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NEW CRETACEOUS BRACHIOPODA
FROM ARIZONA

(WITH 4 PLATES)

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NEW CRETACEOUS BRACHIOPODA
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(WITH FOUR PLATES)

Cretaceous brachiopods, except for the occurrences of *Kingena* in Texas, are a great rarity in the United States, and it is also unusual to find here more than one kind of brachiopod of that age in abundance. However, in 1947, Dr. J. B. Reeside, Jr., of the U. S. Geological Survey, called my attention to several species of brachiopods from the Cretaceous Mural limestone of Arizona. These were insufficient for study; therefore, in the summer of that year I went to the Bisbee area of Arizona with Dr. Ellis Yochelson, now of the U. S. Geological Survey, to obtain more material.

Occurrence of Cretaceous brachiopods in Arizona is mentioned by Ransome (1904, p. 6) in his description of the Bisbee Quadrangle. The single occurrence cited is said to be the only one on the quadrangle and is a small hill on the east side of the quadrangle opposite the mouth of Glance Canyon and about 3 miles east of Glance. This hill is in the NW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 36, T. 23 S., R. 25 E. and lies about 0.2 mile east of U. S. Highway 80 about 12.7 miles west-northwest of Douglas, Cochise County. The location is thus easily accessible because of its proximity to an excellent road, and it is from this locality that Dr. Yochelson and I collected the specimens described below.

The low hill from which the brachiopods were taken consists of massive limestone, through which the brachiopods are scattered. They are not concentrated in bands, although some pieces were found in which they were fairly common. A large part of the collection consisted of small lumps showing one or two specimens. Although some large pieces were taken, they were not rich and it was best, therefore, to collect individual specimens or small groups in small pieces. The limestone lumps taken produced few specimens aside from brachiopods. These included small oysters, small rudistids, and a few poorly

preserved small echinoids. The brachiopods are fairly well silicified. The silicification is not coarse or crude in the large specimens, but it is in some of the immature ones. In general the specimens are brittle and fragile and must be handled with great care.

These brachiopods occur in the Mural limestone but, because of the isolated character of the hill, the exact stratigraphic position of the specimens is uncertain. Ransome, who defined the Mural, states that "The little hills near the eastern edge of the quadrangle north of Hay Flat are composed mainly of the hard limestones of the upper member of the formation. Some of the beds here contain abundant corals (*Astrocenia* and another form not collected). *Caprina*, and a number of little brachiopods (*Rhynchonella*, *Terebratella* and *Terebratula*) not seen at any other locality in the quadrangle."

Stoyanow (1949, p. 20) divides the Mural limestone into three units: (a) Basal thinner-bedded limestone with *Orbitolina texana*; (b) massive "rudistid" limestone, and (c) thinner-bedded limestone with *Orbitolina texana*. He says: "In the basal beds of the Mural limestone, small brachiopods, corals, specimens of *Lima muralensis*, and large forms of *Lunatia?* sp. often occur. The massive limestone is usually replete with *Radiolites?* sp., whereas the specimens of *Caprina* sp. are comparatively rare and come from the thinner-bedded layers below the reef." These remarks suggest that Stoyanow identified the brachiopod beds as low in the Mural. Perhaps brachiopods occur in more than one level and were not seen by Ransome. At any rate the Mural limestone is now placed (Cobban and Reeside, 1952) at about the middle of the Albian stage in the Lower Cretaceous.

CRANISCUS HESPERIUS Cooper, new species

Plate 3A, figures 1-3

Pedicle valve unknown.

Brachial valve a low cone about medium size for the genus, sub-rectangular in outline; length about two-thirds the width; maximum width in anterior third; sides slightly oblique and gently rounded; anterior margin broadly rounded; anterolateral extremities narrowly rounded; posterior margin nearly straight. Apex approximately central, blunt; anterior slope steep; lateral slopes about as steep as anterior slope, but posterior slope gentle. Surface irregular.

Interior with low median ridge rising to a sharp point at the valve middle; anterior adductor scars narrowly elliptical, obliquely placed and forming low ridges which, with the median ridge, divide the valve into three parts; posterior adductor scars large, but lightly impressed. Anterior half with strong pallial ridges.

Measurements in mm.—Length, 10.6; maximum width, 14.0; height, 3.4.

Types.—Holotype U.S.N.M. No. 124192.

Horizon and locality.—Mural limestone, from a small hill 300 yards east of U. S. Highway 80, NW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 36, T. 23 S., R. 25 E., Bisbee Quadrangle, Arizona.

Discussion.—This genus has not hitherto been identified among North American fossils. The laterally elongated muscle scars and short median septum are characteristic. The species is like *Cramiscus suessi* (Bosquet) from the Maastrichtian of Holland in having the apex near the middle and a long, flat posterior slope, but the Dutch species is more swollen anteriorly and is a much deeper shell.

CYCLOTHYRIS AMERICANA Cooper, new species

Plate 1A, figures 1-17

Shell of about medium size for the genus, subtriangular in outline; maximum width at or near the middle; valves subequal in depth, the brachial valve having a slightly greater depth; anterior commissure gently uniplicate; surface costellate, costellae numbering about 32 to 42 along the anterior margin.

Pedicle valve moderately convex in lateral profile, with the maximum convexity near the middle; beak apiculate, nearly straight to sub-erect, making an angle of 60° to 80°. Umbo swollen; beak ridges moderately strong and defining a fairly broad, gently concave inter-area; sulcus originating in the anterior third to half, shallow and occupying about one-third the width. Flanks gently convex, descending steeply to the sides. Deltoidal plates conjunct, auriculate; foramen submesothyrid, oval in outline.

Pedicle valve interior with strong but small teeth; dental plates stout and fairly long, not surrounding the muscle field which is large and broadly elliptical; diductor scars subreniform in outline; adductor scars posterior to diductors; no pedicle collar.

