal area or rostrum. Inferior margin gently convex in the anterior two-thirds of the shell, almost straight posteriorly.

A shallow sinus extends slightly backwards from the umbo to the inferior margin and marks the junction between the more or less swollen anterior and the flattened posterior end of the shell.

Umbones small and depressed, recurved posteriorly. Lunule distinct, narrow and elongate. Escutcheon flattened, lanceolate, and divided into two parts by a ridge arising from the base of the umbo and passing backwards and inwards to meet in the mid-line. The ridges appear to have been ornamented with about sixteen evenly-spaced nodules.

The hinge-plate is divided into anterior and posterior portions, separated by a small and deep ligamental pit. The anterior portion is convex, situated higher on the shell than the posterior portion, and bears approximately 10 teeth which diminish in size rapidly towards the umbo. The posterior portion is longer, concave, bearing about 16 teeth.

The surface of the right valve is ornamented by extremely fine wavy ribs with wide, smooth interspaces. These follow the characteristic pattern of the genus in possessing the large V, but smaller Vs are not developed. The ribs on the anterior end of the valve extend obliquely from the antero-dorsal margin to a central line extending almost vertically from the umbo to the inferior margin, when they pass abruptly to the cardinal margin, forming the wide V. The Vs are small on the umbonal flank but increase in size towards the inferior margin. Following the course of the inferior margin is a narrow area of heavy concentric growth lines. This narrow marginal area is possibly due to weathering.

Internal muscular markings are not exhibited.

The dimensions of the holotype are as follows:

Length	43 mm.
Height	21 mm.
Thickness	14 mm.
Apical Angle	132°

Observations.—This Western Australian species is represented by a single well-preserved right valve, and two badly weathered imperfect specimens. An immature shell (J44) is also recorded as this species. It is a distinctive form, characterized by

[3] Co-ordinates of Trig. 37. Lat. 24° 56′ 50″, Long. 148° 18′ 16″.

[4] Co-ordinates of Mt. Serecold. Lat. 24° 50′ 21″, Long. 148° 16′ 53″.

[5] Co-ordinates of Ingelara Station. Lat. 25° 0″, Long. 148° 20′ 21″.

the anterior end of the shell being inflated, while the posterior end is somewhat flattened or compressed.

The inferior margin is not regularly curved, as in other species of the genus, but is anteriorly convex and posteriorly almost straight. The ornamentation differs from other species of this genus in the ribbing being finer and the larger sides of the V not developed into any pattern by zig-zag structure.

Localities and Geological Horizon.—Western Australia: Barrabiddy Creek, 19 chains upstream from the fence between Weir and Barrabiddy Paddocks. (Holotype locality.) (In shales of the Cundlego Series.) About 10 chains from the southern bank of Whitfield's Creek, 110 chains from its junction with the Minilya River. (Paratype locality.) (Cundlego Series.) River Flat of Minilya River, 36 chains N.W. of mouth of Whitfield's Creek. (Cundlego Series.) J44.

Genus **Nuculana** H. F. Link, 1807.

Beschreib. der Naturalien-Samml. der Universitat zu Rostock, Vol. iii, p. 155.

Observations.—The genus *Nucula* was established by Lamarck (1799, p. 87) to include a group of shells of which *Arca nucleus* Linn. was the type species. Included in this group were shells with a prolonged posterior end, and Link (1807, p. 155) proposed the genus *Nuculana* to include this form, with *Arca rostrata* Chem. as the type species.

However, Schumacher (1817, pp. 55 and 173) instituted the genus *Leda* for the same type of shell, even selecting *Arca rostrata* Chem. as the type species of his genus. On page 172, Schumacher states that: "Lamarck established a genus under the name *Nucule* (*Nucula*) and takes as the type of his genus *Nucule nacree* (*Nucula margaritacea*) or *Arca nucleus* Linn. In examining this shell I have found that the hinge has much more in common with that of *Pectunculus* and that is the reason I have changed the name of his genus into that which I have given it."

From this statement one can only conclude that Schumacher established the genus *Leda* for shells of the *Nucula* type, although he figured *Arca rostrata* as the type species of his genus. He actually has instituted *Leda* as a substitute name for *Nucula* of Lamarck, as he considered the shells were more referable to *Pectunculus* and therefore changed the name of the genus to *Leda*.

It will be clearly seen from the above evidence that the name *Leda* cannot be used for shells after the type *Arca rostrata* for several reasons. *Nuculana* of Link has clear priority over the genus *Leda* as it was established ten years earlier and, furthermore, it seems very apparent that *Leda* of Schumacher must be associated with the genus *Nucula* of Lamarck, either as a new name or as a synonym of that genus.

Waagen (1887, p. 248) states the name *Nuculana* must stand in preference to *Leda* of Schumacher for two reasons: because *Nuculana* has long priority, and because *Leda* had already been pre-occupied for a genus of Arachnids. Waagen's first reason is perfectly correct, but his second reason is not a valid one as the Arachnid genus *Leda* was not proposed by Koch and Berendt until 1845 (1845, p. 93), so that according to the law of priority it would have had no standing.

In most palaeozoic species of *Nuculana* an internal ridge originates at the apex of the umbo and extends downwards towards the inferior margin. This ridge on internal casts is shown as a distinct groove in which two small but well-defined muscle scars are usually situated high on the valve. Various authors, e.g. Thomas (1928, p. 217), Hind (1897, p. 194) and Girty (1915, p. 123), have referred to this feature in a number of British and American species, but its function still remains largely in doubt.

The muscle scars are considered, and logically so, to represent the points of attachment of the mantle. In some Australian species, however, the groove and muscle scars are absent, and in *N. waterhousei*, a form in which the groove is well developed, no muscle scars are present. Furthermore, in recent shells of *Nuculana* there is no trace of an internal ridge or muscle scars on the umbonal flank.

The two muscle scars are well defined in *N. abrupta* and *N. darwini*, consisting in both species of a large dorsal scar and a smaller subsidiary scar immediately below it. The groove in these species is, however, short and shallow.

Nuculana abrupta (Dana).

(Plate xxi, figs. 4–6.)

1847. *Nucula abrupta* Dana, Amer. Journ. Arts and Sc. (2), iv, p. 157.

1849. *Nucula abrupta* Dana, U.S. Explor. Exped. (Wilkes') Geology, x, p. 698, pl. 7, figs. 3, 3a (Atlas).

Holotype: Imperfect specimen described by Dana (1847, p. 157), in the collection of the Smithsonian Institution, United States National Museum.

Plesiotype: F.24240, Australian Museum Collection.

