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A SILICIFIED MORROWAN BRACHIOPOD FAUNULE
FROM THE BIRD SPRING FORMATION,
SOUTHERN NEVADA

Invertebrate Paleontology
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BY

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A SILICIFIED MORROWAN BRACHIOPOD FAUNULE FROM THE BIRD SPRING FORMATION, SOUTHERN NEVADA

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ABSTRACT—Five species of brachiopods have been described from the lower Bird Spring Formation in Clark County, Nevada. One new genus, *Anthracospirifer*, is proposed for Lower Pennsylvanian spiriferids, as well as three new species, *Anthracospirifer birdspringensis*, *Spiriferellina lata* and *Orthotetes occidentalis*. Relative abundances of brachial and pedicle valves of each species in two weighed blocks of limestone have been tabulated.

SILICIFIED late Paleozoic brachiopods are of especial interest because they reveal diagnostic internal features of the shell that can be observed only with luck or tedious preparation in unreplaced fossils. A small faunule of five brachiopod genera representing as many superfamilies is described below, together with information relating to the relative abundance of these fossils in limestone matrix. A lower Pennsylvanian Morrowan age is assigned to the faunule, partly from consideration of faunas stratigraphically above and below in the Bird Spring Formation and partly from comparison of the faunule with described species of Morrowan age in other areas. All five genera described here are reported in a faunal list for the Moleen Formation, considered to be principally Morrowan by Dott (1955). Directly below the brachiopod-bearing bed discussed here there is a silicified bryozoan-trilobite faunule to be described later.

All types are deposited in the paleontologic collection of the University of California at Los Angeles. Because brachial and pedicle valves are almost never found articulated in this faunule, cotypes consisting of a brachial and a pedicle valve are designated for new species described below.

Takeo Susuki, curator in the U.C.L.A. Geology department, is gratefully acknowledged for preparation of the photographs and Mrs. Opal Kurtz for final drafting of the text figures.

Preservation.—The brachiopods described below were all obtained from a single four-inch-thick limestone bed. The shells are distributed uniformly through the bed and are

equally well silicified in all samples. From observations made during etching it is apparent that the brachiopods are almost universally preserved as single valves. Only a few articulated specimens of *Composita* and one of *Schizophoria* have been obtained. Many valves of *Schizophoria* seem to have been worn at the postero-lateral margins, presumably prior to entombment in the sediment. Whether this was caused by the brachiopods living in dense clusters and rubbing together or wear after death is not known. The possibility of selective transportation of the valves of some or all of the brachiopods was considered but rejected.

Two weighed blocks were separately etched and specimens tabulated. The results are shown on Table 1. In block A (1814 gr.) the undissolved residue remaining on a 120-mesh screen weighed 150 grams, or 8.2 percent of the original weight. In block B (2186 gr.) similar residue weighed 159 grams or 7.2 percent of the weight of the block. In block A there was one identifiable valve for almost every gram of original sediment. From about 8.5 pounds of limestone over 2000 identifiable brachiopod valves were obtained. Discrepancies in number of brachial and pedicle valves of some of the genera, especially *Schizophoria*, *Anthracospirifer* and *Spiriferellina*, originally were thought to be significant. In block A, which was etched first, there are conspicuously fewer large brachial valves of *Schizophoria* than pedicle valves, but this trend was reversed when block B was etched. Some of the difference in number of valves is undoubtedly the result of differential breakage of the delicate shells during

TABLE 1—NUMBER OF BRACHIOPOD VALVES FROM TWO BLOCKS OF LIMESTONE. BROKEN SPECIMENS HAVING LESS THAN ONE HALF THE MEDIAN POSTERIOR REGION ARE NOT INCLUDED. FOR BLOCK B ONLY SPECIMENS RETAINED ON A 5-MESH SCREEN ARE TABULATED

	Block A	Block B	Total
<i>Schizophoria texana</i>			
Brachial valves	481	243	724
Pedicel valves	592	207	799
<i>Orthotetes occidentalis</i>			
Brachial valves	26	24	50
Pedicel valves	21	20	41
<i>Anthracospirifer birdspringensis</i>			
Brachial valves	33	28	61
Pedicel valves	18	21	39
<i>Spiriferellina lata</i>			
Brachial valves	82	55	137
Pedicel valves	38	52	90
<i>Composita ovata</i>			
Brachial valves	53	38	91
Pedicel valves	44	25	69
Total	1397	712	2109

washing and drying. Each of the five genera is represented by many specimens ranging from spat one or two mm. in greatest dimension to adults two or more cm. wide. The largest specimen is a brachial valve of *Orthotetes* over five cm. long. The wide size range, high frequency of dissociated valves and presence of worn specimens of *Schizophoria* probably indicate slow sedimentation with burial of shells taking a relatively long period of time, so that all sizes of shells fell apart prior to burial.

It is interesting to note that the genera obtained represent five superfamilies and that one genus cemented directly by the pedicle valve, three genera have open delthyria and one has a foramen. These facts, plus what must have been different arrangements of the lophophores and muscles internally, suggest that these genera found together here may have adjusted to their environment in slightly different ways—mode of food gathering, type of food utilized, distribution density and mode of attachment on the sea floor. The relative abundances are thought to be real and not due to later changes dur-

ing fossilization, although they probably do not represent absolute abundances during life. The presence of one or two very abundant forms with more sparsely represented but often highly diagnostic species is typical of many level bottom marine benthonic communities today (Thorson, 1957).

The brachiopods in this faunule are selectively penetrated by boring organisms of some sort. The penetrants have left lenticular openings in all but the smaller specimens of *Orthotetes* and in a few specimens, less than 5 percent, of the *Schizophoria*. None of the spiriferoid genera exhibits evidence of being penetrated. Openings of this sort in late Paleozoic shells have been given the generic name *Seminolithes* Hyde. Many of the *Orthotetes* shells show evidence of internal repair of the shell, indicating that the penetrants were operating during life of the animal. Other individuals have been bored from the inside of the valve outward and on the cardinal process, indicating that penetrants did not care much whether the *Orthotetes* was dead or alive and probable utilized the shell for shelter.

Other Fossils.—In addition to the brachiopods, which are the most abundant and varied portion of the faunule, scraps of other fossils have been obtained, none preserved well enough for positive identification. The most common element is a small, thin-shelled, extremely fragile myalinid pelecypod with relatively coarse growth lamellae that become interrupted on the posterior portion of larger shells. The hinge and beak area has not been preserved on any specimen. A single large fragment of an elongate smooth-shelled pelecypod, possibly *Aviculopinna*, has been obtained, as well as portions of a columnella of a presumably high-spired gastropod. The only other fossil is a small cylindrical rugose coral that is clearly a lophophylloid. A distinct columnella is present, as well as steeply sloping tabulae and a deep calyx. There are 16 to 18 major septa in the mature portion. The specimens are too fragmentary for generic assignment. No silicified microfossils were observed; the most common item seen under the microscope consists of small sickle-shaped pieces of silica that are judged to be parts of spiralia.