Brachial valve strongly convex in lateral and anterior profiles; umbo swollen; fold low or defined only as a wave of the commissure; flanks convex; posterolateral slopes steep. Brachial valve interior with long, slitlike sockets bounded by moderately strong socket ridges; hinge plate divided; crura curved, short, of radulifer type.

MEASUREMENTS IN MILLIMETERS

	Length	Width	Thickness
Holotype U.S.N.M. No. 124193a.....	14.0	13.6	9.0
Paratype U.S.N.M. No. 124193b.....	11.8	12.0	9.0

Types.—Holotype U.S.N.M. No. 124193a; figured paratypes U.S.N.M. Nos. 124186a-e; measured paratype U.S.N.M. No. 124193b.

Horizon and locality.—Mural limestone, from a small hill 300 yards east of U. S. Highway 80, NW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 36, T. 23 S., R. 25 E., Bisbee Quadrangle, Arizona.

Discussion.—This species is characterized by its moderate size, convex valves and costellate surface. One of the significant features of the Arizona species is the poor development of the fold and sulcus, which is strongly developed only at the front. A few specimens of rhynchonellids have been found in the American Lower Cretaceous which are probably referable to *Cyclothyris*. None of these resembles the present species. The National Museum has a specimen of *Cyclothyris* from the Main Street formation, Fort Worth, Tex., but it is transversely elliptical rather than strongly triangular as the Mural species is. Of three specimens of *Cyclothyris* from the Edwards limestone, Presidio County, Texas, two are strongly transverse, but the third is suggestive of *C. americana*.

The British species most suggestive of *C. americana* is *C. nuciformis* (Sowerby), but this differs in having a pronounced fold and sulcus for at least half the valve length. Some young specimens from the Cretaceous of France called *Cyclothyris compressa* (Lamarck) or *C. depressa* (Sowerby) suggest the American species but they are usually more transverse or are demonstrable aberrations of a variable species.

CYCLOTHYRIS species

A single specimen (U.S.N.M. No. 124216) differing importantly from *C. americana* was found with the other specimens described herein. Although somewhat crushed, it differs from *C. americana* in being much wider and in having a fairly prominent fold and sulcus that originate a short distance anterior to the middle.

RECTITHYRIS VESPERTINA Cooper, new species

Plate 1B, figures 18-37

Shell small for the genus, elongate oval in outline and with the maximum width at the middle; sides gently rounded; anterior margin narrowly rounded. Valves unequal in depth, the pedicle valve having the greater depth. Posterior margin narrowly rounded to subcarinate; anterior commissure rectimarginate to faintly uniplicate; lateral commissure nearly straight. Surface smooth except for concentric lines and varices of growth.

Pedicle valve moderately convex in lateral profile and with the maximum convexity at about the middle; anterior profile fairly strongly convex; umbonal region narrowly convex to subcarinate, the narrow swelling continued nearly to the median region where it dies out. Anterior third flattened to faintly sulcate. Beak erect, obliquely truncated; foramen broadly elongate, moderately large, oval to circular, submesothyrid to mesothyrid. Deltidial plates conjunct, not covered by beak, suture visible. Beak ridges strong.

Interior of pedicle valve with large and thick teeth; dental plates obsolete; pedicle collar small. Muscle marks too indistinct to discern individual scars or pattern of field.

Brachial valve shallow, gently convex in lateral profile and broadly convex in anterior profile; umbonal region gently swollen; beak obscured by the overlapping of the deltidial plates; median region gently swollen and forming a barely perceptible fold which appears at the front margin as a gentle wave of the commissure in the direction of the brachial valve; flanks gently inflated and with short, steep sides.

Interior with short stout loop having short crura and short blunt crural processes; descending lamellae short; transverse ribbon broad in adults, fairly strongly elevated and with a flattened crest at its middle; outer socket plate moderately broad, moderately concave; inner socket plates nonexistent to small; inner socket ridge strong, overlapping the teeth. Cardinal process small, wide and short. Musculature and pallial marks poorly impressed, elongate, somewhat tear-shaped.

MEASUREMENTS IN MILLIMETERS

		Length	Brachial length	Width	Thickness
Holotype	U.S.N.M. No. 124194b.....	17.6	14.0	14.0	9.4
Paratype	U.S.N.M. No. 124194a.....	16.9	13.9	12.5	8.8
"	" " " 124194c.....	20.3	17.4	17.4	11.6
"	" " " 124194d.....	5.4	4.7	3.9	2.7
"	" " " 124194e.....	11.4	9.2	8.9	5.2

Types.—Holotype U.S.N.M. No. 124194b; figured paratypes U.S.N.M. Nos. 124187, 124188, 124194c, d, 124195, 124195a, 124196c; unfigured paratypes U.S.N.M. Nos. 124194a, e, 124196a, b, 124205, 124218.

Discussion.—This species is characterized by the unequal convexity of the valves, the suberect to erect beak (Thomson classification, 1927), rectimarginate to faintly plicate anterior commissure, and short, stout loop. I am not completely happy about the assignment of this

species to *Rectithyris* but this appears to be the only genus at present to which it can be assigned. Points of agreement with *Rectithyris* as defined by Sahni (1929) appear: the mesothyrid foramen, the easily visible deltidial plate, rudimentary cardinal process, the inner hinge plates, even though they are not strongly developed, and the constriction of the broad transverse ribbon to form a median, flattened crest. Deviations from *Rectithyris* are the curvature of the beak, less strongly triangular loop, and smaller foramen.