J. D. Dana, in his preliminary report in 1847, gives the following original description of this species:

"Thick, elongate, transverse, rather abruptly narrowing behind the summit, and diminishing posteriorly; posterior dorsal margin much concave; anterior margin rounded; cast strongly carinate from the beak to the posterior angle, and having a wide and flat cardinal area; pallial impression distinct, somewhat excavate, smooth; anterior muscular impression somewhat excavate, smooth; posterior strongly excavate in upper part (in the cast it lies around the posterior carina, and the upper extremity forms an abrupt angle on the outline of the carina); surface of cast smooth, some faint radiations hardly distinguishable. Length 1⅛ inches; height $\frac{60}{100}$L; thickness $\frac{40}{100}$ or, $\frac{45}{100}$L; apical angle about 135°; height in the line of the upper part of the posterior muscle, about half greatest height."

Observations.—Dana in his more extended account (1849) of the geology of the Wilkes' Expedition redescribed *Leda abrupta*, but did not add a great deal of information. In his observations he states "the specimen is an internal cast, and shows finely the numerous teeth of the hinge. The pallial impression is about 1½ lines from the inferior margin. There are a few faint rays on the surface of the cast, visible in certain lights."

After an examination of a plastotype of Dana's species, figured in this paper, I have no hesitation in referring two specimens in the Australian Museum Collection to his species. Dana's specimen was collected from Wollongong Point, Illawarra, while the two additional shells came from Black Head, near Gerringong, some twenty miles to the south of Wollongong, and from the same horizon, the Crinoidal Stage of the Upper Marine Series. The Crinoidal Stage is the highest stage in the Permian on the South Coast of New South Wales and in all probability is the horizontal equivalent of the Mulbring Stage in the Permian Succession of the Hunter Valley.

A well-preserved specimen of both valves, partly testiferous (F.24240), exhibits the following additional characters to those described by Dana.

A well-defined, cordate escutcheon extends from the umbones to a point opposite the centre of the posterior adductor muscle scars. A wide and distinct lunule is present. The muscle scars are essentially as described by Dana and the pallial line is entire. The anterior adductor scar is oval, of medium size, not deeply excavate, and extends to the dorsal umbonal ridge which it slightly overlaps. The posterior adductor scar is tear-shaped, rather strongly excavate antero-dorsally, situated on and oriented with the posterior umbonal ridge. An internal ridge or furrow extends from the median apex of the umbo towards the inferior margin. In casts it appears as a groove or sinus. A small rounded distinct muscle scar, with a small subsidiary scar immediately below it, is found in the centre of this groove, just below the apex of the umbo. The function of the muscles which these scars represent is doubtful, but they were possibly connected with the mantle.

The teeth are divided into a slightly convex anterior and a concave posterior series, but are not exhibited sufficiently to determine their number.

The ornamentation of the valves consists of close and regularly arranged concentric ribs.

The present species, *N. abrupta*, bears no distinct similarity to other Australian species of the genus because of its large size, and rapidly sloping concave umbonal ridge. The dimensions of two specimens are as follows:

	Plesiotype. F.24240.	Holotype Incomplete.
Length	33 mm.	30 mm.
Height	20 mm.	19 mm.
Thickness	14 mm.	—
Apical angle	130°	125°

Localities and Geological Horizon.—New South Wales: Black Head, near Gerringong (Plesiotype, F.24240); Wollongong (Holotype) (Crinoidal Stage, Upper Marine Series, Permian).

Nuculana ovata Laseron.

(Plate xx, fig. 4; Plate xxi, fig. 3.)

1910. *Nuculana ovata* Laseron, Journ. and Proc. Roy. Soc. N.S.W., xliv, p. 219, pl. xv, figs. 5–7.

Holotype: F.20176, Australian Museum Collection.

Laseron, in describing this species, confused the anterior and posterior portions of the shell and attention must be paid to this fact when reading his diagnosis.

Nuculana ovata differs from other shells of this genus in being almost equilateral. The umbones are almost centrally situated, being placed only slightly anterior to the mid-line. The posterior portion of the shell is therefore not elongated and tapered to such a marked degree as in other species of the genus. A well-marked posterior umbonal ridge, somewhat rounded and concave, extends from the umbo to the posterior extremity, and between it and the raised cardinal line the valve is strongly concave. This enclosed area forming the escutcheon is divided into two portions by a ridge originating at the base of the umbo and extending backwards and inwards to meet at the cardinal line about half-way to the posterior extremity. The inner portion of the escutcheon is flattened and ornamented by longitudinal striae. The outer concave portion is ornamented by a continuation of the valve ribbing which, on crossing the umbonal ridge, passes abruptly forward.

The ornamentation on the valve surface is the characteristic type of the genus, consisting of about 35 fine concentric ribs, becoming more prominent towards the ventral margin and separated by fairly wide, deep interspaces. The pallial line is not shown. The test is comparatively thick for such a small shell. The hinge plate consists of anterior and posterior portions separated by a well-defined ligamental pit immediately below the umbo. Posteriorly there are approximately fourteen teeth, diminishing in size at both ends of the series. Anteriorly the teeth are not exhibited.

The dimensions of two specimens are as follows:

	Holotype.	F.41406.
Length	18 mm.	13 mm.
Height	12 mm.	9 mm.
Thickness	9 mm.	6 mm.
Apical angle	120°	110°

Laseron secured several examples of this species from the Wandrawandian Series at Burrier, south coast of New South Wales. It is a small form, characterized by comparatively heavy concentric ornamentation, by the almost central position of the umbones, and by the upraised posterior cardinal line. It has some similarity with *N. abrupta*, but, as pointed out by Laseron, is separated from that species by "the more central situation of the umbones, and the much shorter nature of the anterior extremity and also in the relative proportions of the length to the height".

A small complete and beautifully preserved specimen of both valves and an internal cast from the lower part of the Branxton Stage, near Cessnock, have been identified as *N. ovata*. There is a tendency for the ribbing to become slightly wavy towards the posterior end of the shell in this species.

Localities and Geological Horizon.—New South Wales: Burrier, near Nowra (Holotype locality) (Wandrawandian Series, Upper Marine Series). Abermain No. 3 shaft, near Cessnock (Lower Branxton Stage, Upper Marine Series).

Nuculana concinna (Dana).

(Plate xxii, figs. 3–5.)

1847. *Nucula* .....? Dana, Amer. Journ. Arts and Sci. (2), iv, p. 157.

1849. *Nucula concinna* Dana, U.S. Explor. Exped. (Wilkes') Geology, x, p. 699, pl. 7, fig. 4. (Atlas.)