Age.—A Morrowan age is postulated for

this faunule, based on comparison of the faunule with described fossils and on stratigraphic and paleontologic evidence within the Bird Spring Formation. Although the section in which the faunule occurs is interrupted by alluvium in the valley floor, *Chaetetes* and Middle Pennsylvanian fusulines are found in stratigraphically higher beds on the west side of the valley. The brachiopod fauna is certainly older than Middle Pennsylvanian (Desmoinesian). At other localities in Kyle Canyon an abundant megafauna that includes *Antiquatonia*, true *Linoproductus*, a large *Anthracospirifer* that is considered to be *A. occiduus*, as well as abundant *Millerella*, indicates a Pennsylvanian age for Bird Spring beds approximately 100 feet above the base of the formation, or 150 feet below the faunule being discussed. Faunas that are judged Late Mississippian in northern Clark County and that include *Rhipidomella nevadensis*, *Archimedes*, *Diaphragmus phillipsi* and species of *Flexaria* have not been found as yet in the Spring Mountains. Consequently on evidence within the formation the faunule is considered to be Morrowan.

Morrowan fossils described by Mather (1915) include forms similar to some of those described here. *Schizophoria texana* is a Morrowan species, probably present in the type Morrowan and certainly in the Marble Falls Limestone. *Schizophoria* in the basal Wells Formation of southeastern Idaho is considered conspecific by Girty (1927) and lower Wells beds are generally assigned to the Morrowan. Unfortunately the stratigraphic position of *Orthotetes mutabilis* Girty from the Wells is not known. The Morrow form referred to *Orthotetes* by Mather is externally similar to the species described here. Spiriferids with bifurcating lateral costae are common in lower and middle Pennsylvanian rocks but their precursors in Mississippian strata commonly have simple lateral costae (Sadlick, 1960).

Locality.—The locality (U.C.L.A. No. 4414) from which the faunule was obtained is the SW corner of SE $\frac{1}{4}$ NE $\frac{1}{4}$ Sec. 25, T. 19 S, R. 58 E., Corn Creek Springs Quadrangle, Clark County, Nevada. The locality can be reached by an unmarked ranch road from Nevada State Highway 39 that branches east from marked ranch road in north half of

section 26. The bed crops out on a west-facing dip slope forming the east bank of major north-trending gully approximately 200 yards upstream from cattle pen and water tank along the road. The Monte Cristo-Bird Spring contact is exposed in a small gully approximately one quarter mile east of the locality and 250 feet stratigraphically below the brachiopod-bearing bed.

SYSTEMATIC PALEONTOLOGY

Family SCHIZOPHORIIDAE Schuchert, 1929

Genus SCHIZOPHORIA King, 1850

SCHIZOPHORIA TEXANA Girty

Pl. 43, figs. 9-19

Schizophoria texana GIRTY, 1927, p. 432, pl. 27, figs. 1-8.

Schizophoria resupinoides (Cox) MATHER, 1915, p. 145, pl. 8, figs. 6, 7 (not 8).

Description.—Small- to medium-sized shells, unequally biconvex in side view. Pedicle valve gently convex, maximum width anterior to midlength; lateral margins more strongly convex anteriorly, anterior margin slightly emarginate; beak small, acute; sulcus broad, shallow, evenly concave, initiated at about midlength of a mature shell, absent in small valves; interarea a little more than half the maximum width of valve, almost twice as wide as high, inclined at about 45 degrees to the plane of commissure, flattened next to hinge and becoming gently concave under the beak, delthyrium open, triangular, almost as wide as high. Brachial valve more strongly convex than pedicle valve, evenly convex longitudinally, greatest transverse convexity near midwidth; lateral margins evenly rounded, anterior slightly emarginate; fold indistinguishable, but growth lines at anterior edge of mature shells gently sinuous across dorsum; beak small, inconspicuous; interarea low, about six times as wide as high, notothyrium as wide as high. Both valves ornamented with very fine, even radial costellae, growth lines widely spaced, more prominent on pedicle valve.

Pedicle interior with long, narrow, deeply recessed muscle scars bounded at posterolateral margins by stout short dental plates descending from the hinge teeth. In mature shells the antero-lateral margins of the muscle scars are bounded by a low, rounded ridge continuing from the dental plates, that

may or may not be continuous around the anterior edge of the scars. The muscle scars are separated by a conspicuous median ridge that is rounded above, low posteriorly, and rises anteriorly, terminating abruptly in a triangular facet that faces antero-ventrally and forms the median anterior boundary of the scars. In some specimens a faint groove continues anteriorly from the anterior terminus of the median ridge. Brachial interior with small slightly elongate cardinal process situated in the apex of the notothyrium. The process is elongate dorso-ventrally and narrow transversely. In some specimens two small accessory lobes are developed at either side of the more prominent median lobe of the process. Crural plates diverging, reaching floor of the valve and bounding the posterior half of the oval muscle scar area. Sockets deep, narrow, bounded dorsally and ventrally by small transverse plates. Muscle scars indistinct, a low rounded median ridge separating right and left halves of the field.

Young or worn shells of both valves are evenly convex in top or bottom view and do not show a sulcus in the pedicle valve or an emarginate anterior. The ventral muscle scar field is much less strongly impressed in young shells and the ventral interarea is relatively higher and narrower than in mature valves.

Remarks.—These specimens assigned to *Schizophoria texana* agree very closely with Girty's original illustrations and his description of the internal features that were not illustrated. A Permian species, *Orthotichia heuconiana* (Girty), recently illustrated by Stehli (1954) is similar in size and external appearance to *S. texana*, but has somewhat more strongly developed dental plates and median ridge in the pedicle valve. In our specimens the prominence of these plates is dependent on the size of the shell. Larger, presumably older pedicle valves have a more prominent ridge and dental plates than smaller valves. The pedicle valves described here have been compared with silicified Devonian *Schizophoria* in the U.C.L.A. collections and the degree of development of dental plates and median ridge is essentially comparable. It is doubtful whether the strength of development of the median

ridge and dental plates is sufficient for generic separation of *Schizophoria* and *Orthotichia*.

Mather (1915) illustrates a *Schizophoria* from the Morrowan that is considered to be conspecific with *S. texana*. Girty (1927) indicates that *S. texana* is common in the basal part of the Wells Formation, although the types are from the Marble Falls Limestone in Texas. *Schizophoria texana* is the most abundant fossil in the silicified faunule, shells of the species outnumbering all other fossils combined. Large brachial valves are commonly fragile and easily broken. Specimens of both valves with the postero-lateral margins worn away are fairly common.

Material.—Illustrated specimens are U.C.L.A. Nos. 34823, 34824, and 34825 for pedicle valves and 34826, 34827, and 34828 for brachial valves. Remainder of the specimens are catalogued as No. 34836.

Measurements.—Illustrated specimens have the following measurements in mm.: Nos. 34823 and 34824, respectively, maximum width, 20.7, 23.1; maximum length, 18.5, 21.8; thickness, 6.0, 7.0; width, interarea, 11.6, 10.2; height, interarea, 4.7, 5.4; height, delthyrium, 3.2, 4.1; width, delthyrium, 3.0, 3.2; distance, beak to anterior end of median ridge, 9.6, 10.1; maximum width muscle scar field, 6.5, 6.4. Nos. 32826 and 32827, respectively, maximum width, 17.1, 18.0; maximum length, 17.6, 16.6; thickness, 9.0, 6.1; width, interarea, 9.6, 7.5; height, interarea, 1.7, 2.1; width, notothyrium, 3.1, 1.9; height, notothyrium, 2.4, 2.0.