Some points of similarity exist between the Arizona species and *Neolothyrina*. The loop of the latter is like that of *R. vespertina* and according to Sahni's figures (1929, pl. 9, figs. 19, 20) shows the same type of variation. The loop shown in figure 20 has nearly parallel sides and the crural processes are well anterior to the crural bases, whereas the loop shown in figure 19 has the crural processes located almost at the junction of the crura and the crural bases. The beak characters and other details of *Neolothyrina*, however, are too different to permit use of that name.

No known species of *Rectithyris* is like this American species; consequently, no direct comparison is possible.

Variation of the loop.—Variations in parts of the loop are evident in many of the specimens, but these variations could not be correlated with shape or shell differences. In some specimens the brachial valve is distinctly flatter than in others, but this difference did not accord with loop differences. In the young, loop variation is evident in the length of the descending branch anterior to the crural base. One specimen, paratype U.S.N.M. No. 124196a, has the crural process given off almost at the junction of the descending branch with the crural base. In another, plate 1B, figure 33, the crural process is located a short distance anterior to the crural base. In this specimen the crural base appears as a ridge bounding the inner socket plate. This is true of a somewhat larger and more-elongate specimen shown in figures 29-31 on the same plate. This is not true, however, of the largest and oldest loop figured, same plate, figures 34 and 35, in which the descending process is short and the posterior extension of the crural base is buried in the formation of modest inner hinge plates. The presence of inner hinge plates appears to be an age character, at least in this case.

Abnormal specimen.—This species shows considerable variation in exterior as well as interior features. Such variability is to be expected, but the occurrence of a freak specimen having the crural processes united is unusual. This specimen is paratype U.S.N.M. No. 124195a. The beak is broken and most of the brachial valve broke from the

specimen during the etching and was not recovered. Unfortunately the loop is thus revealed from the dorsal side which is not the most advantageous view for appreciation of the structure.

The loop is of the normal size as shown by other specimens. The descending branch is very stout and the transverse band is strong and thick. The crural processes appear to have been normal but the points grew inward and united to form a transverse band, thinner than the anterior one but with the band convex toward the pedicle valve and having a form like that of the normal ribbon.

GEMMARCULA ARIZONENSIS Cooper, new species

Plate 2A, figures 1-28; plate 4B, figures 3-6

Shell small, attaining a width of slightly more than one-half inch, transversely elliptical in outline; wider than long and with a narrow hinge. Widest at about the middle. Sides rounded; anterior margin subnasute to broadly rounded; anterior commissure rectimarginate to faintly uniplicate, the uniplication clearly visible only in old specimens. Valves unequal in depth, the pedicle valve having the greater depth. Surface multicostate, the costae appearing in three generations. Costae numbering 20 to 24 on the front margin of an average adult.

Pedicle valve moderately to strongly convex in lateral profile and broadly to strongly convex in anterior profile, the convexity in both profiles depending upon age. Umbo somewhat narrowly convex, the convexity continued anteriorly as an indistinct fold which is bounded somewhat indistinctly by two costae stronger than those surrounding them; median region swollen; flanks and anterior slope steep. Beak irregular from pedicle pressure against rough surface; interarea wide and long; foramen large and circular; deltidial plates disjunct in the young, conjunct in old specimens and forming a symphytium.

Interior of the pedicle valve with short but stout dental plates, strong transverse teeth; callosity of pedicle collar on floor of delthyrial cavity thick; median septum low, extending anteriorly to beyond the valve middle.

Brachial valve gently to moderately convex in lateral profile, broadly but gently convex in anterior profile; umbo gently convex, often abraded by pedicle pressure against the substratum. Fold barely perceptible except in old specimens, and usually defined by a median crowding and smaller size of the costellae. Flanks gently swollen and with long, gentle slopes to the margins.

Interior of the brachial valve with a thick concave notothyrial callosity buttressed by a strong median septum that extends to about the

valve middle; plates bounding sockets broad; outer socket ridges broad; sockets long and deep. Crura short; crural processes short and pointed; loop having form of early dallinid development, braced at its junction with the septum by a wide plate concave toward the anterior; descending branches slender; ascending branches broad; transverse ribbon broad and with two prongs on each side which are directed toward the pedicle valve. Hinge plate usually obscured by callus which smooths the notothyrial region; cardinal process a wide, bilobed thickening on the posterior margin of the notothyrial platform formed by the callus covering the hinge plate.

Development of the loop.—The smallest specimens showing interior details are 2.0 mm. wide (paratype U.S.N.M. No. 124200a) and 2.7 mm. (paratype U.S.N.M. 124198a). In these specimens the septum is continuous from the hinge platform to the valve middle where it is expanded ventrally toward the pedicle valve to form the pillar. Viewed from the anterior the expanded pillar is divided by a groove and the ventral and dorsal sides diverge slightly from each other, the beginnings of the loop ring. Crural processes and descending branches are either not preserved or not yet formed, probably the former. The notothyrial region is filled with solid callus.

The next larger specimen is 3.6 mm. in width (paratype U.S.N.M. No. 124199). Both valves are preserved. The pedicle valve shows a wide and completely open delthyrium with no trace of the deltidial plates. Thickening on the floor of the delthyrial cavity is strong and the median ridge anterior to this thickening is well developed. Inside the brachial valve the notothyrial region is solid as in the preceding specimen, but the septum is short and high. The crural processes are well developed and the crura are short and thick. The descending lamellae join the lower or dorsad diverging branches of the anterior end of the pillar, the anterodorsal side of which is now more deeply cleft. The ventral portion of the septum is elongated and the two lamellae diverging widely from the pillar are roofed by a flat plate, the pre-campagiform hood of Elliott.

A third specimen of 5 mm. width (paratype U.S.N.M. No. 124201a) also shows the median septum and its anterior expansion. This specimen differs from the preceding one in having a definite concavity in the notothyrial callus, bounded by the crural bases. Other details of the loop can only be inferred.