Holotype: Specimen figured by Dana (1849, pl. 7, fig. 4), in the collection of the Smithsonian Institution, United States National Museum.

The original description of this species published by Dana in 1849 is as follows:

"We thus name a small delicate species of which we have but an imperfect specimen. It has a smooth exterior with occasional lines of growth, and the valves thin. The form is oblong ovate, subacuminate and thinning much behind; length nearly twice the height; surface not at all carinated posteriorly; apical angle nearly 150°."

A plaster replica of Dana's single imperfect specimen (No. L.671, in the Australian Museum Collection) shows it to be a decorticated shell of both valves, with the lower posterior portion missing. Dana records an apical angle of 150°, an extreme reading due to the poor preservation of the shell, and in my opinion the apical angle is nearer 135°.

There are two specimens in the Australian Museum Collection, including one exceptionally well-preserved shell of both valves, from the Abermain No. 3 Shaft, near Cessnock, New South Wales, which, after some hesitation, I have assigned to Dana's species *Nuculana concinna*. They agree well in general appearance with the poorly preserved holotype collected by Dana at Harper's Hill, low in the Allandale Stage of the Lower Marine Series. On the other hand, the two additional specimens were collected from strata about 200 feet above the base of the Branxton Stage of the Upper Marine Series.

Additional characters of this species are as follows:

Shell equivalve, very inequilateral, elongated, anterior end short and rounded; posterior portion long and tapering posteriorly to an almost pointed extremity.

Anterior margin broadly rounded, joining evenly with the inferior margin which for the anterior two-thirds is rounded, the posterior one-third straight. Antero-dorsal slope convex; posterior umbonal ridge slightly concave, almost straight, extending from the apex of the umbo to near the ventral margin, where it forms a bluntly-pointed posterior margin or extremity. The umbonal ridge cuts off a narrow, elongated escutcheon which is well defined and lanceolate. A well-marked ridge originates at the base of the umbo and, passing backwards and inwards, meets the cardinal line in about the centre of the escutcheon. This ridge, ornamented with twelve distinct regularly-spaced nodules, divides the escutcheon into an inner and an outer portion. The inner area is flattened and ornamented with fine longitudinal striae. The outer portion is concave, ornamented with ribs which are a continuation of the valve ornamentation, but are finer and bend sharply forward as they cross the umbonal ridge.

The hinge-plate is divided into anterior and posterior portions by a well-defined ligamental pit at the base of the umbones. The anterior portion is convex with about eight–ten teeth, while the much longer posterior and slightly concave portion has about fourteen teeth. Anterior adductor muscle scar elongate, oval, not excavate. Posterior adductor muscle scar not exhibited. Umbonal sinus or furrow not present.

The surface ornamentation consists of fairly coarse, concentric, regularly-arranged ribs which increase in strength towards the ventral margin. The ribs are 35 in number,

crowded on the umbonal region, but on the flanks and towards the ventral margin are separated by comparatively wide interspaces.

The dimensions of a well-preserved specimen (F.39313), chosen as a plesiotype, are herewith compared with measurements of the plastotype:

	Plesiotype (F.39313).	Plastotype (L.671).
Length	23 mm.	25 mm.
Height	13 mm.	15 mm.
Thickness	10 mm.	10 mm.
Apical angle	130°	135°

Observations.—This species has ornamentation somewhat similar to *N. ovata* Laseron, but is easily distinguished from that species by the more elongated nature of the shell. From *N. darwini*, a species with which it is found in the Branxton Stage, it is readily distinguished by the numerous and fine ribbing of the ornamentation of the latter species. Both species possess nodules on the dividing ridge of the escutcheon, but in *N. concinna* they are more distinct than in *N. darwini*, where they appear to be more in the form of whitish dots than nodules.

Localities and Geological Horizon.—New South Wales: Abermain No. 3 Shaft, near Cessnock (200 feet above base of the Branxton Stage, Upper Marine Series). Harper's Hill (Holotype locality.) (Lower Allandale Stage, Lower Marine Series.)

Nuculana darwini (De Koninck).

(Plate xxi, figs. 1–2, plate xxii, figs. 1–2.)

1877. *Tellinomya darwini* De Koninck, Foss. Pal. Nouv. Galles du sud, Mem. Soc. Roy. Sci. Liége, Ser. 2, Vol. ii, p. 147, pl. xvi, fig. 9.

Holotype: Destroyed in the Garden Palace Fire, 1882 (Sydney International Exhibition, 1879).

Neotype: F.41409, Australian Museum Collection.

Plesiotype: F.41412, Australian Museum Collection.

This species was described by De Koninck from a single shell found in a greyish sandstone, in a railway cutting between Maitland and Stony Creek, New South Wales (Branxton Stage of the Upper Marine Series). The holotype of the species was destroyed in the Garden Palace Fire of 1882 and our knowledge of the species is derived from the description and figure given by De Koninck, and a single specimen figured by Johnston (1888, pl. xv, fig. 12) as occurring in the marine mudstones at Porter's Hill, Hobart, Tasmania. In the text, however, there is no mention of this species from Porter's Hill, and on page 115, in a list showing the distribution of species in Australia, the author records *N. darwini* as occurring only in New South Wales.

I have included in this species a series of well-preserved shells which are found in abundance in the matrix from Abermain No. 3 Shaft, and the Caledonian Shaft, near Cessnock (base of the Branxton Stage, Upper Marine Series). The specimens are slightly smaller in size, but otherwise agree so well in all other characters that I have no hesitation in assigning them to De Koninck's *N. darwini*. It is an interesting species and as internal casts have been preserved showing the internal structure the following additional characters are noted.

Shell small, equivalve, inequilateral, elongated posteriorly; moderately convex, tapering rapidly to form an attenuated and pointed posterior extremity. Anterior margin oval, produced inferiorly and merging with the broadly convex ventral margin. Antero-dorsal margin almost straight; posterior umbonal slope concave, extending to posterior extremity. Apical angle 125°.

Umbones situated anteriorly, recurved posteriorly, depressed. An indistinct, rounded ridge originates at the apex of the umbo and extends backwards to the bluntly-pointed posterior extremity.