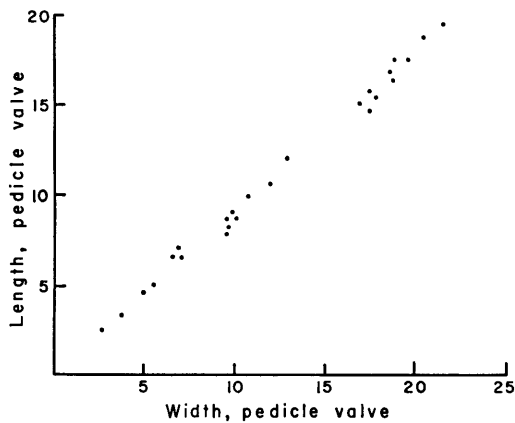
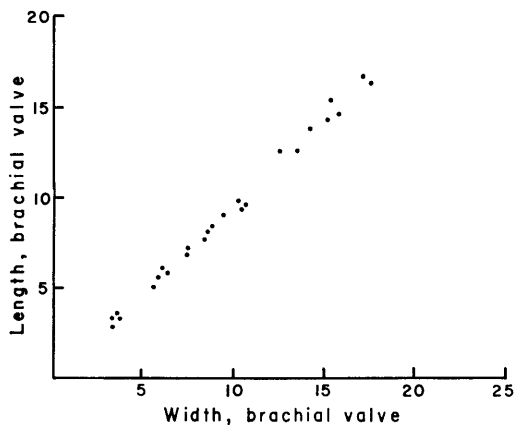
Maximum length and width of 25 brachial and 25 pedicle valves of *S. texana* are plotted as Text-fig. 1.

Family ORTHOTETIDAE McEwan, 1939
Genus ORTHOTETES Fischer, 1850

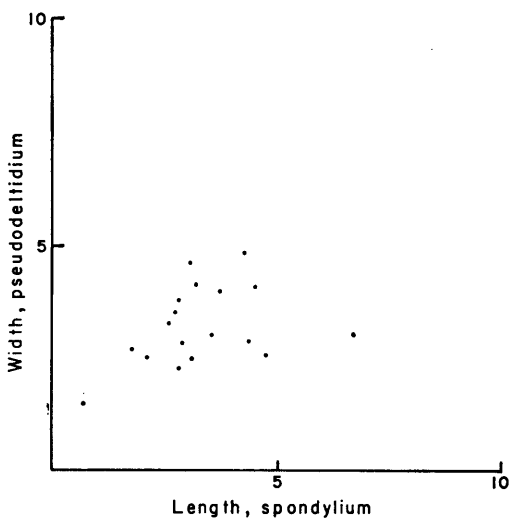
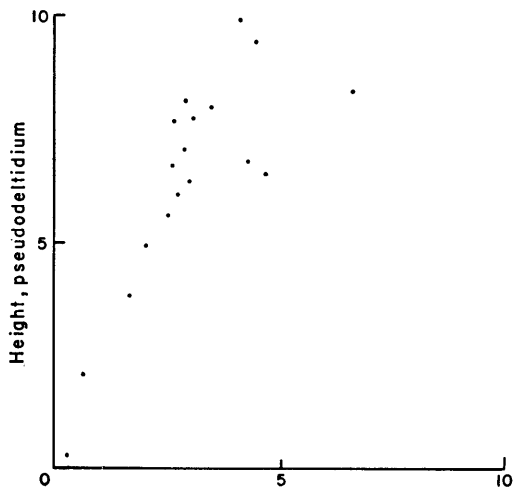
Discussion.—Since Sokolskaya's (1954) recent redescription and illustration of *Orthotetes radiata* Fischer, the type species of the genus, and placement of *Derbyia* Waagen in synonymy with *Orthotetes*, there is need for careful consideration of these two genera. Thomas (1958) and Campbell (1957) interpret *Orthotetes* to have the following distinctive characters based on description and illustration of Sokolskaya. The genus pre-

sumably has a biseptum in the pedicle valve formed by fusion of the dental plates and the spondylium is short, generally present only in youthful growth stages. In the brachial valve the cardinal process is low and broad, the socket (crural of authors) plates are recurved toward the hingeline, socket ridges are absent, and the chilidium is divided.

Specimens at hand contrast in character in that the median septum is apparently independent of the dental plates (insofar as this can be determined from silicified speci-



TEXT-FIG. 1—Scatter diagrams of length and width, in mm., of 25 brachial and 25 pedicle valves of *Schizophoria texana* Girty.



TEXT-FIG. 2—Scatter diagrams of height and width of pseudodeltidium plotted against length of spondylium, in mm., of *Orthotetes occidentalis*, n. sp.

mens) and the spondylium increases in length with growth of the shell (Text-fig. 2). In the brachial valve the cardinal process is long and markedly bifid in mature shells, although it is low, relatively broad and undivided in young brachial valves; the socket plates diverge out onto the floor of the valve and are not recurved; distinct socket ridges are present; and there is a divided chilidium.

These characters can be summed up to point to the fact that the dorsal cardinalium of the species described here is essentially derbyoid in nature and that the pedicle valve is essentially orthotetoid except for the apparent uniseptum. The only genus thus far described that combines these features is *Orthotetella*, a monotypic Permian genus known only from west Texas. *Orthotetella* differs from *Orthotetes occidentalis*, n. sp., in its cardinal process, more extravagantly developed spondylium and very short median septum. A form like *O. occidentalis* could be ancestral to *Orthotetella*. Genera *Werriea* Campbell and *Permorthotetes* Thomas both have short spondylia and recurved dorsal socket plates and may be synonymous with *Orthotetes*, as noted by Thomas (1958, p. 20).

It is not entirely certain that *Orthotetes* has a biseptum, this interpretation of Thomas and Campbell being based entirely on Sokol'skaya's rather poor text figure. In view of uncertainties regarding the relationship of *Orthotetes* and more recently named genera cited above, the species described below is allowed to remain in the former genus, recognizing that it may have to be assigned to some other named or yet unnamed genus in the future.

Because Russian paleontologists now place *Derbyia*, probably unjustifiably, in synonymy with *Orthotetes*, there is serious need to examine carefully the internal features of both valves of the many species of *Derbyia* described from the Pennsylvanian and Permian of North America.

ORTHOTETES OCCIDENTALIS Lane, n.sp.

Pl. 43, figs. 1-8; Pl. 44, figs. 1-3,5,6,8,9

Diagnosis.—Spondylium developed to a greater or lesser degree in all specimens. Interarea high, relatively narrow, perideltidium wide, pseudodeltidium with median convex portion.