A fourth specimen 5.7 mm. in width (paratype U.S.N.M. No. 124198b) shows additional details of the loop, but part must be inferred from ridges and remnants. The notothyrial callosity is thick and is buttressed by a strong median septum. The crura are very short

and the descending lamellae are moderately broad and extend from the crural processes anteriorly to join the median part of the curved lateral plates at the distal end of the septum. The incision at the anterior end is much deepened and the anterior ends of the broken loop ring are beginning to diverge widely.

No specimens between 6 and 12 mm. preserving good details of the loop were taken from the acid residues. Specimens 12 mm. wide or wider evidently have adult loops, but none of them are complete. The lateral branches connecting the septum to the loop are broad, stout, and long, frequently being strengthened by a median triangular plate. The loop of an adult specimen 16.5 mm. wide (paratype U.S.N.M. No. 124220) has a broad transverse ribbon with long ears.

MEASUREMENTS IN MILLIMETERS

	Length	Brachial length	Mid-width	Hinge width	Thickness
Holotype U.S.N.M. No. 124197a..	10.1	8.8	12.3	8.7	5.2
Paratype U.S.N.M. No. 124197b..	13.1	11.1	13.5	10.4	8.7
“ “ “ 124206a..	12.2	9.6	14.0	10.8	6.5
“ “ “ 124206b..	13.4	10.6	14.0	10.7	7.6
“ “ “ 124206c..	11.5	9.0	13.0	10.9	6.4
“ “ “ 124206d..	7.2	5.3	7.5	?	4.2
“ “ “ 124206e..	5.1	4.3	5.8	5.9	2.6

Types.—Holotype U.S.N.M. No. 124197a; figured paratypes U.S.N.M. Nos. 124197b, d-j, 124198a, b, 124199, 124201a, b, 124220; measured paratypes U.S.N.M. Nos. 124206 a-e; unfigured paratypes U.S.N.M. Nos. 124197c, 124200a, b.

Horizon and locality.—Mural limestone, from a small hill 300 yards east of U. S. Highway 80, NW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 36, T. 23 S., R. 25 E., Bisbee Quadrangle, Arizona; Rancho Nuevo, 3 miles east of Santa Rosalia, Sonora, Mexico.

Discussion.—This species is characterized by having a low and indistinct fold and sulcus and differs from all other described species of *Gemmarcula* in this respect. This is the first report of the genus in North America. *Gemmarcula arizonensis* is about the same size as *G. aurea*, type species of the genus, and has a cardinal process like it, but the exterior is different as noted above. *Gemmarcula menardi* (Lamarck), a well-known species in France and Great Britain, is larger than the American species and has a much more pronounced fold and sulcus. It also differs from the Arizona shell in having a more elaborate cardinal process.

GEMMARCULA MENARDI (Lamarck)

Plate 2B, figures 29-34

Figures of the interior and exterior of this fine species are introduced for comparison with *G. arizonensis*. Note elaborate development of the cardinal process in this European species.

Horizon and locality.—Cretaceous (Green Sand), LeMans, Sarthe, France.

PSILOTHYRIS Cooper, new genus

Generally small to medium size, oval to subpentagonal in outline; anterior commissure rectimarginate to uniplicate; valves unequally convex, the pedicle having the greater depth and convexity.

Pedicle valve with strong beak ridges; beak erect; foramen round, small to large, submesothyrid to mesothyrid; deltidial plates disjunct to conjunct, often worn away by pedicle pressure. Interior with stout, thick teeth, buttressed by stout dental plates; no pedicle collar; muscle scars not discernible in available material.

Cardinalia small; hinge plate undivided, short, often upturned on its anterior edge; inner socket plate concave, stout; crura short, stout; crural process long and slender; loop simple, long dalliniform, forming a broad ribbon and having a broad transverse band in the adult; median septum of the adult short, slender, and may or may not buttress the hinge plate, and reduced to a faint myophragm at the valve middle. Young stages with loop metamorphosis like that of the Dallinidae.

Type species.—*Psilothyris occidentalis* Cooper, new species.

Discussion.—This species is characterized by its smooth exterior, simple uniplicate folding, short inner hinge plate and long dalliniform loop. Details of the formation of the hinge plate and the development of the loop are discussed under the specific description. The combination of characters exhibited by *Psilothyris* is different from any described Cretaceous dallinoid and is also unlike any described smooth Jurassic zeilleroid and dallinoid.

Of smooth Jurassic zeilleroids that resemble *Psilothyris* more or less closely, *Zeilleria*, *Microthyridina*, *Rugitela*, and *Ornithella* are provided with a strong median septum in the brachial valve and the folding of all of them is different from that of *Psilothyris*. *Aulacothyris* and *Antiptychina* are differently folded, these two genera having a strongly sulcate brachial valve. The dallinoids *Plesiothyris* and *Obovothyris* have long septa and different folding. *Epicyrta* has a carinate brachial valve and is thus quite different externally.

This genus, although not named until now, was recognized by Deslongchamps (1884, p. 189) in his discussion of the genus *Zeilleria*. He characterizes the division as having a relatively short, thick beak having a very large foramen. The shell is globular, short, and compact. It is unique in the Cretaceous.

PSILOTHYRIS OCCIDENTALIS Cooper, new species

Plate 3B, figures 4-24; plate 4A, figures 1, 2

Shell small, attaining a length of five-eighths inch; outline sub-pentagonal with the length slightly greater than the width; greatest width located slightly posterior to the middle; sides sloping medially; anterior margin subtruncate; posterior margin forming an obtuse angle. Anterior commissure uniplicate; lateral commissure straight. Valves unequal in depth, the pedicle valve deeper; surface smooth except for concentric lines and varices of growth.