Above this ridge the valve is concave to the cardinal margin and forms a well-defined escutcheon. The outer portion is ornamented with closely-packed fine longitudinal ribs,

the continuation of the valve ribbing, bent sharply backwards as they cross the umbonal ridge to run parallel with the cardinal line. A ridge passing from the apex of the umbo, backwards and inwards to the cardinal margin, encloses an inner portion of the escutcheon. This is ornamented with fine striae. The ridge possesses regularly-arranged indefinite nodules. On internal casts a shallow groove extends from the umbo towards the inferior margin, on the flank of the umbonal slope; the groove is short and does not quite reach the middle of the valve. Two distinct muscle scars are present in the furrow, an oval dorsal one and a smaller elongate lower one. The scars are deeply excavate and ornamented with several lines, denoting stages of growth. On the interior of the test the two deep cavities for the reception of these muscles are clearly visible, but the ridge itself is not well defined.

The adductor muscle scars are very distinct. The anterior scar is rounded, deeply excavate posteriorly, and possesses a very fine cancellate sculpture, the concentric lines being the stronger; it is situated high on the valve near the end of the cardinal line, and is excavate posteriorly. A fine ridge passes back parallel to the cardinal line, joining the adductor scar with a small pedal scar placed at a point half-way to the umbo and alongside the cardinal line. The posterior adductor scar is situated more on the umbonal ridge than on the flank of the valve, and is more than two-thirds of the way from the umbo. The scar is deeply excavate anteriorly, ornamented with four distinct lines; a notch is developed in the anterior margin of the scar. The pallial line is distinct and does not possess a sinus.

The surface of the valve is ornamented with at least seventy-five closely-packed fine concentric ribs, fairly regularly arranged. Where the valve narrows posteriorly, the ribs at times merge together and they become slightly wavy. The surface of the valve is covered with fine longitudinal ridges of a very fine character which, under the glass, in certain lights, gives a strong cancellate appearance to the ornamentation.

The dimensions of the neotype and plesiotype are as follows:

	Neotype. Partly testiferous (F.41409).	Plesiotype. (F.41412).
Length	19 mm.	19 mm.
Height	10 mm.	11 mm.
Thickness	7 mm.	8 mm.
Apical angle	134°	132°

Observations.—This small and distinct species is plentiful in a calcareous shale, 200 feet above the Greta Coal Seam, from the Caledonia Shaft, near Cessnock. A suite of similar shells has also been collected from similar strata in the Abermain No. 3 Shaft, also at Cessnock, New South Wales.

It has already been pointed out, in the discussion on *Nuculana concinna*, how that species is readily distinguished from *N. darwini*. In general outline the shells are somewhat similar, but the latter are smaller, possess more than double the number of ribs and are characterized by a definite cancellate ornamentation caused by an indistinct fine radial ribbing. *N. darwini* possesses a well-developed umbonal groove with two well-marked muscle scars. *Nuculana abrupta* is also characterized by a similar groove which contains two muscle scars, but it is impossible to confuse these two species. In discussing *N. abrupta*, mention was made of the similarity of the umbonal muscle scars with *N. bellistriata* Stevens, from the Wewoka Formation of Oklahoma. Girty (1915, p. 122) records in the American species a small strong scar, whereas in the Australian species two scars are developed. The groove in the latter, however, is restricted to the umbonal area, whereas in *N. bellistriata* the furrow is deeper and wider, and extends almost to the ventral border. The two small anterior and posterior pedal scars present in *N. bellistriata* are also found in *N. darwini*, and have been observed in *N. abrupta*.

Localities and Geological Horizon.—New South Wales: Caledonian Shaft, near Cessnock (Neotype and Plesiotype locality); Abermain No. 3 Shaft, near Cessnock (Lower Branxton Stage, Upper Marine Series). Railway Cutting between Maitland and Stony Creek (Branxton Stage, Upper Marine Series).

Nuculana etheridgei Johnston.

1886. *Tellinomya etheridgei* Johnston, Proc. Roy. Soc. Tasmania (1886), 1887, p. 17; Geology of Tasmania, pl. xv, fig. 14.

Holotype: The specimen described and figured by Johnston, from Upper Marine beds at the River Styx, Porter's Hill, Tasmania.

The original description of this species is as follows:

"Shell inequilateral, trigonal, elongately oval; concentric striae well defined; valves moderately convex; anterior side straight and somewhat truncate, rounded inferiorly; posterior slope longest, scarcely concave, produced to a sharp point; ventral margin gently curved, simple."

Height, 13 mm. Length, 27 mm.

Observations.—I have not examined any specimens of this species, but Johnston records it as being common in the Upper Marine beds at the River Styx, Porter's Hill, near Hobart, Tasmania. He states "this shell is easily distinguished from *N. darwini* by its more convex valves, and by its narrowly elongated form".

Cowper Reed (1932, p. 43) suspected that *Nuculana* (*Leda*) *thompsoni* from the Agglomeratic Slate of Kashmire is probably identical with *Nuculana etheridgei*. The Indian species, however, is of comparatively large size, and has an acutely-pointed posterior extremity. It is also nearly three times as long as high, and is quite distinct from any Australian species of the genus.

In general characters *Nuculana etheridgei* resembles *N. concinna* (Dana), but differs in the umbonal ridge of the former being decidedly concave; the inferior margin is strongly convex posteriorly and is produced upwards posteriorly to form a pointed extremity. In *N. concinna* the inferior margin is almost straight posteriorly and the extremity is more inferior than in *N. etheridgei*. A small internal cast in the Australian Museum Collection (F.37841) from the Linoproductus Horizon of the Macleay Series at "Colraine", Manning River, has been tentatively identified as *N. etheridgei*. It is only 14 mm. in length, height 7 mm., but agrees well with that species in most other respects.

Localities and Geological Horizon.—Tasmania: River Styx, Porter's Hill, near Hobart (Upper Permian). *New South Wales*: "Colraine", near Kimbriki, Manning River (Macleay Series, Permian).

Nuculana waterhousei Etheridge.

1888. *Nuculana waterhousei* Etheridge, Ann. Rept. Dept. of Mines, N.S.W., p. 168, pl., figs. 5–10.

Type Material: Specimens described and figured by Etheridge, from Wollombi Road Cutting, by Farley Railway Station, near West Maitland, New South Wales. Farley Stage, Lower Marine Series. The internal cast (figs. 7–8) is in the Australian Museum Collection, F.35413. The other specimens are mislaid in the Mining Museum Collection, Sydney.

This species has been adequately described and figured by Etheridge. As the publication may not be readily accessible to some workers, the description of the species is reprinted.