Description.—Shell large, roughly dorsiconvex, some pedicle valves slightly resupinate. Pedicle valve subequal in length and width, surface irregularly planar, undulating. Interarea high, up to 2.5 cm., considerably narrower than maximum width of valve, commonly distorted or twisted; pseudodeltidium high, narrow, moderately convex, with a narrow median portion more

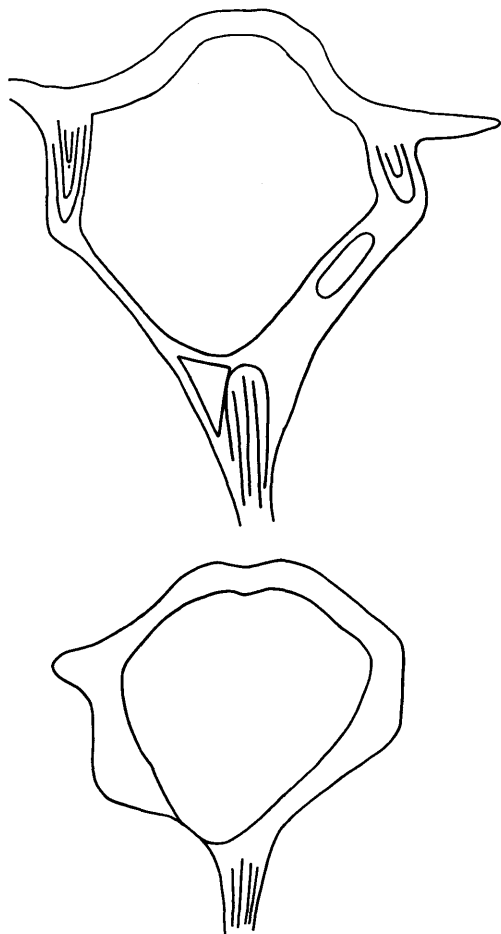
strongly convex and distinctly set off from lateral parts; sides of pseudodeltidium form an angle of about 25 degrees. Perideltidium wide, strongly and irregularly striate at right angles to the hinge, somewhat elevated above lateral, nonstriate parts of the area, edges form an angle of 80 to 100 degrees. Brachial valve regularly convex longitudinally and transversely; hinge straight, relatively short, lateral and anterior margins evenly rounded.

Surface of both valves bears fine, even costellae that are rounded above with straight or slightly concave sides, 14 to 16 in 5 mm., 15 mm. from the beak, decreasing only slightly in number to the anterior margin where 13 are present in 5 mm., 45 mm. from the beak. Costellae increase by intercalation, are all of same size, equal in width to interspaces, and are crossed by fine, closely spaced, concentric growth lines and wide irregularly spaced lamellae.

Interior of pedicle valve with a high median septum that is thin anteriorly and thickened posteriorly, relatively short, extending anteriorly less than one third the length of a mature shell. Septum wedge-shaped in side view, increasing in height gradually from the beak, reaching a maximum height about three quarters of its length anteriorly and then sloping sharply forward to the valve floor. Septum preserved as a bundle of high, very narrow, vertical plates that represent original calcite laminae. Dental teeth stout, subtriangular in cross-section, supported by dental ridges that are thick, taper dorsally and join dental plates for some distance from the apex of the deltidium. Dental plates thin, of variable length, but thickened apically in large specimens, apparently partly enclosing sides and top of posterior portion of the median septum. Muscle scars faint, suboval in outline, extending anteriorly a short distance beyond anterior end of septum, bounded posterolaterally by a low rounded ridge. Brachial interior with a cardinal process that ranges from a high, bifid type to a broad, low, undivided process, supported by widely diverging, relatively short stout socket plates. Posteriorly the diductor grooves of the process are strongly serrate, and a thin median ridge is present dorsally. Anteriorly

the process is smooth, without a median ridge, convex anteriorly and strongly concave transversely. Chilidium low, divided into two small bulbous plates. Socket plates diverge at an angle of about 90 degrees, bound the median-anterior edge of the socket and possess a distinct socket ridge that is narrow in small specimens, becoming broader and higher in large individuals. The muscle scars are faint, inverted heart shaped, longitudinally striate, and divided by a low, gently convex median ridge.

Remarks.—Placement of this species in genus *Orthotetes* is discussed above. Among some 50 silicified pedicle valves ranging in width from less than 1 cm. to 5 or 6 cm. the median septum unites with dental ridges some distance from the apex, forming a more or less distinct spondylium. There is great variability in development of the spondylium but it is present in all specimens. The longest chamber observed is 14 mm. long. With increase in height of the pseudodeltidium the length of the spondylium also increases (Text-fig. 2), indicating that the structure grew during growth of the shell. The dental ridges are distinct from the dental plates in all stages of growth, being thicker and set off from the dental plates along their external sides by a distinct ridge. Concerning the nature of the septum the following points are advanced that seem to indicate the septum is separate in origin from the dental plates. In large shells the entire septum is seen to be composed of a series of thin vertical plates. These are silicified but are always present and seem to indicate that silicification has faithfully reproduced the original calcite structure of the septum. The bundle of plates composing the septum can be observed continuing posteriorly through the part of the septum that is united with dental plates. The septal plates terminate ventrally at the base of the spondylium and there is no evidence that they continue up into the dental plates or are connected with those plates in any way. On the contrary, the silicified dental plates seem partly to surround the bundle of septal plates as shown in Text-fig. 3. Although all the valves are dissociated in the sample, the variability of height and width of the cardinal process is judged to be partly a func-



TEXT-FIG. 3—Cross-sections of two spondylia of *O. occidentalis*, n. sp., showing distribution of silica replacing original calcite shell, $\times 5.5$.

tion of relative length of the spondylium because it seems there would be difficulty in opening the valves if a high narrow process developed in an individual that also had a long spondylium.

Orthotetes occidentalis differs from most described *Orthotetes* in the height of the interarea, the wide perideltidium and median convex part of the pseudodeltidium. Among described species there is no doubt that *O. mutabilis* Girty is most similar to *O. occidentalis*. The former species differs in having a groove rather than a ridge down the pseudo-

TABLE 2—MEASUREMENTS OF
Orthotetes occidentalis, N. SP.

Pedicle Valve			
Width, interarea	Height, interarea	Width, perideltidium	Distance between hinge teeth
29.6	16.8	21.6	7.7
35.0	15.8	20.5	7.8
23.1	10.5	14.8	5.2
30.8	14.7	21.0	7.4
14.2	7.8	8.2	3.6
11.0	3.6	7.3	3.6
Brachial Valve			
Maximum length	Maximum width	Length, hinge to anterior margin	Maximum thickness
31.5	39.2	28.9	13.8
32.5	32.6*	30.1	11.4
18.5	21.6	18.1	7.7
46.9	54.3	44.8	13.7
13.0	15.4	12.8	3.8

* Estimated.

deltidium, a long rather than a short median septum, and in the elongate nature of the pedicle valve. Unfortunately the interior of

Girty's species has never been adequately illustrated. It is possible that the species described as *O. robusta* (Hall) by Mather (1915) from the Morrow may be close to *occidentalis*. The assignment of this Morrowan form to *robusta* is probably incorrect and the specimens need restudy. If American Mississippian species long assigned to *Orthotetes* belong in *Werreia* as Campbell seems to indicate, then *Orthotetes* is largely restricted to Pennsylvanian and Permian occurrences in North America. The type species is Moscovian in age which accords well with representation of the genus in the lower Pennsylvanian of western North America.

The species name is in allusion to its occurrence in western United States.