Pedicle valve strongly convex in lateral profile, with the maximum convexity slightly posterior to the middle; anterior profile strongly convex; umbonal region inflated; beak small, erect; beak ridges strong. Median region swollen; anterior slope flattened; flanks swollen and steep. Foramen small, round, mesothyrid, slightly labiate. Deltidial plates conjunct, suture visible. Interior of pedicle valve with large teeth supported by stout dental plates. No pedicle collar. Muscle marks lightly impressed.

Brachial valve in lateral profile flattened in the median region but convex at the posterior and anterior; anterior profile broadly and gently convex. Umbonal region swollen but median area flattened; flanks narrowly convex.

Interior of the brachial valve with short, undivided hinge plate deeply excavated anteriorly and thickened, elevated or puckered on the anterior edge. Socket ridge short, stout. Crura short; crural processes long and slender in the adult loop but short and blunt in the young. Loop long and free in the adult; loop short, broad, and attached to a short septum on the floor of the valve in the young. Septum in the adult short and confined to a position at the beak and under the hinge plate and may or may not support the hinge plate.

Development of the loop.—In the smallest specimen available, measuring 3 mm. in length and probably the same in width (paratype U.S.N.M. No. 124190k), the notothyrial region is deeply concave and without a hinge plate. The crura are slender and arise from ridges bordering the notothyrial cavity. The descending lamellae are short and their anterior ends converge to unite with a septal blade or pillar

that springs from the floor of the valve near the middle. This pillar is much expanded longitudinally with free edges extending a short distance posteriorly, but also anteriorly to a point about three-fourths the length of the valve from the beak. The anterior extension appears to be a long, broad-ribbed ring. The details cannot be ascertained because this part of the structure is obscured by silicious material. This is the pre-campagiform stage.

Details of the cardinalia are clear in a specimen without loop measuring 4.2 mm. in length (paratype (U.S.N.M. No. 124202d). The floor of the notothyrium is thickened by ridges joining the crural bases and the septum is now extended posteriorly to meet the center of these lateral ridges (pl. 3B, fig. 13). The expanded anterior end of the septum is free, but no other details are available.

A specimen measuring 4.5 mm. in diameter (paratype U.S.N.M. No. 124202g) is somewhat more advanced than the previous one. The notothyrial cavity is now deeply concave, the lateral extensions thickened and anteriorly excavated to simulate a hinge plate supported by the median septum. The crural processes on the loop are well developed and are located just anterior to the hinge plate. The descending branches of the loop attach to the distal expanded end of the septum near its dorsal extremity. The greatest change has taken place at the free part of the septum, the anterior end of which is distinctly divided by an incision in its anterior end and the remains of a ring mounting the ventral edge is clearly visible. This is probably the frenuliniform stage of development.

A still more advanced stage, the terebrataliform stage, is shown by a specimen 6.6 mm. in diameter (paratype U.S.N.M. No. 124202i). The hinge plate is still deeply concave and the crural processes moderately long. The septum is well developed and high but does not now reach to the middle. The descending branches of the loop are broad and are now extended far anterior to the end of the septum. The loop is nevertheless still attached to the distal end of the septum by two short branches, but the septum does not extend anterior to its point of contact (plate 3B, figure 17). The specimen does not preserve a ring or ascending branch, but remnants of it are visible.

The next specimen of the series is 7.6 mm. in length and slightly less in width (paratype U.S.N.M. No. 124190h). The hinge plate has become considerably shallower by anterad growth of a transverse plate at its anterior end; the crural processes are large and the branch between them and the hinge plate is now nearly obsolete. The descending branches are free of the septum, but projections, which face inward and represent the remnant of the septal attachments, appear at

about their middle. The septum has been absorbed to a mere remnant which extends for a short distance only anterior to the hinge plate. Except for the incompletely developed hinge plate and the remnants of the septal attachments, the loop is essentially adult in character. This stage is the dalliniform stage.

By summarizing the evidence from these few specimens it is possible to give a fairly complete account of the loop development. Prior to 3 mm. the median septum must show as a small projection from the floor. At 3 mm. the septum has become elongated and the descending branches have grown anteriorly to meet the sides of the elongated free distal expanded part of the septum and the ring bud starts to develop. By 4½ mm. the expanded end of the septum splits laterally and the ring enlarges, the septum having a deep reëntrant anteriorly and the descending branches extended a considerable distance anteriorly. At 6.6 mm. the loop is strong, with broad descending branches extended beyond the anterior end of the septum, and the loop attachment to the septum is a small process. At 7.6 mm. the loop is now free of the septum which has become nearly completely resorbed except for the short remnant supporting the hinge plate. Remnants of the process attaching the loop to the septum can be seen in specimens having attained a length of 12.5 millimeters.

The hinge plate is deeply concave in the young, but in the 7.6 mm. stage the transverse plate forming the flat and undivided hinge plate forms, and this lengthens with advancing age. In old age it becomes puckered or upturned on its free edge.

MEASUREMENTS IN MILLIMETERS

	Length	Brachial length	Width	Thickness
Holotype U.S.N.M. No. 124191.....	15.1	12.4	13.9	9.7
Paratype U.S.N.M. No. 124189.....	13.3	11.0	12.2	8.1
“ “ “ 124190a.....	11.4	9.6	10.7	6.0
“ “ “ 124190b.....	12.4	10.4	11.7	7.5

Types.—Holotype U.S.N.M. No. 124191; figured paratypes U.S.N.M. Nos. 124190a, c, e, f, h-j, 124202a, d-i; measured paratypes U.S.N.M. Nos. 124189, 124190a, b; described but unfigured paratypes U.S.N.M. No. 124190k; unfigured paratypes U.S.N.M. Nos. 124190d, g, 124202b.