"Sp. Char.: Shell obliquely triangular-deltoid, obliquely produced posteriorly, valves convex in the umbonal region, rapidly declining to the ventral margin, which is sharp and knife-edged, the flanks sometimes slightly sulcate posteriorly. The dorsal margin arched and much shorter than the length of the valves; hinge teeth less than twelve on either side; cartilage pit apparently semi-circular. Ventral margin gently convex in the centre and in the direction of the anterior end, but slightly inflected towards the posterior. Anterior end, small, much more gibbous than the posterior, the margin obliquely rounded below, and insensibly disappearing. Umbones sharp, inrolled, and anteally incurved, flattened from above; escutcheon wide and well marked; pseudo-lunule defined by anterior rounded slopes. Muscular impressions large, the anterior close to the margin and rather low down; posterior scars prominent, thick at their

front ends. Ornamentation consisting of close, always more or less concentric, although variously directed, subimbricating, rather fluctuating, wavy, zig-zag, or V-shaped laminae, and at times abruptly faulted near the centre of each valve."

The dimensions of two of Etheridge's specimens are as follows:

	Fig. 6. (F.35408.)	Fig. 7. Paratype (int. cast). (F.35413.)
Length	26 mm.	23 mm.
Height	17 mm.	16 mm.
Thickness	12 mm.	11 mm.
Apical angle	105°	103°

Observations.—A great deal of variation is exhibited in the ornamentation of *N. waterhousei*. This has been described by Etheridge and rarely do two shells show the same pattern. The ribs are exceedingly fine and numerous, with no set pattern and usually very wavy.

The ornamentation, although it has some points of similarity with that found in the genus *Glyptoleda*, is of a different nature, and specimens of the two genera could never be confused. *N. waterhousei* is an outstanding species with high umbones, a rapidly declining posterior umbonal ridge, and the shell only half again as long as high.

An internal cast of a right valve, from the Ravensfield Sandstone, exhibits a narrow, well-defined groove extending from the apex of the umbo towards the inferior margin, gradually shallowing and widening and merging with the valve surface at the pallial line. Muscle scars are not developed in the groove. The pallial line is entire. A small pedal scar, attached to the anterior adductor scar by a fine, curved ridge, is situated near the cardinal line where the anterior set of teeth terminate.

The species is fairly abundant in the Farley Stage of the Lower Marine Series and is also known from the Ravensfield Sandstone. Two specimens collected by Voisey (1939, p. 250) from the Macleay Series in the Manning River district of New South Wales belong to this species.

Localities and Geological Horizons.—New South Wales: Railway cutting near Farley, Wollombi Road, by Farley Railway Station, near West Maitland (Farley Stage, Lower Marine Series). Ravensfield (Ravensfield Sandstone, Farley Stage, Lower Marine Series). "Colraine", near Kimbriki, Manning River (Macleay Series, Lower Permian).

Nuculana undulostriata sp. nov.

1907. *Nuculana waterhousei* Etheridge, (?) var. Off. Contrib. Pal. of South Aust., No. 18, p. 6, pl. v, figs. 10–11, Supplement to S.A. Parl. Paper No. 55 of 1906.

Holotype: Specimen described and figured by Etheridge, from Fossil Head, Treachery Bay, northern Australia. Its whereabouts is unknown.

Etheridge described a shell from the Permian beds of Fossil Head, Treachery Bay, as a probable variety of *Nuculana waterhousei*, because of the "sculpturing which consists of irregular fluctuating, or V-shaped concentric, and not too close lines". He thought it could be considered a variety of that species, but in my opinion other outstanding differences prove it to be a distinct species and I have named it *N. undulostriata*. A single imperfect specimen, L36 (3), of both valves, from the Minilya River, is tentatively referred to this species. The general outline of *N. undulostriata* differs entirely from *N. waterhousei*, a characteristic species in which the umbones are prominent and elevated. The antero-dorsal margin and the posterior umbonal ridge slope rapidly downwards from the umbones, whereas in *N. undulostriata* these slopes are not at all pronounced. The apical angle of *N. waterhousei* is about 150° and in the present species, after an examination of the specimen figured by Etheridge (pl. v, fig. 10), would be at least 140°. The ornamentation agrees with *N. waterhousei* in being wavy, but apart from that is dissimilar. The ribs on *N. undulostriata* follow a more or less concentric pattern, whereas in *N. waterhousei* the ornamentation is generally concentric on a narrow zone near the inferior margin but above that the ribs are arranged diagonally.

The specimen from the Minilya River is very similar to *N. undulostriata* in its ornamentation but, nearing the posterior umbonal ridge, the concentric ribs bend abruptly upwards. The posterior portion of this shell is damaged and an indication of this feature only can be discerned. The curved arrangement of the ribs on the inflated anterior flank, figured by Etheridge (pl. v, fig. 11), is also present but the bases of the curves are more acute.

This species is approximately 20 mm. in length and 15 mm. in height. It cannot be confused with *N. basedowi* with which it is associated in the Bulgadoo Series, as in that species the anterior two-thirds of the valve is inflated, the posterior portion is flattened, while the posterior umbonal ridge descends at a fairly steep angle to the extremity of the inferior margin. In *N. undulostriata* the posterior umbonal ridge is abbreviated and the posterior extremity is rounded and not pointed as in *N. basedowi*.

Localities and Geological Horizon.—Western Australia: Southern bank of the Minilya River, near Bulgadoo Pool, 3,380 yards N. 110° W. from Bulbawardoo Windmill. Probably upper part of the Bulgadoo Series. *North Australia*: Fossil Head, Treachery Bay, Victoria, River estuary. Permian (stratigraphy unknown).

Nuculana basedowi Etheridge.

(Plate xxii, figs. 6–7.)

1907. *Nuculana basedowi* Etheridge, Off. Contrib. Pal. of South Aust., No. 18, p. 8, pl. vi, fig. 6. Supplement to S.A. Parl. Paper No. 55 of 1906.

Holotype: Specimen described and figured by Etheridge from Fossil Head, Treachery Bay, northern Australia. Its whereabouts is unknown.

The original description of this species is as follows:

"Shell (replacement) obliquely triangular, very inequilateral, prolonged or nasute posteriorly, moderately convex, the greatest convexity in a line below the umbone. Dorsal margin concave (posteriorly)—convex (anteriorly); dorsal area somewhat concave, umbos sub-median, depressed. Ventral margins gently rounded; anterior ends rather compressed, the margins obliquely rounded; posterior ends much produced, nasute, gradually contracting between dorsal and ventral, and gradually compressed transversely, or through the valves. Sculpture consisting of fine and very close regular concentric lines."

Etheridge stated that the form and dimensions of his species are quite sufficient to separate it from *Nuculana waterhousei* and from *Nuculana* sp. described by him (1892, p. 273) from the Star River Carboniferous beds of Queensland. Etheridge says "as a matter of fact, except for its size, it presents greater analogy with the little unnamed Queensland fossil, which was, unfortunately, only an external impression".