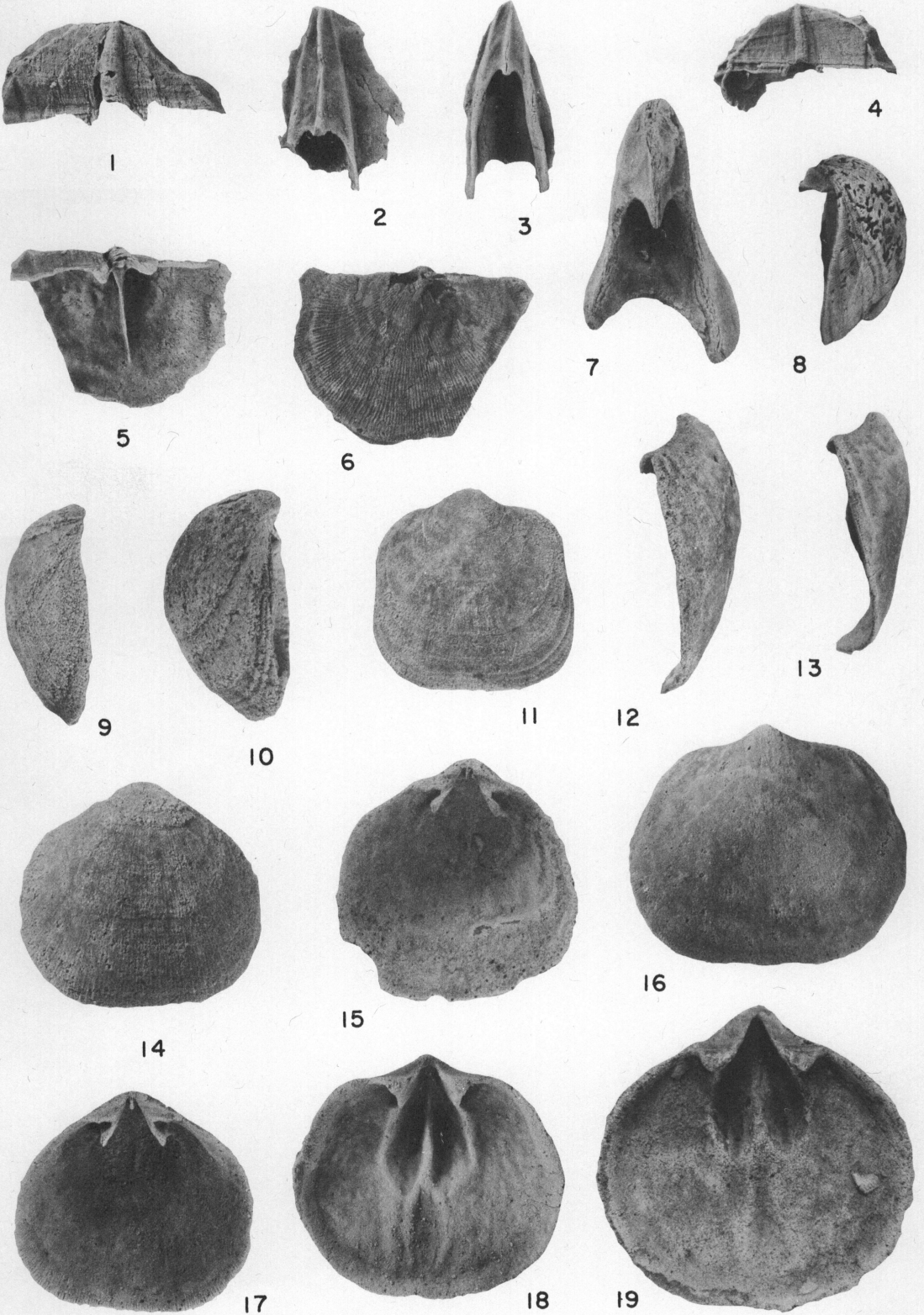
Types.—U.C.L.A. specimen no. 34813, a brachial valve, and 34814, a pedicle valve, are designated cotypes. Specimens 34815 and 34819, brachial and pedicle valves respectively, are designated paratypes.

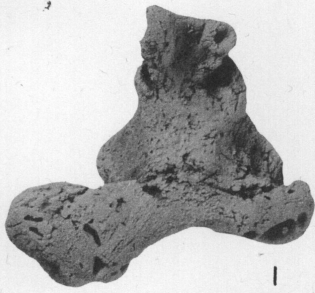
Measurements.—Because the large thin shells of this species generally became broken during etching, length and width measurements of the pedicle valve could not be obtained. Pertinent measures that could be recorded are given in Table 2 and Text-fig. 2.

EXPLANATION OF PLATE 43

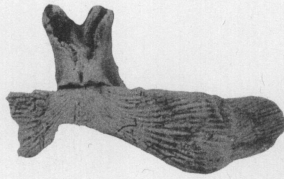
All figures $\times 2$ unless otherwise indicated.

- FIGS. 1-8—*Orthotetes occidentalis* Lane, n. sp. 1,5,6, posterior, internal, and external views of pedicle valve, cotype, U.C.L.A. 34814, $\times 1$; 2,3,7, internal views of three isolated spondylia, U.C.L.A. 34821, 34820 and 34822, respectively; 4, posterior view of pedicle valve showing median convex part of pseudodeltidium, paratype, U.C.L.A. 34819, $\times 1$; 8, side view of brachial valve, cotype, U.C.L.A. 34813, $\times 1$.
- 9-19—*Schizophoria texana* Girty. 9,14,17, side, external and internal views of brachial valve, hypotype, U.C.L.A. 34827; 10, side view of a convex brachial valve, hypotype, U.C.L.A. 34826; 11, external view of a small pedicle valve with worn shoulders, hypotype, U.C.L.A. 34825; 12,19, side and internal views of a large pedicle valve, hypotype, U.C.L.A. 34824; 13,16,18, side, external and internal views of pedicle valve, hypotype, U.C.L.A. 34823; 15, internal view of brachial valve, hypotype, U.C.L.A. 34828.

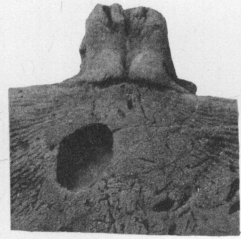




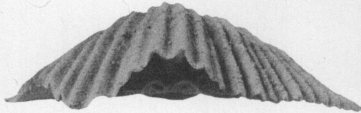
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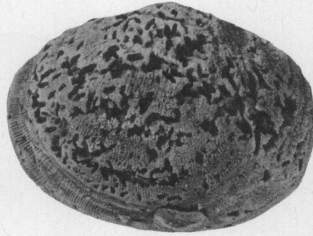
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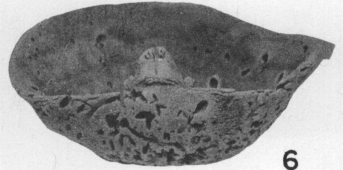
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4