Horizon and locality.—Mural limestone, from a small hill 300 yards east of U. S. Highway 80, NW¼SW¼NE¼ sec. 36, T. 23 S.,

R. 25 E., Bisbee Quadrangle, Cochise County, Arizona; Rancho Nuevo, 3 miles east of Santa Rosalia, Sonora, Mexico.

Discussion.—This species is characterized by its compact form, small foramen, moderately strongly uniplicate commissure, flatly convex brachial valve and deep pedicle valve. No other species of this genus is now known in North America to which this one can be compared. The species most like *P. occidentalis* outside of North America is "*Waldheimia*" *tamarindus* (Sowerby) from the British Isles. A variety of forms now appears under this name in the British Isles, but specimens of *P. tamarinda* from Faringdon, England, are most like the American species. They differ, however, in having a narrower anterior region, a larger foramen and much less convex pedicle valve. The development of the median septum in the interior of both the British and American forms is very slight.

PSILOTHYRIS TAMARINDA (Sowerby)

Plate 3C, figure 25

The interior of a brachial valve is introduced for comparison with *P. occidentalis*. Note the low and reduced median septum and the short undivided hinge plate.

Horizon and locality.—Cretaceous (Aptian—Lower Green Sand), Faringdon, Berkshire, England.

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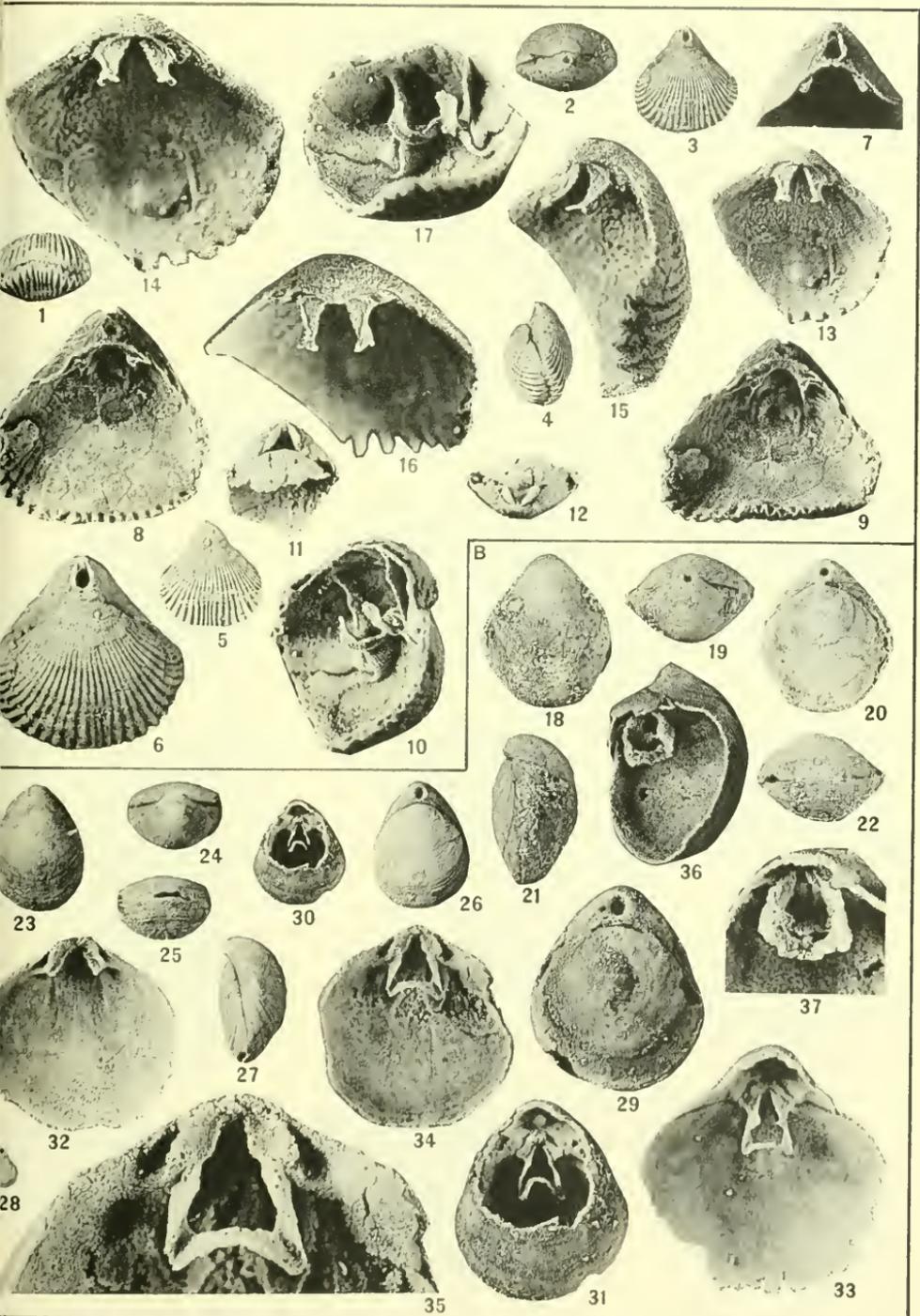
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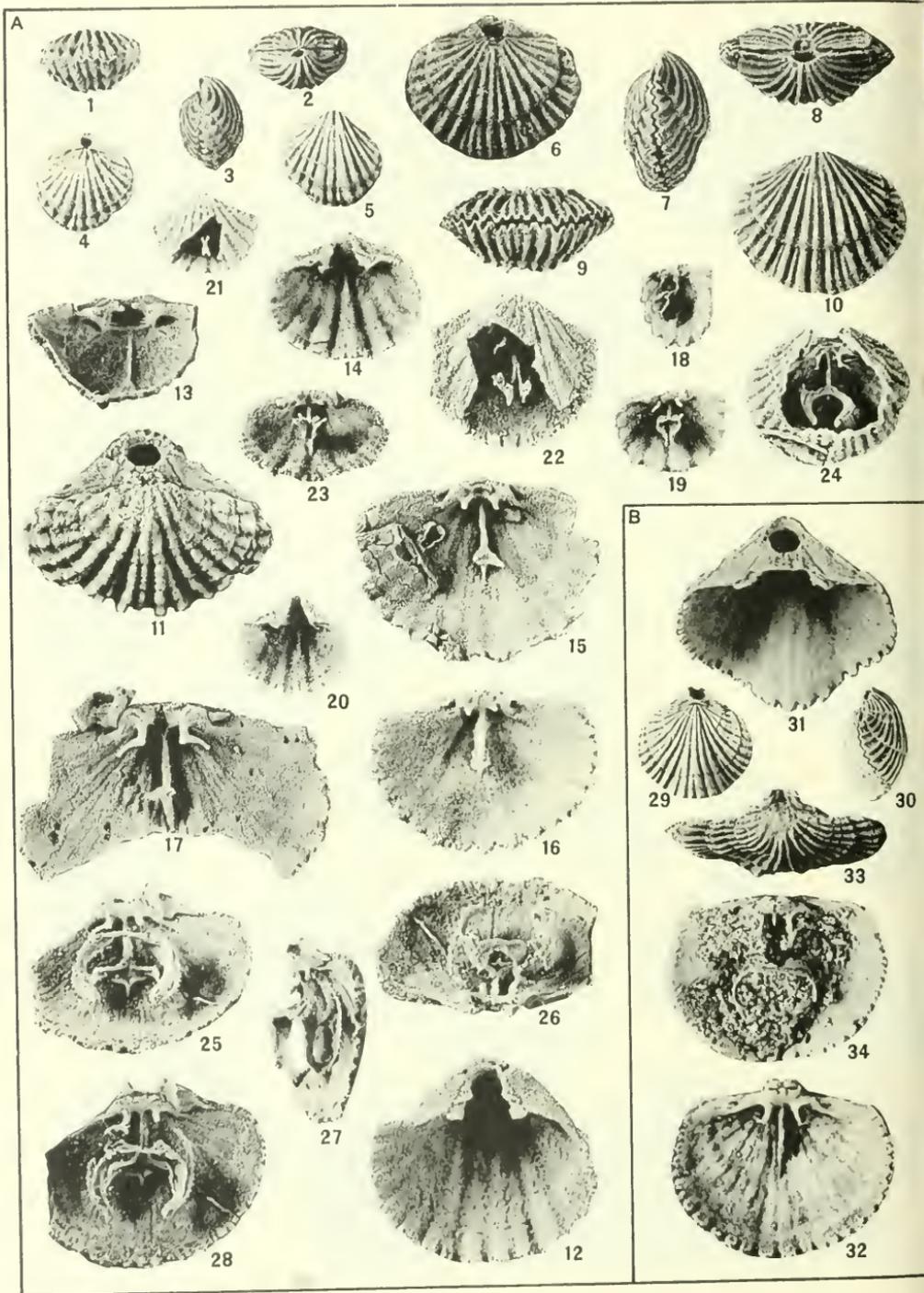
Abbreviations