I have not examined any of the type material of *N. basedowi*, but Dr. Curt Teichert, of the University of Western Australia, forwarded me six specimens from the Upper part of the Bulgadoo Series, at Wandagee Station in the North-West Division, Western Australia, which in my opinion must be referred to this species.

The following characters have been compiled from these specimens:

Shell elongated, inequilateral. Anterior part of the shell strongly inflated in the umbonal region, becoming flattened and compressed posteriorly. Anterior end oval, produced inferiorly. Inferior margin broadly convex directed upwards posteriorly to meet the rapidly declining umbonal ridge in a bluntly-rounded posterior extremity. The umbonal ridge increases in width towards the bluntly-pointed posterior extremity.

Umbones contiguous, depressed, recurved posteriorly. On internal casts, a shallow umbonal groove extends for a short distance ventrally and backwards from the apex, but is devoid of muscle scars. Anterior to the umbo a deep narrow lunule is developed while posterior to it a very narrow elongated escutcheon is present. This is divided into an inner portion, ornamented with fine longitudinal striae, and an outer portion sculptured with a continuation of the surface ribs which bend sharply forward as they cross the umbonal ridge. The distinct ridge usually found separating the escutcheon into two portions is not developed.

The valves are sculptured with 50–60 concentric ribs, closely packed on the umbonal slope, but becoming more widely separated near the inferior margin.

The dimensions of two specimens are as follows:

	L.36(1).	L.36(2).
Length	23 mm.	14 mm.
Height	16 mm.	9·5 mm.
Thickness	13 mm.	9 mm.
Apical angle	124°	123°

Cowper Reed (1932, p. 43) suspected that *Nuculana* (*Leda*) *thompsoni*, from the Agglomeratic Slate series on Bren Spur, Kashmir, may have strong affinities with *N. basedowi*, but it would be difficult to be confused between the two species. The former is an outstanding species and could not be compared with any Nuculanid in Australian Permian rocks.

Thomas (1928, p. 216) in describing an "Upper Carboniferous" fauna from N.W. Peru, included *Leda browni* and made analogies with *Nuculana basedowi*. He said it closely resembled the Australian form, but differed in its longer and less quadrate anterior end, and its more elevated umbones.

Nuculana basedowi is a characteristic form and cannot be confused with other species of the genus. It is strongly inflated in the median umbonal region and compressed in the posterior one-third of the shell.

Localities and Geological Horizon.—Western Australia: Fossil Head, Treachery Bay, Victoria River estuary, north Australia. Permian (stratigraphy unknown). On the south bank of the Minilya River, near Bulgadoo Pool, 3,380 yards N. 110° W., from Bulbawardoo Windmill (probably Upper part of the Bulgadoo Series).

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EXPLANATION OF PLATES.

PLATE XIX.

Glyptoleda reidi sp. nov.

Figs. 1-3.—The holotype (F.41404). 1. Left valve showing outline and ornamentation. 2. Right valve. 3. Dorsal view.

Figs. 4-5.—Slightly weathered paratype (No. 265). 4. Right valve. 5. Dorsal view.

Fig. 6.—Internal cast of a left valve (F.36431).

Glyptoleda coleyi sp. nov.

Fig. 7.—The holotype [No. J.35(2)]. Right valve showing characteristic outline and ornamentation. The valve is weathered near the inferior margin revealing concentric growth lines.

Fig. 8.—Right valve of a smaller specimen (No. J.44).

Fig. 9.—Dorsal view of a cast of both valves [No. T.168(1)]. The teeth, and outer series of small pits marking the position of the ridge which separates the escutcheon into two portions, are clearly shown.

PLATE XX.

Glyptoleda glomerata sp. nov.

Figs. 1-3.—The holotype (F.41405). 1. Left valve showing outline and ornamentation. 2. Right valve. 3. Dorsal view.

Nuculana ovata Laseron.

Figs. 4-6.—The holotype (F.20176). 4. Right valve showing ornamentation. 5. Decorticated left valve. 6. Dorsal view.

Fig. 7.—Right valve of a smaller specimen (F.41406).

Fig. 8.—Dorsal view of a cast of both valves (F.41407) showing dentition.

PLATE XXI.

Nuculana darwini (De Koninck).

Fig. 1.—The neotype (F.41409). Left valve showing closely arranged ribbing and cancellate appearance of the ornamentation.

Fig. 2.—Dorsal view of a cast of both valves (F.41412), showing anterior adductor and pedal muscle scars. The furrow, corresponding to the ridge on the inside of the valve; may be seen on the umbo of the right valve.

Nuculana ovata Laseron.

Fig. 3.—Dorsal view of a small specimen (F.41406).

Nuculana abrupta (Dana).

Fig. 4.—A plastotype (after Dana), L.670, showing left valve partly covered with matrix.

Figs. 5-6.—Partly decorticated specimen (F.24240). 5. Left valve showing traces of concentric ornamentation. High on the flank of the umbo the groove or furrow containing two small muscle scars is present. 6. Dorsal view.

PLATE XXII.

Nuculana darwini (De Koninck).

Figs. 1-2.—Cast of both valves (F.41412). 1. Decorticated left valve showing pallial line and notched posterior adductor muscle scar. 2. Partly decorticated right valve showing shallow groove and muscle scars on umbonal flank.

Nuculana concinna (Dana).

Fig. 3.—A plastotype (after Dana) L.671, showing the imperfect shell from which the species was described.

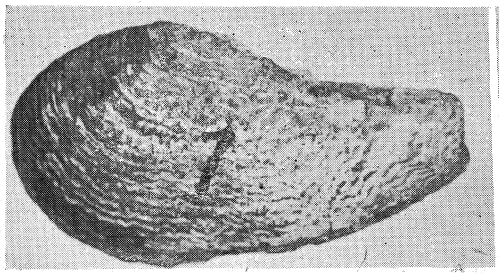
Figs. 4-5.—The plesiotype (F.39313). 4. Partly decorticated left valve showing general outline and ornamentation. 5. Dorsal view showing lunule and escutcheon.

Nuculana basedowi Etheridge.

Fig. 6.—A left valve [L.36(1)] showing ornamentation and characteristic outline of the species.

Fig. 7.—A right valve [L.36(2)] showing the inflated anterior portion and the smaller, flattened, posterior portion.

Photographs by G. C. Clutton.