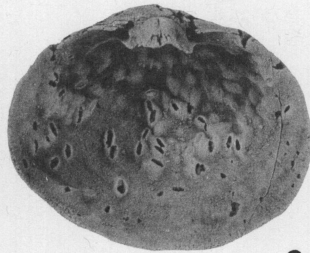
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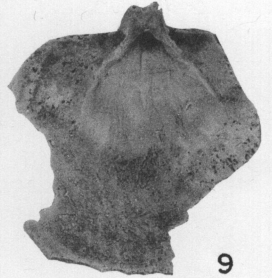
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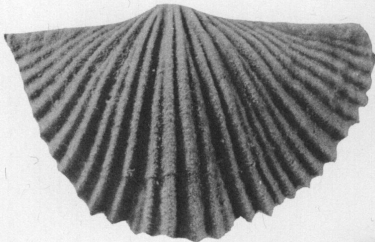
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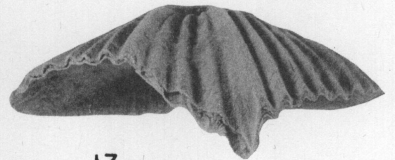
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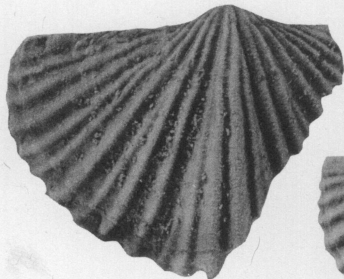
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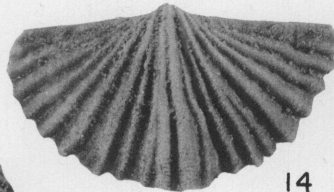
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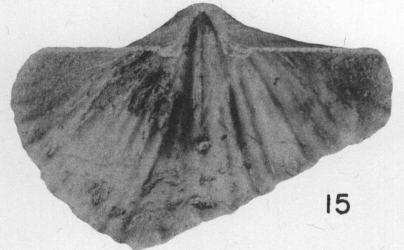
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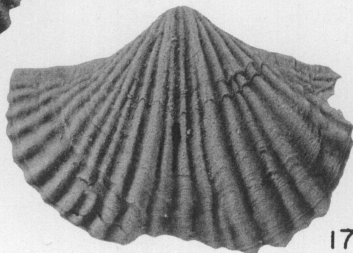
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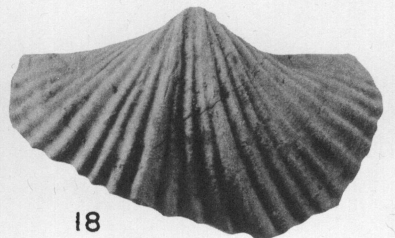
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Family SPIRIFERIDAE King, 1846
Genus ANTHRACOSPIRIFER Lane, n. gen.

Diagnosis.—Spiriferidae having an undivided median sulcal costa originating at the ventral beak; two to eight undivided lateral sulcal costae that originate from the sides of the sulcus; and six to 13 costae on each lateral slope, inner ones of which split in both valves. Dental lamellae reach floor of the pedicle valve, bounding the postero-lateral edge of the muscle field. Dorsal area with prominent vertical grooves and denticulate edge.

Description.—Medium to small Spiriferidae with shell wider than long. Lateral costae angular to rounded, one to four inner costae bifurcating next to fold and sulcus. Simple median sulcal costa originating at or near umbo and two to six lateral sulcal costae originating from the inner sides of costae bounding the sulcus. Two to eight costae compose the fold, the median two of which originate at the beak and are most prominent. The outermost lateral costae of the fold may bifurcate. Interarea of pedicle valve relatively low, concave, vertically grooved and slightly denticulate at margin. In the interior of the pedicle valve the dental amellae reach the floor of the valve for a

short distance anterior to the beak. Adductor scars slightly elevated, long, narrow and separated by a narrow groove. Diductor scars impressed, situated at antero-lateral margins of adductors, indistinct. Interior of brachial valve with long, tubular dental sockets, small sessile vertically striate cardinal process, and a short median ridge on the floor of the valve. The adductor scars are faint, apparently long and narrow, and situated principally on the inner surfaces of the sulci bounding the fold.

Type Species.—*Anthracospirifer birdspringensis*, n. sp.

Remarks.—No previously described spiriferid genus serves as a suitable repository for Pennsylvanian species long assigned to the genus *Spirifer*. The modern tendency to restrict *Spirifer* to large, short-hinged shells with multicostate fold and sulcus and a high triangular area closely similar to *S. striatus*, the type species, means that many Mississippian and all Pennsylvanian species must be placed elsewhere (see Brown, 1953, p. 58, pl. 5, fig. 6; Campbell, 1957, p. 67). American Mississippian species such as *S. rowleyi* and *S. grimesi* are of the type of *S. striatus* and should remain in *Spirifer*.

Among described genera *Unispirifer* Campbell and *Brachythyryna* Fredericks are

EXPLANATION OF PLATE 44

All figures $\times 2$ unless otherwise indicated.

- FIGS. 1-3, 5-6, 8-9—*Orihotetes occidentalis* Lane, n. sp. 1-3, external views showing variation in cardinal process, hypotypes, U.C.L.A. 34816, 34817 and 34818, respectively; 5, 6, 8, external, posterior and internal views of brachial valve, cotype, U.C.L.A. 34813, $\times 1$; 9, internal view of brachial valve showing socket plates and muscle scars, paratype, U.C.L.A. 34815, $\times 1$. 4, 7, 10-18—*Anthracospirifer birdspringensis* Lane, n. sp. 4, 7, 10, 11, anterior, internal, external and side views of brachial valve, cotype, U.C.L.A. 34810; 12, 13, 15, 18, side, anterior, internal and external views of pedicle valve, cotype, U.C.L.A. 34807; 14, 16, external views of brachial valves, paratypes, U.C.L.A. 34812 and 34811, respectively; 17, external view of pedicle valve, paratype, U.C.L.A. 34808.

judged to be most closely allied to *Anthracospirifer*. *Unispirifer* shares the vertically grooved interarea, presence of a median costa in sulcus, and absence of intercalated costae between primary and median sulcal costae with *Anthracospirifer*. As interpreted by Campbell (1957) his genus consists of shells that are commonly larger, more transverse, have many more costae on lateral slopes than *Anthracospirifer*. In addition, the median and primary costae of the sulcus of the former genus originate at the beak, rather than just the median costa, and the median costa commonly bifurcates once some distance from the umbo, rather than remain simple. *Brachythyrina* is closely similar to *Anthracospirifer* externally but differs in lacking dental plates descending to the floor of the pedicle valve.

Species assigned to *Anthracospirifer*, in addition to the type species, include *Spirifer matheri* Dunbar & Condra, *Spirifer opimus* Hall, *S. occiduus* Sadlick, and *S. oliveirai* Mendes.

The name *Anthracospirifer* is an allusion to the occurrence of this genus in the Coal Measures, or Pennsylvanian.

ANTHRACOSPIRIFER BIRD-
SPRINGENSIS Lane, n. sp.