- | | |
|--------------------------------|---|
| ab = ascending branch of loop | g = groove of pillar |
| cb = crural base | p = septal pillar |
| cp = cardinal process | pf = remnant of pre-campagiform flange |
| dl = descending branch of loop | s = septum |
| e = ear of loop | sdl = scar of broken descending lamella |

(Drawings by Lawrence B. Isham.)

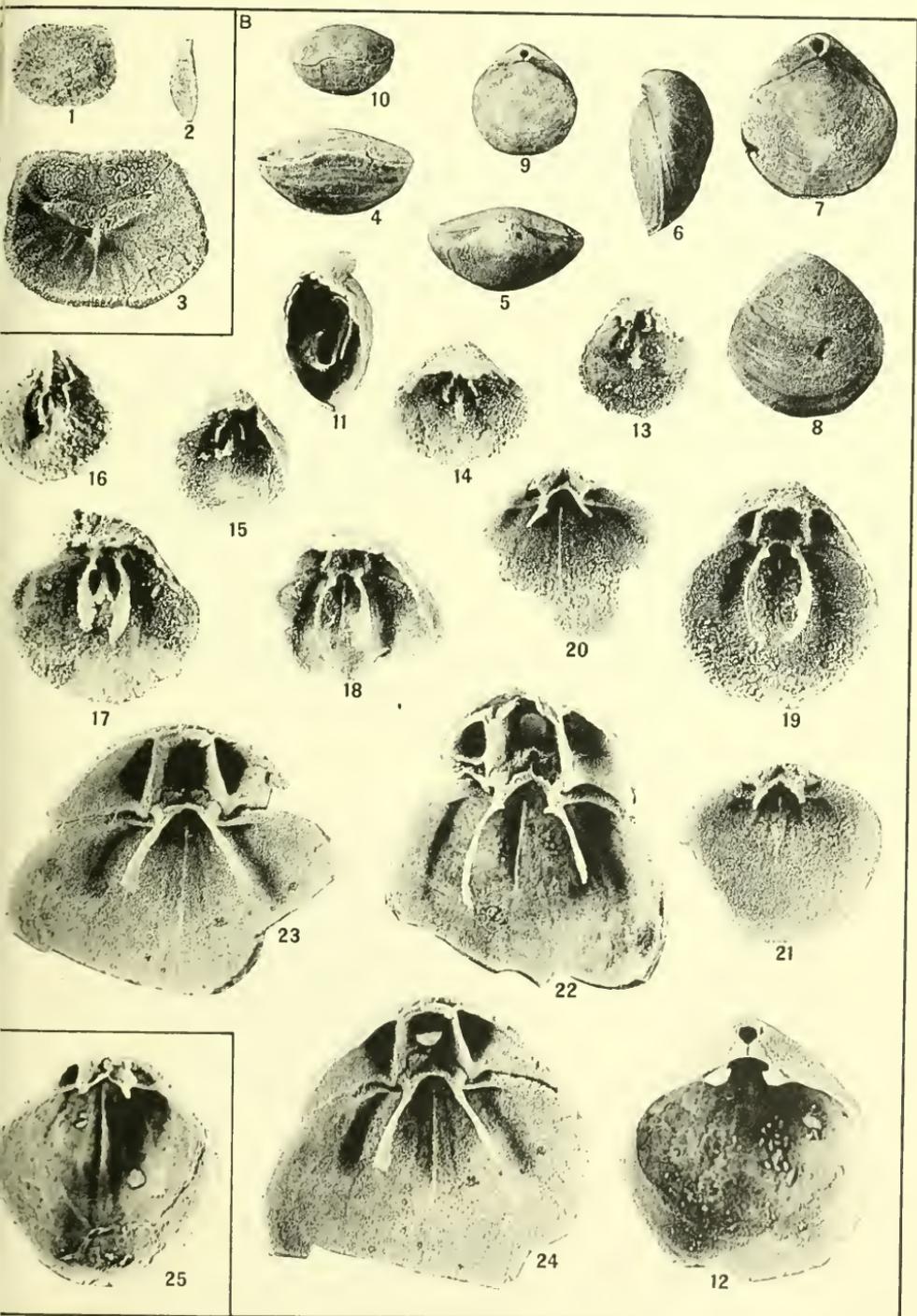


CYCLOTHYRIS AND RECTITHYRIS
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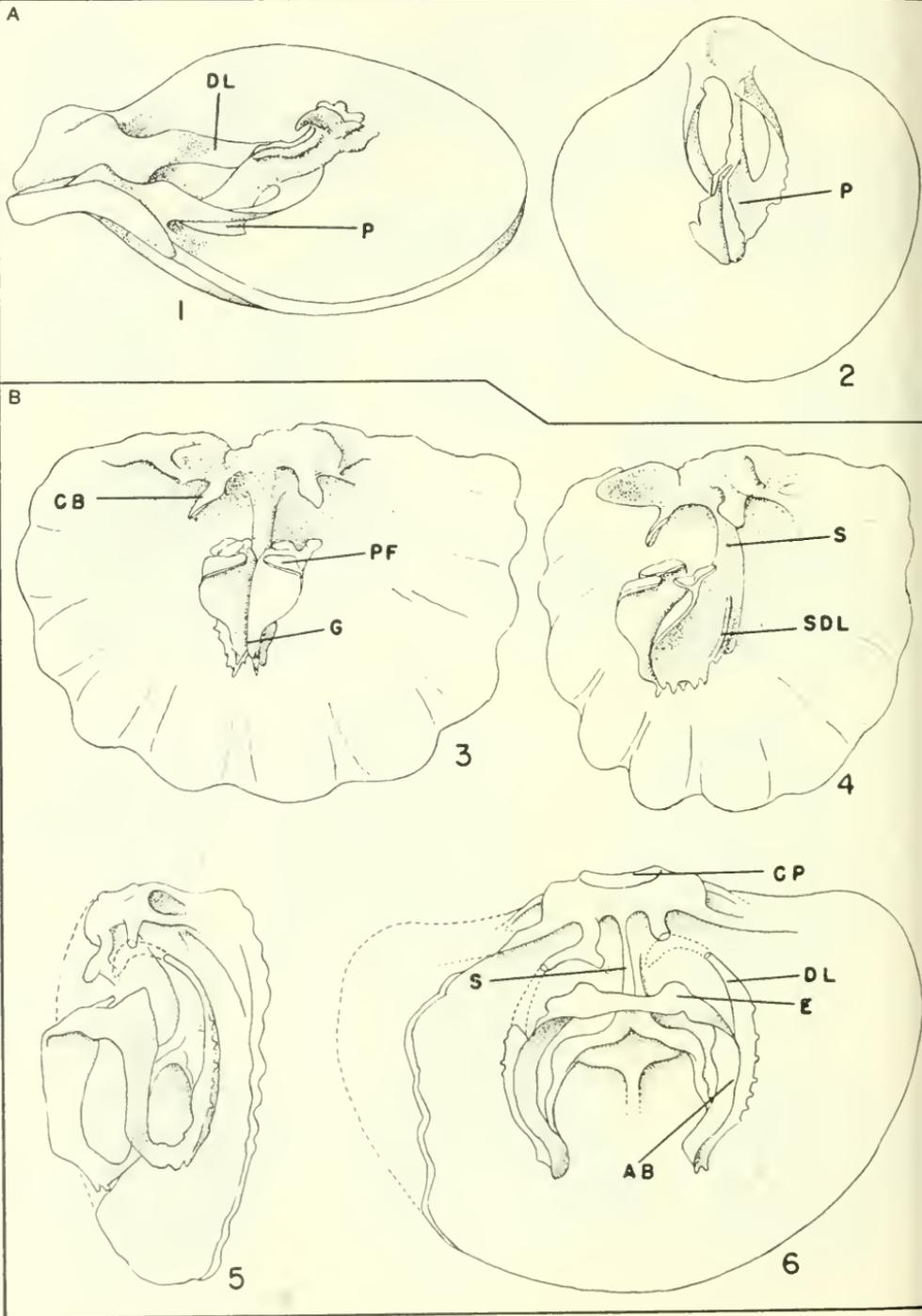


GEMMARCULA

(SEE EXPLANATION AT END OF TEXT.)



CRANISCUS AND PSILOTHYRIS
(SEE EXPLANATION AT END OF TEXT.)



PSILOTHYRIS AND GEMMARCULA
(SEE EXPLANATION AT END OF TEXT.)