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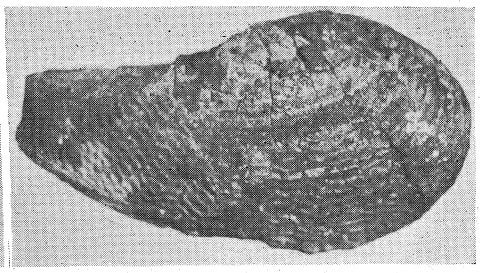

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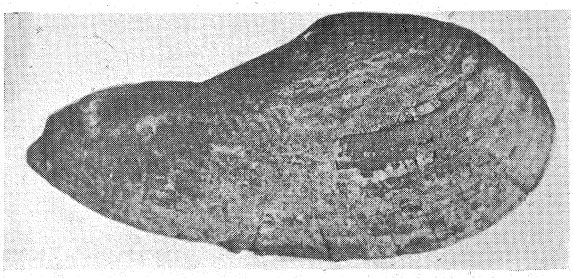

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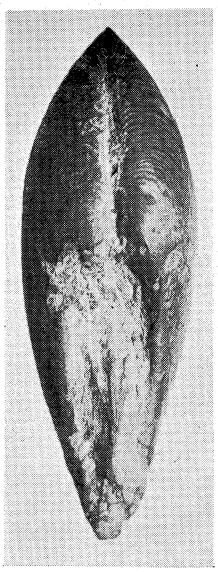

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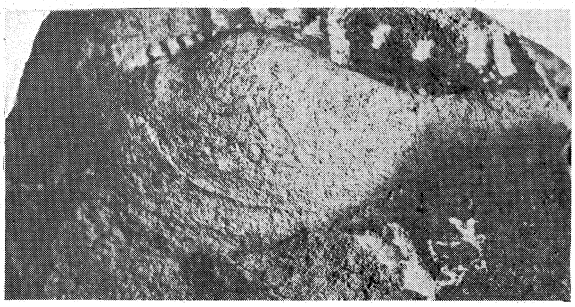

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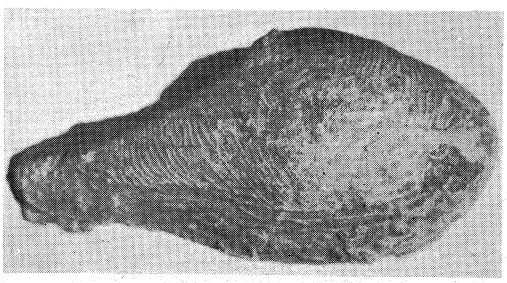

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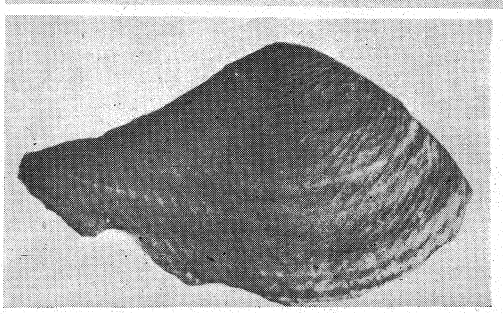

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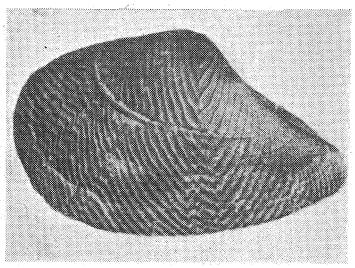

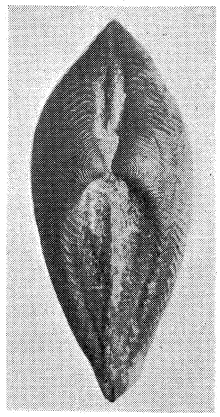

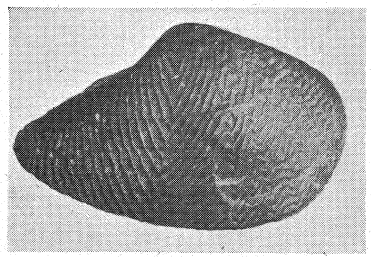

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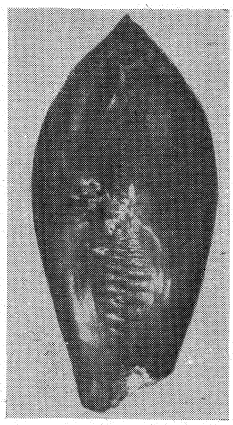

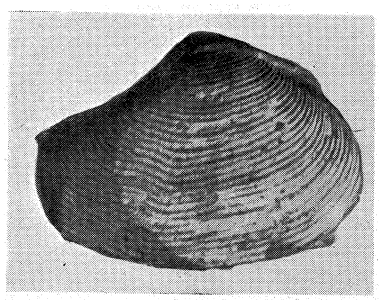

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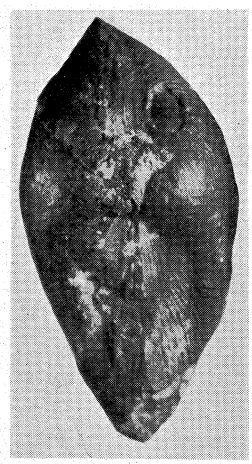

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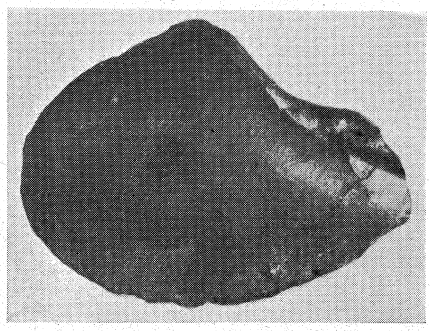

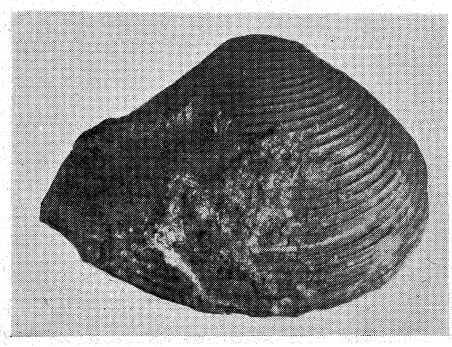

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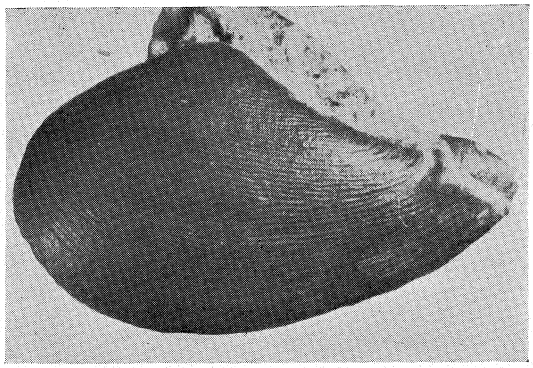