Pl. 44, figs. 4,7,10-18; Pl. 45, fig. 3

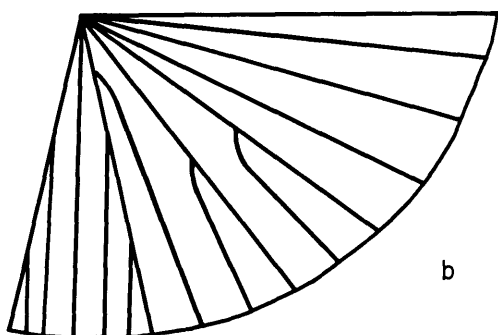
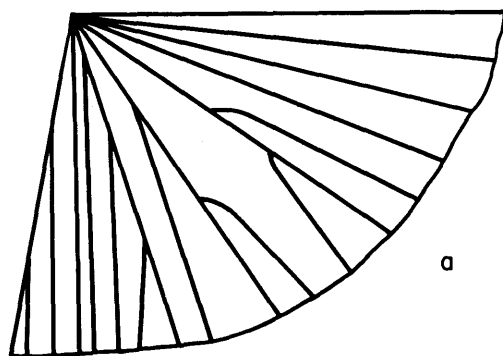
Description.—Shell approximately twice as wide as long. Lateral costae up to 13 in number, but seven to nine most common, sharp crested, subequal in width to intercostal sulci. On the pedicle valve the innermost lateral costa originates from the side of the primary costa bounding the sulcus, one or two mm. posterior to the origination of the primary sulcal costae. The second and third lateral costae begin at the umbo and each one splits off a small costa on its median side some distance from the umbo. In the brachial valve the primary costa next to the fold bifurcates equally into two costae two or three mm. from the beak. The outer of these two costae gives off a small secondary costa on its outer side 7 or 8 mm. from the beak. The second primary costa splits off a small costa on its outer side about 4 mm. from the beak, and one on its inner side adjacent to the second bifurcation of the innermost primary costa. The median two primary

costae of the lateral slope account for six costae at the anterior margin of a mature brachial valve. More laterally placed costae are all simple. Three or five costae are present in the sulcus and the sulcal angle is 25 to 27 degrees. Brachial valves longer than 11 or 12 mm. have six costae on the fold, smaller valves have only four. Faint radial striae can be observed on well preserved specimens, as can concentric lamellae. The ventral interarea is relatively low, concave, and exhibits vertical grooves as well as horizontal striae. The delthyrium is open, higher than wide, with a small callus at the apex. Brachial interarea is narrow but distinct and extends the full width of the shell. The interior of the valves is as described for the genus.

Remarks.—This species is to be compared with *A. occiduus*, *A. opimus* and *A. matheri*. Based on Sadlick's (1960) designation of a lectotype for *A. occiduus*, *A. birdspringensis* is smaller, has fewer lateral and sulcal costae and a more rounded anterior and lateral margin. It agrees with *A. occiduus* in its shape, extended hingeline, presence of a rather strong median intercostal sulcus in the fold and shape of costae. The new species is like *A. opimus* in size and number of costae on lateral slopes, but its width considerably exceeds length, the valves are less convex, it has up to three divided lateral costae instead of one, and the lateral extremities are more extended. The lectotype of *A. occiduus*, as well as specimens figured by Dunbar & Condra (1932), has lateral margins rather distinctly set off from the anterior margin of the fold and sulcus. The new species has rounded margins extending forward from the ears. *Anthracospirifer matheri* is much like *A. birdspringensis*, especially in shape and contour, but has more numerous costae on lateral slopes and in fold and sulcus. Mather's specimens (1915, pl. 12, figs. 5, 6) figured as *S. rockymontanus*, are more closely similar to the species being described here than the lectotype selected by Sadlick (Mather, pl. 12, fig. 4).

The name of the new species is in reference to its occurrence in the Bird Spring Formation of southern Nevada.

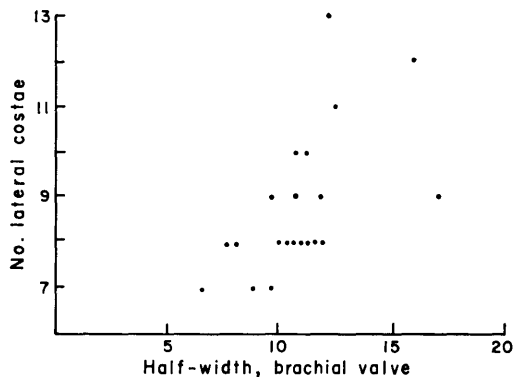
Types.—U.C.L.A. specimen nos. 34807 (pedicle) and 34810 (brachial) are desig-



TEXT-FIG. 4—Schematic representation of costal arrangement in (a) brachial valve and (b) pedicle valve of *Anthracospirifer birdspringensis*, n. sp.

nated cotypes. Specimens no. 34808 and 34809 (pedicle) and 34811 and 34812 (brachial) are designated paratypes.

Measurements.—Arrangement of costae on fold, sulcus, and lateral slopes is shown in Text-fig. 4. Relationship of width of brachial valve to number of lateral costae is shown in



TEXT-FIG. 5—Relationship of number of lateral costae and half-width of brachial valve (in mm.) of *Anthracospirifer birdspringensis*, n. sp.

Text-fig. 5. Principal measurements of the cotypes and paratypes are shown in Table 3.

Family SPIRIFERINIDAE Davidson, 1884

Genus SPIRIFERELLINA Fredericks, 1919

SPIRIFERELLINA LATA Lane, n. sp.

Pl. 45, figs. 1,2,4-14

Diagnosis.—Large, transverse *Spiriferellina* having three or four costae on lateral slopes.

Description.—Shell relatively large, transverse, anterior margin gently rounded, cardinal extremities angular to rounded. Hinge-line equal to or slightly less than maximum width of shell. Pedicle valve evenly convex longitudinally, lateral slopes less convex and tapering to cardinal extremities. Sulcus simple, straight sided, subangular, extending farther anteriorly and dorsally than bordering costae. A minute median elevation is present in the sulcus of a few pedicle valves,

TABLE 3—MEASUREMENTS, IN MM., OF *Anthracospirifer birdspringensis*, N. SP.

Specimen No.:	Brachial valve			Pedicle valve		
	34810	34811	34812	34807	34808	34809
Maximum length	14.5	16.1	11.8	16.3	15.6	10.9
Maximum width	23.2*	26.0*	20.1	24.0	22.6*	15.6*
Thickness	5.6	7.4	5.5	6.9	6.6	4.7
Height, interarea	0.9	1.2	0.8	3.1	3.4	2.7
Number lateral costae	13	9	8	9	9	8
Number costae, fold or sulcus	6	6	4	3	4	3

* Based on half-width.

but is not present in many. Four costae are on each lateral slope, including costae that bound the sulcus. The inner one or two costae originate at the beak, the outer two along the hinge. Postero-lateral surface of valve smooth next to interarea. Pedicle area triangular, strongly concave, at right angles to plane of commissure next to hinge, and curving regularly upward to beak. Brachial valve has three or four high angular costae on each lateral slope. Only the median two costae originate at the beak. Fold high, straight sided and subrounded to flat on top. Narrow interarea extends width of the valve.

Surface of both valves is covered by small, closely spaced, slightly elliptical granules. These are up to 0.2 mm. in maximum dimension, larger and more prominent on flanks of costae, apparently absent in the bottom of intercostal sulci, but present on some specimens on the crests of costae. There are 2.5 to 4 granules in 1 mm. radially on the flanks of costae. Shell substance is coarsely punctate, the punctae arranged in more or less irregular longitudinal rows, 6 to 8 in 1 mm. Growth lamellae irregularly developed on both valves, more crowded and becoming imbricated near anterior margins, but individual lamellae may occur any distance from the beaks.

Interior of pedicle valve with a high, short median septum that extends less than one half the length of the shell anteriorly. Dental teeth prominent, supported by short, inconspicuous dental plates that extend only a short distance along the floor of the valve from the apex of the delthyrium. In the brachial valve two inconspicuous ridges, one on top of each sulcus bordering the fold, bound the muscle scar field. A faint median ridge on the bottom of the trough formed internally by the fold extends slightly farther forward than the lateral ridges. The cardinal process is small, a rounded knob.

Discussion.—Several points of difference between this species and the type, *S. cristata*, recently redescribed by Campbell (1959) can be noted. The granules or pustules of *S. lata* are larger and more widely spaced, the species is more transverse, larger in mature shells, and has fewer lateral costae. The species most closely resembling *S. lata* is *Reticulariina atava* Chronic from the lower Per-

mian of Peru. The latter species is somewhat more mucronate, has up to six costae on a side and the anterior margin is straight rather than gently rounded. Pennsylvanian *Spiriferellina* such as *S. campestris* White commonly are smaller, less transverse, and have more lateral costae than does *S. lata*.

The species is assigned to *Spiriferellina* because imbricate growth lamellae, present in *Punctospirifer*, are lacking, and large spines, characteristic of *Reticulariina*, are not present. Among other Spiriferinidae *Crenispirifer* Stehli was considered, but it lacks a median elevation in the sulcus and the costae are relatively higher and more angular. Presumably the median sulcal elevation was not firmly established in this lower Pennsylvanian species of *Spiriferellina*, because only about one half the larger specimens show this feature. Small shells do not exhibit the character.

Types.—U.C.L.A. specimen nos. 34800 (pedicle) and 34804 (brachial) are designated cotypes. Specimens 34801 and 34802 (pedicle) and 34805 and 34806 (brachial) are designated paratypes.

Measurements.—The length and width of 39 brachial valves are shown in Text-fig. 6. Principal measurements of the types are shown in Table 4.

Family ATHYRIDAE Davidson, 1884

Genus COMPOSITA Brown, 1849

COMPOSITA OVATA Mather, 1915

Pl. 45, figs. 15-18

Composita ovata MATHER, 1915, p. 202, pl. 14, figs. 6-6c; DUNBAR & CONDRA, 1932, p. 370, pl. 43, figs. 14-19.

Composita wasatchensis MATHER (not White), 1915, p. 200, pl. 14, figs. 7-10.

Remarks.—Specimens of *Composita* identified as *C. ovata* are similar to that species in their oval outline, relatively unpronounced fold and sulcus that do not originate until the shells attain a length of 15 or 20 mm., and in the lack of a protruding tongue of the fold and sulcus at the anterior margin of mature shells. Few large complete valves have been recovered, the shells are quite thin and break up easily. The silicified *Composita* in this sample invariably are lighter colored than shells of other brachiopods. A sequence of brachial valves shows that the hinge plate

TABLE 4—MEASUREMENTS, IN MM., OF *Spiriferellina lata*, N. SP.

Specimen No.:	Pedicle valve			Brachial valve		
	34800	34801	34802	34804	34805	34806
Maximum length	15.3	11.3	11.1	13.8	11.9	11.5
Maximum width	22.1	18.4	13.0	28.1*	24.0*	20.2*
Thickness	6.9	6.1	5.2	7.7	5.8	4.7
Height, interarea	4.8	3.7	3.3	1.2	0.8	0.7
Width, delthyrium	3.8	2.7	2.3	—	—	—
Number lateral costae	4	5	4	3	4	3

* Based on half-width.

is rather variable in shape, ranging from sub-quadrate to ones that are almost triangular in plan. A minute hole is commonly present in the center of the posterior edge of the hinge plate. *Composita ovata* is a common Pennsylvanian species, and although origi-

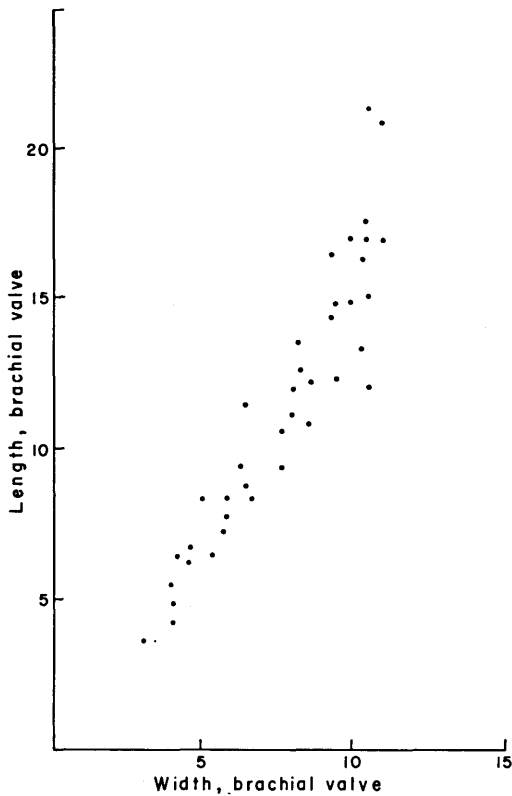
nally described from the Morrowan, it has been reported to range throughout the Pennsylvanian of the Midcontinent. It seems likely that some of the *Composita* figured and listed by Girty from Pennsylvanian rocks of the western United States as *C. subtilita* belong in this species.

Material.—Illustrated specimens of *C. ovata* are U.C.L.A. nos. 34829, pedicle valve, and 34830, brachial valve.

Measurements.—Pedicle valve no. 34829 has a width of 17.0, length of 17.1 and thickness of 5.8 mm. Brachial valve no. 34830 has a width of 18.8, length of 19.2, thickness of 8.8, height of fold, 3.9, width of fold, 9.8 mm.

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TEXT-FIG. 6—Length and width, in mm., of 39 brachial valves of *Spiriferellina lata*, n. sp.

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MANUSCRIPT RECEIVED SEPTEMBER 19, 1961

EXPLANATION OF PLATE 45

All figures $\times 2$.

- FIGS. 1,2,4-14—*Spiriferellina lata* Lane, n. sp. 1, external view of brachial valve, paratype, U.C.L.A. 34806; 2, external view of small pedicle valve, paratype, U.C.L.A. 34801; 4, internal view of pedicle valve, paratype, U.C.L.A. 34801; 5,8,11,13, side, anterior, internal and external views of pedicle valve, cotype, U.C.L.A. 34800; 6,7,9,12, side, anterior, external and internal views of brachial valve, cotype, U.C.L.A. 34804; 10, external view of pedicle valve showing median ridge in sulcus, hypotype, U.C.L.A. 34803; 14, external view of brachial valve, paratype, U.C.L.A. 34805.
- 3—*Anthracospirifer birdspringensis* Lane, n. sp. External view of small pedicle valve, paratype, U.C.L.A. 34809.
- 15-18—*Composita ovata* Mather. 15,16, external and internal views of pedicle valve, hypotype, U.C.L.A. 34829; 17,18, external and internal views of brachial valve, hypotype, U.C.L.A. 34830.