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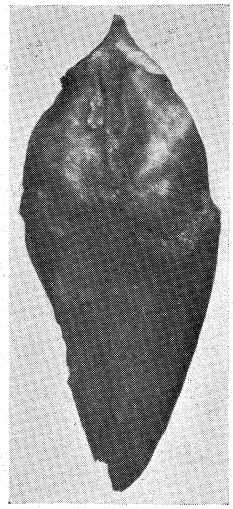

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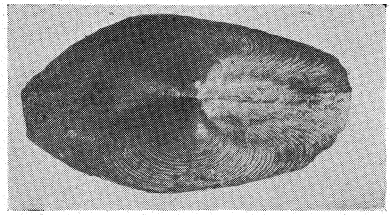

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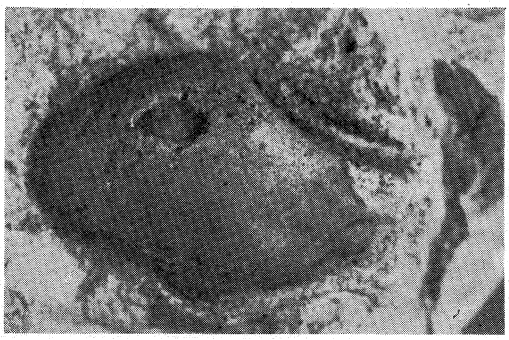

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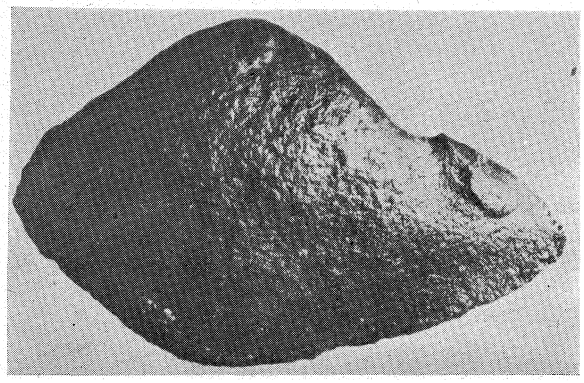

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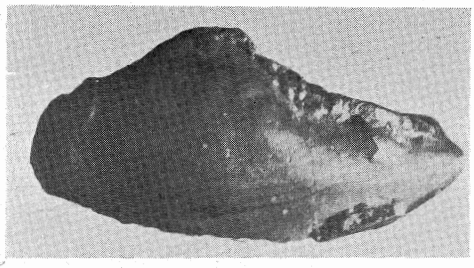

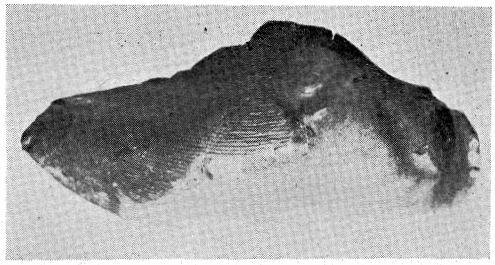

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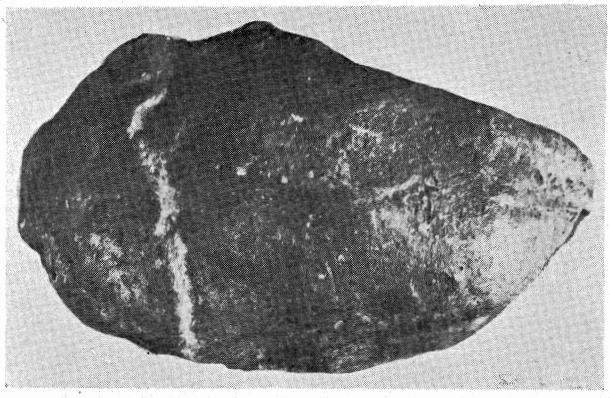

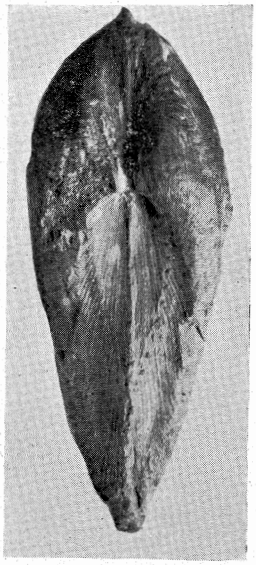

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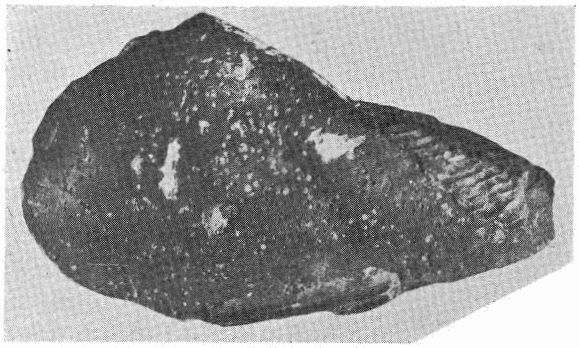

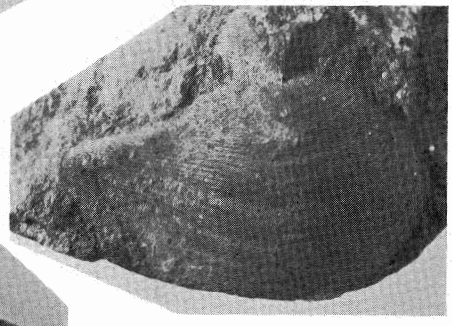

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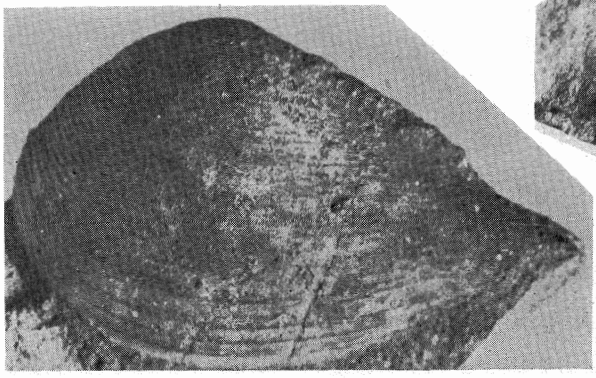

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